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Original article

GeoGebra and the "solve shape, motion and location problems" competency in secondary school teachers

GeoGebra y la competencia "resuelve problemas de forma, movimiento y localización" en profesores de secundaria

GeoGebra e a competência "resolver problemas de forma, movimento e localização" em professores do ensino médio

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ABSTRACT

Mathematics education has become a global challenge in the 21st century, highlighting the need to adapt new teaching methods to enable the development of various competencies. These

competencies include problem-solving in shape, motion, and location. This involves getting students to apply geometric concepts in two or three dimensions, including measurements and descriptions of trajectories. This article aims to determine whether the proposed incorporation of GeoGebra software into junior high school mathematics education contributes to achieving this competency. This work had a qualitative approach, an exploratory level, a basic type, and a phenomenological design. The research was conducted using an interview guide with thirteen junior high school teachers in the province of Lambayeque, teaching the subject of mathematics. The main result was that when using GeoGebra software in teaching mathematics, junior high school students in Lambayeque developed this competency. This leads to the conclusion that there is a need to make the technological tool GeoGebra mandatory in schools in this region.

Keywords: competency-based education; mathematical programming; technological education; technological innovations.

RESUMEN

La educación matemática viene constituyendo un desafío global en el siglo XXI, visibilizando la necesidad de adaptar nuevas formas de enseñanza, de tal manera que permita el desarrollo de distintas competencias, entre ellas, la competencia resuelve problemas de forma, movimiento y localización, la cual consiste en lograr que los alumnos apliquen conceptos geométricos en dos dimensiones o tres, incluyendo mediciones y descripciones de trayectorias. Este artículo tiene como objetivo determinar si la propuesta de incorporación del software GeoGebra en la educación matemática del nivel secundario contribuye al logro de dicha competencia. El presente trabajo tuvo un enfoque cualitativo, nivel exploratorio, tipo básico y diseño fenomenológico. La investigación se llevó a cabo con una guía de entrevista a trece profesores de secundaria de la provincia de Lambayeque de la asignatura de Matemática. Se obtuvo como principal resultado que al emplearse el software GeoGebra en la enseñanza de la matemática, los estudiantes de educación secundaria de Lambayeque desarrollaron dicha competencia, lo que permite concluir que existe la necesidad de emplear la herramienta tecnológica del GeoGebra de manera obligatoria en los colegios de esta región.

Palabras clave: educación basada en competencias; programación matemática; educación tecnológica; innovaciones tecnológicas.

RESUMO

Na introdução, observa-se que a educação matemática tem vindo a constituir um desafio global no século XXI, tornando visível a necessidade de adaptação de novas formas de ensino, de forma a permitir o desenvolvimento de diferentes competências, entre elas, a competência "resolve problemas de forma, movimento e localização", que consiste em levar os alunos a aplicar conceitos geométricos em duas ou três dimensões, incluindo medições e descrições de trajetórias (Ministério da Educação, 2020); daí a importância de analisar a incorporação do software GeoGebra no ensino secundário de matemática para alcançar essa competência; Portanto, o objetivo foi conhecer como o GeoGebra contribui para o desenvolvimento da referida competência nos professores do ensino secundário em Lambayeque no ano de 2024. Nos materiais e métodos, houve abordagem qualitativa, nível exploratório, tipo básico e design. A pesquisa foi realizada com um roteiro de entrevista com 13 professores do ensino médio da província de Lambayeque na disciplina de matemática. O principal resultado obtido foi que quando o software GeoGebra foi utilizado no ensino da matemática, os alunos do ensino secundário de Lambayeque desenvolveram a referida competência, o que nos permite concluir que existe a necessidade de utilização obrigatória da ferramenta tecnológica GeoGebra nas escolas. da região de Lambayeque.

Palavras-chave: educação baseada em competências; programação matemática; educação tecnológica; inovações tecnológicas.

INTRODUCTION

Over the years, the need to reconsider mathematics education has become evident, with the aim of incorporating technological tools into the teaching of this subject in educational institutions in the Lambayeque region. This is intended to foster the development of skills and competencies in students, especially the competency "solving problems involving shape, motion, and location," which

involves having students apply geometric concepts in two or three dimensions, including measurements and descriptions of trajectories (Ministry of Education, 2020).

Proof of this is that, at an international level, specifically in Europe and the United States, although a significant improvement in education could be seen, especially in the United States, after the COVID-19 pandemic it could be verified that education suffered a delay, making it a challenge to be able to implement information technologies precisely in the teaching of mathematics (Henríquez-Rivas & Verdugo-Hernández, 2023).

Furthermore, Arias *et al.* (2023) argued that, of the 72 countries that participated in PISA (Program for International Student Assessment) in the years 2018 and 2022 in the evaluation of Mathematics, 44 countries reduced their score in such subject. In addition, at the national level it was verified that, in 2023, for the second grade of junior high school, the average measure registered a decrease of six points in relation to that of the previous year with respect to Mathematics, and in addition, a decrease was seen with respect to students who reach a satisfactory level in the subject, being only 11.3%.

In the Lambayeque region, it was noted that only 8.6% of second-year junior high school students achieved a satisfactory level in Mathematics, as confirmed by the PISA assessment. Therefore, it is evident that the subject of Mathematics reflects a need to be restructured in its teaching, such that Information and Communication Technologies are a key element in achieving significant development in the teaching of Mathematics and, consequently, in the competence to solve problems of shape, movement, and location.

Thus, GeoGebra, a technological tool for the development of competencies in the area of Mathematics, has been part of an updating program in Mathematics and Information and Communications Technologies, in which 31 teachers from the province of Lambayeque participated. From there, the curiosity arises to investigate how the proposal of activities with the aforementioned software contributes to the development of the competence to solve problems of shape, movement and location in junior high school teachers in Lambayeque in the year 2024, being important as an object of research, since it goes hand in hand with Sustainable Development Goal 4 (Quality Education) by addressing the deficiency in technological skills, a main barrier to global educational progress.

Within the background of the research, it is noted, at an international level, that in Chile the difficulties of teaching Mathematics are evident, with the use of GeoGebra playing an important role in optimizing the students' competence and understanding of, especially due to its characteristic of being simple in use (Henríquez-Rivas & Verdugo-Hernández, 2023).

On the other hand, in the national background, it is noted that in Madre de Dios, the research showed that the GeoGebra software contributes significantly to the teaching of Mathematics, improving academic performance in a short time (Pumacallahui *et al.*, 2021).

Likewise, it is important to detail the theories that underpin this work. On one hand, Bruner and Ausubel's theory of cognitivism argues that knowledge arises from the student's prior learning, which is influenced by external factors. It will be important for the new knowledge to be relevant to the learner; therefore, the use of GeoGebra can create new knowledge from the augmented reality it provides (Mex *et al.*, 2020).

Additionally, there is Vygotsky's theory of constructivism, which results, as the name indicates, in a way of restructuring teaching, following the line of the previous theory, but with a scope in the students' specific needs, in such a way that their participation is increasingly greater in the achievement of their own knowledge; interacting with other students, to achieve a greater understanding of their reality through everyday experiences. For this, Vygotsky maintains the importance of systems of signs, language, mnemonics and decision-making processes (Borgobello & Monjelat, 2019).

Siemens' theory of connectivism goes, however, beyond the introduction of Information and Communication Technologies, adding to it the formation of networks (the personal network of knowledge), in addition to evaluating the effectiveness of learning through the use of electronic tools (Ayanwale *et al.*, 2023); hence this theory gives a special role to technology in education.

The aforementioned theories have shown the need to acquire new skills in science and technology, since knowledge is found in different areas of the individual, in interaction with others, and in the creation of networks and systems.

An important method for the development of study competence was Pólya's method which, according to Bravo and Cedeño (2023), facilitates students to acquire skills in interpretation, relationship and

formulation of strategies to solve problems related to first-degree equations, encouraging students to gain extensive experience in problem solving, where the teacher acts as a mentor. Thus, Pólya established four phases to achieve effective problem solving, which include: understanding, planning, execution and evaluation.

Another model that also supports the development of the aforementioned competence is IMPROVE, which is based on metacognitive instruction aimed at primary and junior high school students, where the development of cognitive and metacognitive strategies is sought, with the teacher being a guide instructor in class, providing feedback to students in problem solving (Mevarech & Kramarski, 1997).

In this context, it can be concluded that by highlighting the problems of Mathematics education not only in the Lambayeque region but also internationally, GeoGebra has been studied as a key technological tool for transforming Mathematics education and developing competencies in students. Therefore, the general objective of this research was to determine whether the proposed activities using GeoGebra contribute to developing the aforementioned competency in the province of Lambayeque in 2024. Considering that at least 31 teachers have been part of an update program in Mathematics and Information and Communication Technologies in the province of Lambayeque, only 13 have already applied this software in their Mathematics classes. The specific objectives included determining how the development of object modeling and communication comprehension skills is perceived with the application of GeoGebra, and how the development of the ability to use strategies and procedures is perceived, and arguing claims about geometric relationships.

MATERIALS AND METHODS

The research approach adopted was qualitative, exploratory, theoretical or pure, and phenomenological in design. The focus was on the experience of Mathematics teachers in teaching their classes using GeoGebra. For this study, a categorization matrix was constructed that considered the following (Table 1):

Table 1. Categorization matrix

Study category	Subcategory	Indicator
GeoGebra activities	Combination of objects in space and time.	• Free and flexible exploration. • Navigability. • Learning construction.
	Real-time feedback.	• Dynamic behavior modification. • New information.
	Reliability, relevance and organization.	• Access to information. • Organize the information.
Competence solves problems of shape, movement and location	Object modeling and communication capabilities for compression.	• Location and movement of objects with geometric shapes. • Understanding geometric relationships. • Expression of understanding. • Properties of geometric shapes. • Transformations and position in a reference system.
	Ability to use strategies and procedures, and argue statements about geometric relationships.	• Choose, adjust, combine or develop methods or strategies to build geometric shapes. • Measure and transform two-dimensional and three-dimensional shapes. • Make statements. • geometric shapes.

Note: The table refers to the decomposition of the study categories into subcategories and the latter into indicators for a better approach to the problem

The interview technique and the interview guide instrument were used to collect the data. The interviews were validated by eight experts based on their adequacy, clarity, coherence, and relevance to the research problem. The experts were selected based on their doctoral degree, specialization in computer science, research, membership in Renacyt, specialization in communication, and pure Mathematicians. Furthermore, these doctoral degrees could be from a university or junior high school.

Below are some of the questions used. How do you recognize that students developed the ability to model objects? How do you perceive that the GeoGebra activities used in your class allow students to determine the location and movement of objects with geometric shapes? Do you think that the combination of objects in space and time in GeoGebra contributes to students' development of the ability to model objects? Or what characteristics of GeoGebra do you think contribute to this? What student demonstrations allow you to infer the development of the ability to argue claims about geometric relationships? How do you perceive that the GeoGebra activities used in your class allow students to design strategies to construct geometric shapes, and measure and transform two- and three-dimensional shapes? In your opinion, does dynamic behavior modification with GeoGebra allow the development of the ability to use strategies and procedures, and argue claims? How do you perceive that the GeoGebra software allows for the reliability, relevance, and organization of information?

The participants of this research, according to the inclusion criteria (training in the software, application of the software in class on at least four occasions), were 13 junior high school teachers from the province of Lambayeque of the subject of Mathematics, since of the 31 teachers who have been part of an update program in Mathematics and Information and Communication technologies in the province of Lambayeque, only 13 have already applied such software in their Mathematics classes on at least four occasions.

The following methods were used to analyze the collected information: hermeneutic and inductive, since analysis and interpretation of the results were necessary to reach conclusions from the specific to the general. By understanding the perceptions of junior high school teachers who used the aforementioned software in their Mathematics classes regarding the development of the CRPFML, it is possible to determine the importance of the proposal to use GeoGebra activities in more classrooms and schools in the province of Lambayeque.

ATLAS.ti Web application (version 21) was used to process the data, generating 23 categories based on the coding performed. Once the information collected for each interview question was entered, keywords were selected for the subcategories and dimensions of the study. Finally, codes containing similar responses or similar themes were created to create networks that allowed, through graphics, to visualize the relationship between the responses and the categories, subcategories, or dimensions of the study.

RESULTS

Regarding the general objective of this article, the result was that the use of GeoGebra software allowed the development of problem-solving skills in shape, movement, and location, once it was applied in learning sessions by junior high school Mathematics teachers in the province of Lambayeque.

Now, in accordance with one of the specific objectives, which was to determine how the development of object modeling and communication comprehension capabilities is perceived with the application of GeoGebra, it is noted that, on the one hand, object modeling has a direct relationship with the creation of interactive models in the aforementioned software; this fact allows figures to be created with precision, as well as their adjustment and manipulation.

It was also observed that the creation of these models is achieved because the software has easy-to-understand algorithms, since it uses visual schemes, such as diagrams or graphs, and also uses reliable scientific sources. Therefore, the elaboration of these representations achieved the development of the capacity for reflection and self-assessment of learning, while also the students' awakening the interest and motivations. Furthermore, it was obtained as a result that the interviewees perceived that the students who used GeoGebra for their learning (in their classes) managed to develop the ability to model objects when creating or constructing geometric figures, as well as when translating mathematical concepts into interactive models, developing their creative capacity, observation, and motor skills (Figure 1).

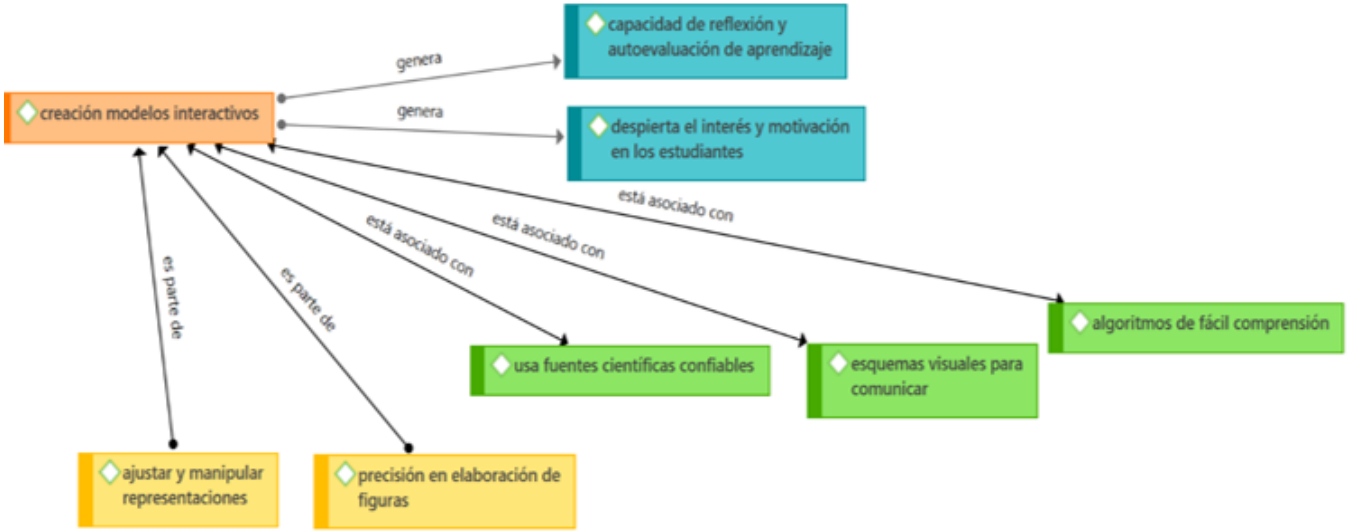

Figure 1. Creating interactive models

Note: The interviewees pointed out, with respect to the object modeling capacity, various characteristics of the software and the relationship that exists to awaken even the students' interest

Additionally, interviewees noted that students developed this skill by using tools to move geometric objects to a specific point on the plane, identifying coordinates, vectors, and trajectories, which demonstrates their understanding of how geometry works in an interactive space.

Furthermore, the interviewees maintain that such software helped in understanding how shapes and their properties change with different object transformations, observing in real time the effects of these manipulations, which deepened their understanding and ability to model objects, identify geometric patterns and relationships, improving their ability to understand geometric properties, identify properties, and use diagrams, schemes, graphs in GeoGebra for their communication (Figure 2).

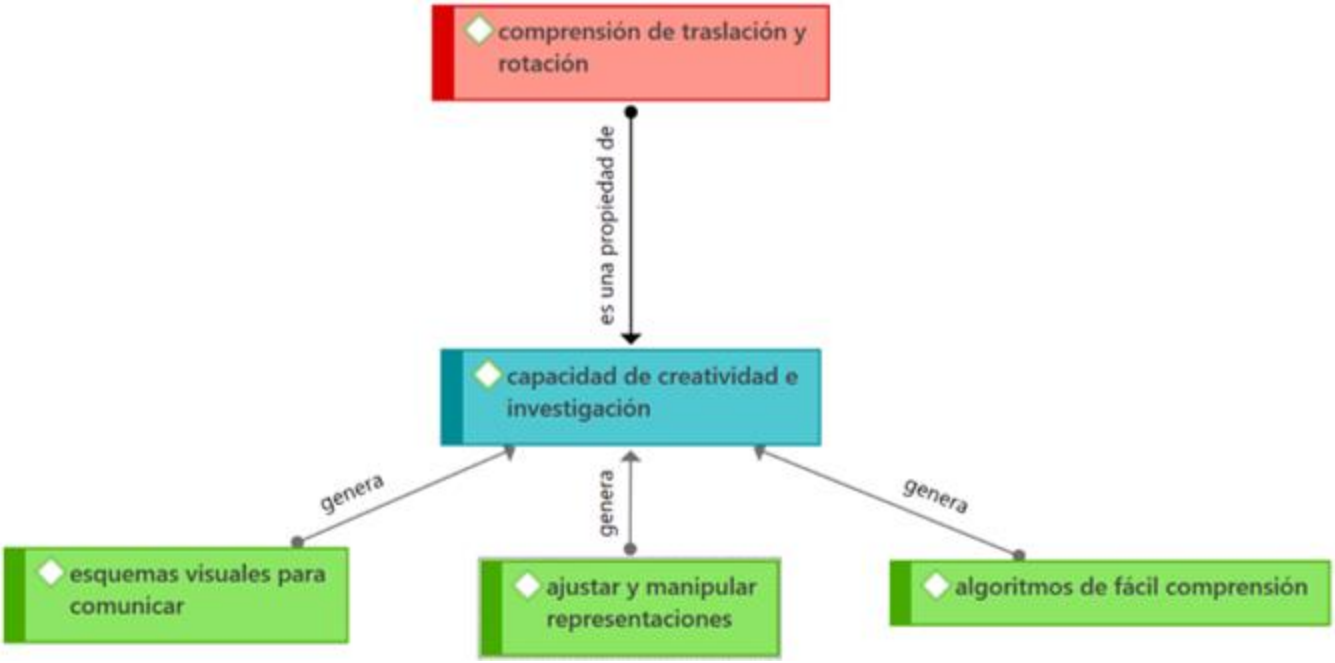

Figure 2. Creativity and research capacity

Note: Interviewees pointed out that understanding translation and rotation would be a property of creative and research capacity, which is generated by virtue of visual schemes, adjusting and manipulating representation since the software has easy-to-understand algorithms

It was also noted that GeoGebra allowed students to experiment with geometric transformations immediately and visually, being able to apply movements such as translations, rotations, and reflections to geometric figures, and observe in real time how these changes affect the position of the shapes within a coordinate system.

In addition, among the features of GeoGebra that contribute to the development of the ability to model objects, there is the ease of understanding and comprehending the elements and tools to create and manipulate objects, allowing the simulation of the movement of geometric objects, providing a dynamic understanding of their properties and relationships, facilitating group work and discussion by sharing and comparing various students' geometric models, favoring collaborative learning.

Regarding the specific objective of determining how the development of the ability to use strategies and procedures and argue statements about geometric relationships is perceived with the application of GeoGebra, it was found that the use of strategies and procedures (thanks to the software's multiple tools and commands) served to program and organize the development of geometric problems, allowed the design of regular and irregular figures, relate the area or volume of figures, use or combine various strategies to solve problems about composite figures; likewise, it allowed the construction of geometric shapes to scale and determined the length, area or volume of geometric shapes. Furthermore, the ability to argue statements about geometric relationships involved a series of behaviors in students, such as: justifying, validating or refuting relationships between elements, making claims about the similarity and congruence of shapes, comparing claims about opposite statements or special cases, and recognizing geometric figures according to their characteristics.

In this context, the interviewees perceived that the students demonstrated that they program and organize the development of geometric problems using the appropriate strategy and methods with flexibility and coherence, considering that these methods are a set of actions carried out through planning procedures. In addition, they justified the procedures they used when solving a geometric problem in a coherent and clear manner, explaining the choice of tools or methods in GeoGebra, using geometric terms when presenting GeoGebra diagrams and constructions to support their arguments; therefore, they had developed the aforementioned capacity.

Furthermore, it was found that the students used different tools, adapting them to their learning pace; that is, they experimented with methods for constructing geometric shapes. Furthermore, they made statements about the possible relationships between elements and the properties of geometric shapes, based on their two- and three-dimensional exploration (Figure 3).

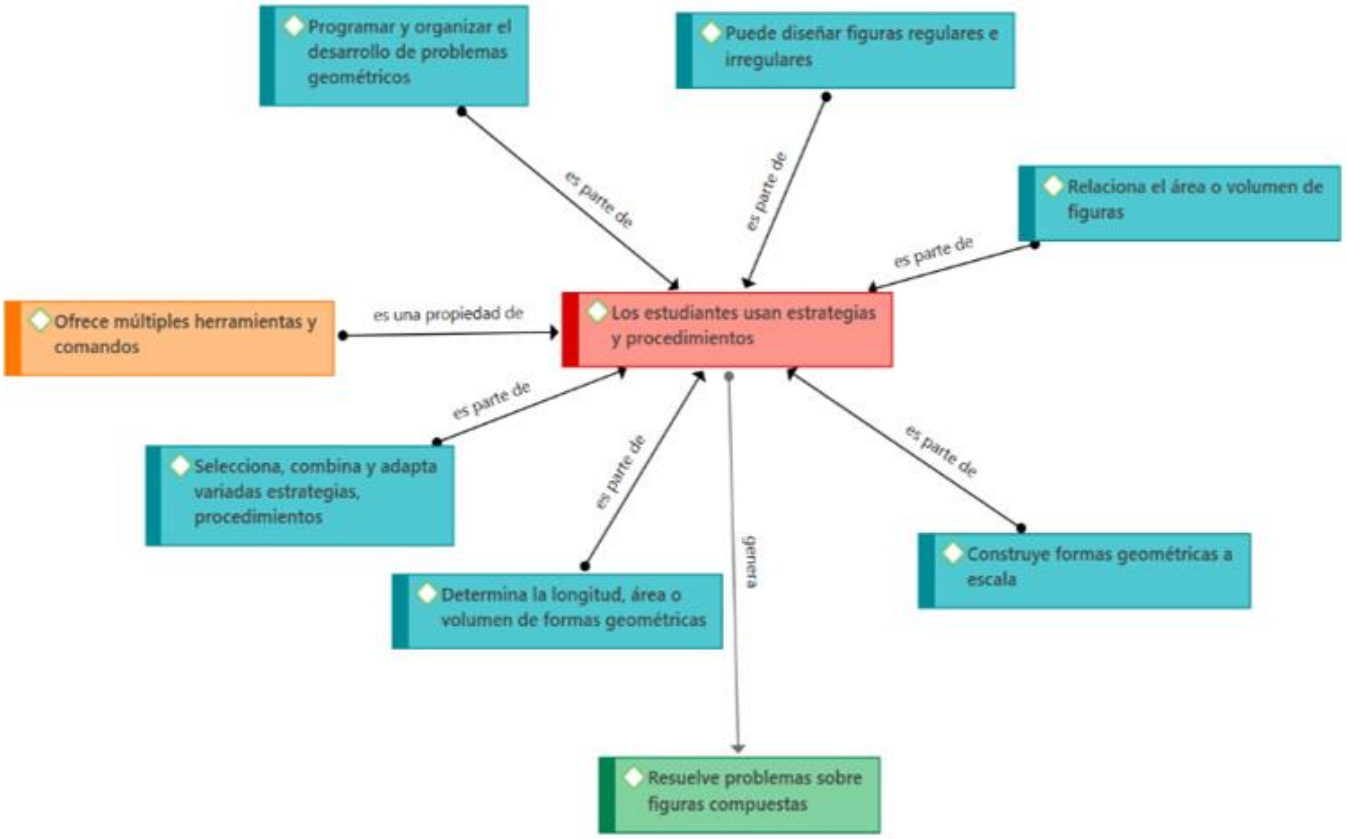

Figure 3. Students use strategies and procedures

Note: The interviewees point out various indicators that allow us to determine that students use strategies and procedures

Students also observed how geometric properties change, transform, and pose hypotheses when creating and experimenting with geometric constructions in GeoGebra, helping them formulate precise statements by visualizing their characteristics in 2D, allowing them to identify, formulate, verify, and communicate conclusions.

Likewise, students connected elements and characteristics with the exploration of geometric shapes, as they noted that they made conjectures about geometric shapes, verifying them through measurement, identifying and connecting elements such as angles, sides, and vertices within a geometric figure; they constructed surfaces delimited by lines (curved or straight) or spaces delimited by surfaces (Figure 4).

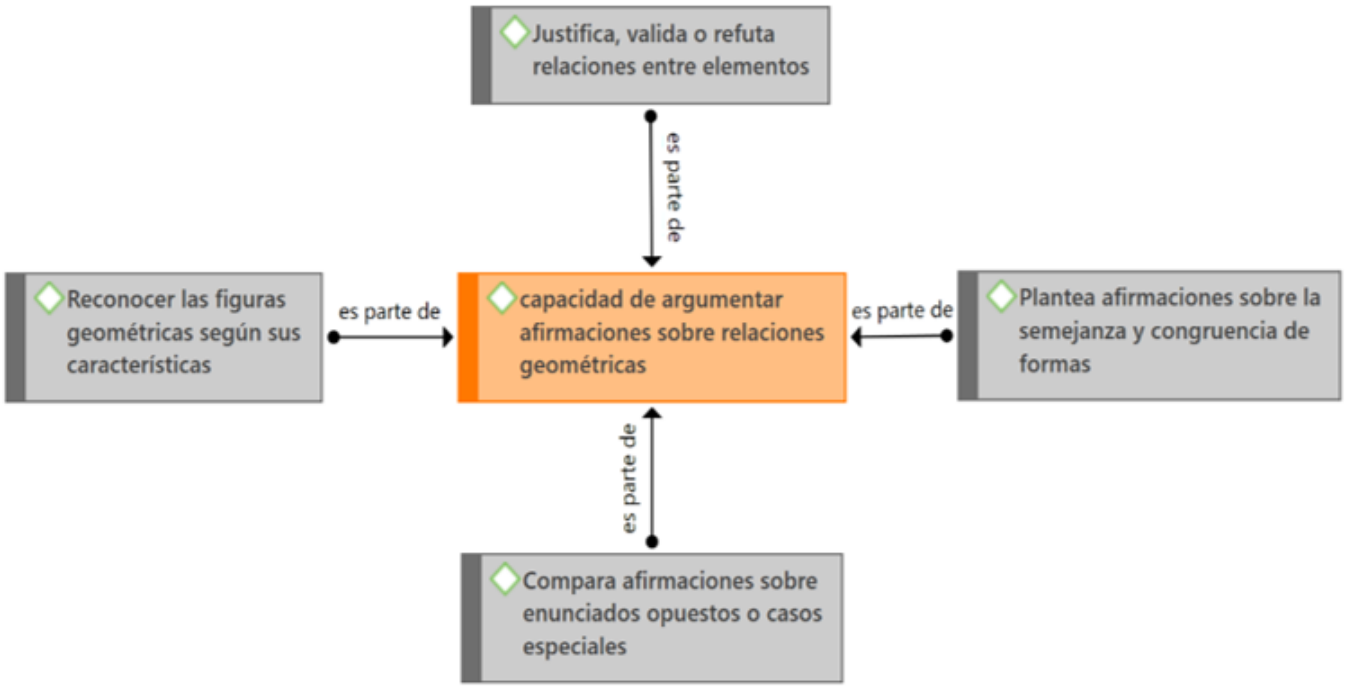

Figure 4. Ability to argue statements about geometric relationships

Note: The interviewees indicated that, to develop this ability, students recognize figures along with their characteristics, which allows them to justify, validate or refute the relationships between elements, make statements and compare them

Interviewees concluded that GeoGebra provided immediate feedback on students' potential responses, helping them to correct and improve their procedures and adapt their problem-solving strategies. This feedback helps to justify and verify their assertions, fostering critical reflection on the strategies and procedures used and fostering the development of critical thinking.

Furthermore, GeoGebra's dynamic behavior modification feature allowed students to experiment and adjust their strategies and procedures in real time, providing a flexible platform for manipulating objects, solving problems, and observing their responses, enabling them to learn meaningfully by helping them argue claims by applying appropriate strategies and procedures.

Finally, it should be noted that the interview guide was the instrument used to collect the data. This was validated by a panel of eight experts. After applying Aiken's V test, all the activities and

subcategories evaluated achieved the highest score in the criteria of sufficiency, clarity, coherence, and relevance. The overall average was 1.0, demonstrating the high quality of the instrument.

Regarding the research proposal, it is important to note that it was also validated by four experts in the field from secondary and higher education. The experts were selected based on their doctoral degree in Mathematics only or with a double major (Physics and Mathematics or Mathematics and Physics) and their teaching experience in regular basic education at the secondary or university levels.

The validation was carried out theoretically and practically (in class through learning activities, considering learning theories developed in the discussion), based on a form structured in three parts: the first evaluated general aspects, the second evaluated the content, and the third, the comprehensive evaluation of the proposal. It consisted of the categories of very adequate (VA), fairly adequate (FA), adequate (A), less adequate (LE), and inadequate (I). In this sense, the experts affirmed that it is an important strategy for achieving the development of the studied competence, since when applied in conjunction with the Pólya and IMPROVE methods, students will be able to acquire object modeling and communication skills, as well as the use of strategies and procedures and argue statements about geometric relationships using GeoGebra (Table 2).

Table 2. Validation of the proposal

Experts	Opinion
Director of IE and Mathematics	Very applicable
University and EBR Professor of Physics and Mathematics	Very applicable
University Professor of Mathematics	Very applicable
University Professor of Mathematics and Physics	Very applicable

DISCUSSION

On object modeling and understanding geometric shapes and relationships

It is noted that the qualities of the GeoGebra software managed to awaken the students´ interest and motivation, developing their creative capacity, observation and motor skills. After using it, the students reflected and self-assessed their learning of Mathematics, developing the ability to model objects and understanding geometric shapes and relationships. This coincides with what was pointed out by Treffinger and Feldhusen (1996; as cited in Tourón *et al.*, 2024), when they stated that talent only emerges, develops, and flourishes through education at home and at school, combined with the child's own efforts; therefore, it is evident that learning requires tools that go far beyond the academic field in order to achieve students' creativity or motivation, just as GeoGebra software does.

In addition, Santos-Trigo *et al.* (2021) argued that various problem-solving strategies, such as measuring attributes of entities and determining their geometric loci, influenced reasoning and problem-solving methods; this was related to the results obtained regarding students' achievement in locating and moving geometric shapes using GeoGebra.

Furthermore, the aforementioned software allowed students to interact with an augmented reality, which agrees with Bruner, who maintains that cognitive development is influenced by external factors (Mex *et al.*, 2020).

On the other hand, the students' understanding of forms and their properties is appreciated, since it was found that meaningful learning is oriented towards such understanding; and this, as expressed by Ausubel (1967), allows the acquisition of new knowledge, giving knowledge a meaning for the learner, and must be relevant and pertinent.

Likewise, it is noted that the students, through the characteristics of GeoGebra (free and flexible exploration, and navigability), when using it in the learning sessions of the interviewees, experimented with geometric transformations immediately and visually, being able to apply movements such as translations, rotations and reflections to geometric figures, and observe in real time how these changes affect the position of the shapes within a coordinate system. Thus, the direct relationship with Vygotsky's theory of Constructivism is evident, which defends that the teacher must abandon the traditional model and adjust their teaching method according to the students´ specific

needs in their environment (Aguirre & Velasco, 2021), which showed the importance of exploration, of the student's real experience with their learning.

On the use of strategies, procedures and arguing statements about geometric relationships

Some indicators of having developed such capacity were appreciated in the interviewed students, since they used GeoGebra, programmed and organized the development of geometric problems, designed figures, related the area or volume, used and combined different strategies to solve problems, constructed geometric shapes to scale, and determined the length, area or volume, allowing the student to be independent in their learning. Thus, Padilla *et al.* (2022) indicated that educational technological tools are used in teaching, which allow fostering autonomy in the learning process.

This coincided with the connectivism theory of Siemens and Downes, who consider that technology in education in the digital age plays an important role (Oddone, 2023).

On the other hand, the aforementioned students used different tools, adapting them to their learning pace, to construct geometric shapes, such as: creation of regular polygons; geometric construction based on theorems and geometric properties such as the Pythagorean Theorem, parallelogram properties, and criteria for congruence and similarity of triangles; design of three-dimensional figures by accurately calculating the dimensions, angles, and areas of two-dimensional shapes; design and transformation of figures in 3D space with the help of GeoGebra. This coincided with the provisions of the Ministry of Education (2020), which expects students to perform rotations, translations, and enlargements on the Cartesian plane, using procedures to construct and measure shapes. It also coincided with Bravo and Cedeño (2023), who concluded that using the Pólya method helps students acquire skills in interpretation, relationships, and formulation of strategies to solve problems related to first-degree equations.

It was also verified that students made statements about the possible relationships between elements and the properties of geometric shapes, based on their two- and three-dimensional exploration; and they designed effective strategies to achieve a geometric construction or to transform a figure, using GeoGebra's measurement tools to verify their results. In this sense, it is evident that the use of GeoGebra incorporated additional features in algebra and calculus, which

enabled the interrelationship among various areas of Mathematics (Ruiz-López, 2012; as cited in Pumacallahui *et al.,* 2021).

It was also noted that students were able to make conjectures, describe patterns, and explain geometric features observed in GeoGebra, which showed that they formulate statements based on their understanding, express themselves about congruent and similar shapes, and the relationship among them. This fact was postulated by Slavíèková (2021), when indicating that the introduction of digital technologies in the teaching and learning of Mathematics that began at the end of the 20th century, which includes GeoGebra, allows for interactive geometry, computer algebra systems, and graphic calculators, favoring the understanding of these areas of mathematics.

It was observed, according to the IMPROVE model, that students connected elements and characteristics with the exploration of geometric shapes, showing that GeoGebra facilitated the connection among different geometric elements through visualization and direct manipulation, allowing students to see how the properties of one figure affect another, which helped them develop a deeper understanding of geometric interrelationships (Mevarech & Kramarski, 1997).

In this sense, it can be inferred that GeoGebra promoted the development of critical-analytical thinking, logical-mathematical reasoning and numerical reasoning, thanks to its qualities, especially since GeoGebra allowed immediate feedback on the students' possible responses, which made it possible to conclude that learning involved building and navigating these digital networks to generate knowledge.

On the proposal of activities using GeoGebra software to help develop the competence to solve problems of shape, movement and location

It was verified that, with the use of the software, students were able to develop skills in object modeling, understanding geometric shapes and relationships, using strategies and procedures, and arguing claims about geometric relationships. Therefore, since these skills constituted the study competency, it is evident that the aforementioned software enabled the development of such competency.

The pedagogical proposal of activities using GeoGebra software, based on teacher perceptions, contributed to the development of the competency of solving problems of shape, movement, and

location among junior high school students in Lambayeque in 2024, which demonstrated the possibility of replicating this teaching with the aforementioned software in other schools in the Lambayeque Region.

Junior High school students from Lambayeque demonstrated that, after completing activities using the GeoGebra software, they were able to create or construct geometric figures, translating mathematical concepts into interactive models, developing their creative, observational, and motor skills. They also clearly and precisely described how they created a figure, how they changed its position, and how it related to other shapes, using geometric terms and justifying their explanations with judgment and confidence. This allowed students to perceive the development of their ability to model objects and communicate their understanding.

Junior High school students from Lambayeque demonstrated that, after completing activities using GeoGebra software, they were able to program and organize geometric problems using appropriate strategies and methods, such as Pólya and IMPROVE, with flexibility and coherence. They also explained the procedures they used in a coherent and clear manner, and used geometric terms to support their arguments. This allowed them to perceive the development of their ability to use strategies and procedures and argue claims about geometric relationships with the aforementioned technological resource.

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Conflict of interest

Authors declare no conflict of interests.

Authors' contribution

The authors participated in the design and writing of the article, in the search and analysis of the information contained in the consulted bibliography.