

Literature Review

Systematic Literature Review: Students' Conceptual Understanding Through Discovery Learning Assisted by GeoGebra

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ABSTRACT

This study aims to systematically examine the effectiveness of the Discovery Learning model assisted by GeoGebra in enhancing students' mathematical conceptual understanding. Using the Systematic Literature Review (SLR) method based on PRISMA guidelines, twelve relevant national articles published between 2021 and 2024 were analyzed. The findings indicate that integrating GeoGebra into Discovery Learning has a positive impact by promoting interactive and exploratory learning experiences. Improvements are reflected in students' learning outcomes and active engagement in the learning process. However, existing research is still limited to specific topics. Therefore, further development is needed, including the use of GeoGebra Class and interactive teaching materials that students can access independently.

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1. PENDAHULUAN

An understanding of important concepts is essential for students in the mathematics learning process, because it enables them to understand concepts well. This is because a deep understanding of mathematical concepts is essential for developing students' critical thinking and problem-solving skills, as strong conceptual understanding can improve mathematical achievement (Manurung & Pappachan, 2025). Concepts in mathematics are organized in a hierarchical, orderly, logical, and systematic manner, ranging from the most basic to the most complex to understand (Rizky, 2021). This ability helps students enjoy learning mathematics and understand its meaning correctly (Hutajulu & Soesanto, 2023). However, if there is a mistake in understanding a concept, it can affect the learning process at higher levels because all mathematical concepts are interrelated, so it is important to understand mathematical concepts (Aprilian, 2023). The goal of learning mathematics is not only to know and remember formulas, but also to understand the concepts of mathematics obtained through logical thinking (Kariani Mendrofa & Mendrofa, 2022).

The application of learning models plays an important role in influencing students' level of concept understanding (Eka Pratiwi & Meiliasari, 2024). One effort to improve concept understanding is through the application of the Discovery Learning model, which provides space for students to actively engage in the learning process through activities such as observation, grouping, reasoning, explanation, and drawing conclusions, thereby enabling them to understand and remember the material better through direct experience

in discovering concepts (Abdullah & Putra, 2024; Wardini et al., 2024; Ramda et al., 2025; Madeole et al., 2023; Maria Simarmata et al., 2022; Nopitria et al., 2022; Sari et al., 2024; Subagio et al., 2021; Suryani et al., 2024). This is because this learning approach emphasizes the importance of understanding the structure and main ideas in a field of study through active student participation (Widari et al., 2023).

The use of the Discovery Learning model would be more effective if supported by learning media to encourage students to be more active and understand the material well (Hermawan et al., 2023). This learning model facilitates students in exploring and discovering concepts independently through the use of technology (Febriansyah et al., 2024; Sholekah et al., 2025). One of the technological media that teachers can use to assist students in the learning process is GeoGebra (Gunanjar & Ansari, 2023; Julia & Kania, 2024; Snae et al., 2025; Taihuttu et al., 2021; Losi et al., 2021). The implementation of the Discovery Learning model supported by GeoGebra has been proven to effectively improve students' understanding of mathematics (Astrilia et al., 2021). Other studies also reinforce that the use of GeoGebra in the mathematics learning process can strengthen students' understanding of concepts (Ama et al., 2024; Khurniati et al., 2023; Suciati et al., 2022; Yao, 2024). In other words, the use of GeoGebra software can support teachers and students in carrying out the learning process more effectively in the school environment (Anjarwati et al., 2022). GeoGebra can be used as an option in learning activities, from elementary to higher education, to visualize mathematical concepts, help construct concepts (Aisyah et al., 2024; Rahman & Saputra, 2022), and create interactive learning that allows students to learn various abstract mathematical concepts, thus demonstrating that the use of GeoGebra can improve students' understanding of mathematical concepts (Afhami, 2022; Aprilian, 2023; Simbolon, 2020; Sudihartinih & Amaliah, 2019).

Various studies have shown that the GeoGebra-assisted Discovery Learning model can improve students' understanding of mathematical concepts, but most of these studies are still limited to specific classroom contexts, specific subject matter, or implementation approaches alone. For example, a study by Anjarwati et al. (2022) highlighted the influence of the model on critical thinking skills, while research by Suciati et al. (2022) dan Aprilian (2023) focused more on conceptual aspects and general reviews without systematic grouping based on variables such as education level, subject matter, location, or learning design. Similarly, a study by Sianipar et al. (2024), although a literature review, did not provide a comprehensive mapping of the characteristics of the studies analyzed. This condition emphasizes the need for a systematic literature review that not only summarizes previous findings but also identifies trends, research gaps, and directions for the development of Discovery Learning and GeoGebra-based learning in a more structured and comprehensive manner.

Based on the objectives of this study to systematically review various research findings related to the application of the Discovery Learning model assisted by GeoGebra in mathematics learning, particularly in improving students' mathematical concept understanding, this study is important because it contributes in the form of a Systematic Literature Review (SLR) following the PRISMA guidelines. By grouping research findings based on specific characteristics, the systematic literature review provides a systematic and comprehensive overview of the literature. Therefore, this study is important because it contributes in the form of a Systematic Literature Review (SLR) following the PRISMA guidelines. By grouping research findings based on specific characteristics, this systematic literature review not only summarizes the effectiveness of the model from various perspectives, such as educational level, subject matter, and learning tools, but also identifies gaps (research gaps), exploring research gaps that have not been widely studied, and opportunities for future development, such as the use of GeoGebra Class and interactive self-learning materials. Thus, the novelty of this study lies in its comprehensive mapping of the results of previous studies and its synthetic analysis of the effectiveness and relevance of the GeoGebra-assisted Discovery Learning model in improving students' conceptual understanding. Thus, this research occupies an important position in the development of mathematical education science because it presents a structured and useful synthesis as a foundation for further research development or the implementation of innovative learning at various educational levels.

2. METODE

This study uses a qualitative approach with the Systematic Literature Review (SLR) method to analyze and summarize various studies related to the effectiveness of the GeoGebra-assisted Discovery Learning model in improving students' conceptual understanding. SLR was conducted through several processes, such as identification, evaluation, and interpretation of all available and relevant studies that could answer questions about the topic or phenomenon of interest from previous studies (Adiyono & Novianto, 2023).

In this study, Covidence was used as a tool to manage and facilitate the data screening, extraction, and synthesis processes (Cleo et al., 2019). To obtain data relevant to the research objectives, the following inclusion criteria were used: i) Articles published between 2021 and 2024, ii) Articles published in journals or proceedings, both international and national, and indexed in databases such as SINTA, iii) Articles that are

quantitative or qualitative studies related to students' conceptual understanding through the GeoGebra-assisted Discovery Learning approach, iv) The subjects in this study include students from elementary school (SD) to high school (SMA), without specific restrictions on any one level.

This study uses a systematic literature review approach with reference to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (Ariati & Juandi, 2022). This method was chosen to systematically select and analyze articles discussing students' conceptual understanding through Discovery Learning assisted by GeoGebra. The study began with data collection through Publish or Perish of relevant research related to "Discovery Learning," "GeoGebra," and "mathematical concept understanding." After the articles were collected, with the help of Covidence, a screening stage was conducted to select articles that met the basic criteria, such as the availability of full text, the use of appropriate language (Indonesian or English), and the relevance of the topic to this study. At this stage, articles that were irrelevant or did not meet the criteria were discarded. Next, articles that passed the screening stage were examined in more depth in the eligibility stage to ensure that the content of the articles actually discussed students' conceptual understanding through GeoGebra-assisted Discovery Learning. At this stage, the researchers also evaluated the methodology used in the study to ensure its suitability for the research objectives. Articles that meet the eligibility criteria then enter the inclusion stage, where only articles that are truly relevant and of high quality are included in further analysis. In this study, 12 national research articles indexed in Science and Technology Index (SINTA) 3–5 and published between 2021 and 2024 were selected as the main data sources, as shown in Figure 1.

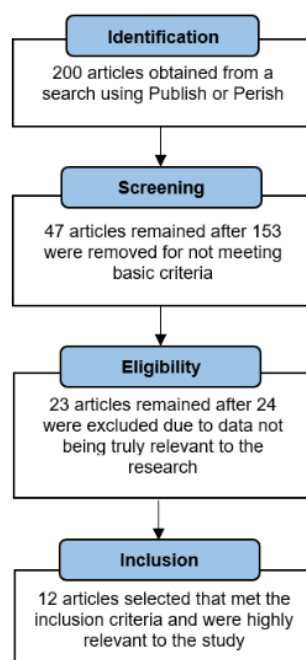


Figure 1. PRISMA Diagram of the Selection Process for Studying Students' Conceptual Understanding through the GeoGebra-Assisted Discovery Learning Model

3. RESULTS AND DISCUSSION

From the initial screening of 47 articles, a selection process was carried out based on inclusion criteria, resulting in 12 articles that were eligible for further analysis. Based on the inclusion criteria for the relevant studies, the selected articles were then classified according to several characteristics or moderating variables, such as year of publication, type of journal index, level of education, location of the study, and subject matter studied. This information is summarized in Table 1. The table shows variations in the implementation of research on students' conceptual understanding through Discovery Learning assisted by GeoGebra, as viewed from the characteristics of each study.

Table 1. Results of Characteristic Classification Analysis

Study characteristics	Criteria	Total
Year	2021	3
	2022	3
	2023	2
	2024	4
SINTA index level	S3	3
	S4	7
	S5	2
Educational level	Elementary school	1
	Junior high school	5
	Senior high school	5
	Junior & senior high school	1
Research Location	Sumatera	2
	Central Java	3
	West Java	4
	East Nusa Tenggara	1
	Not mentioned	2
	Straight Line Equations	1
Lesson topic	Cartesian Coordinates	1
	Circles	2
	Fractions	1
	Plane Geometry	2
	Area of Triangles and Quadrilaterals	1
	Indefinite Integrals	1
	Spatial Geometry	1
	Sets	1
	Not Mentioned	1

3.1. Studies based on year of publication

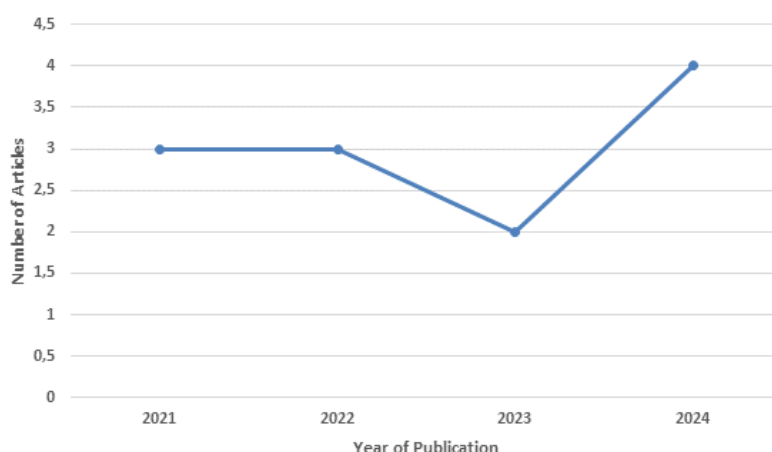
**Figure 2.** Article Data Based on Publication Year

Figure 2 shows the number of articles reviewed based on the year of publication between 2021 and 2024. It can be seen that in 2021 and 2022, there were the same number of articles, namely three articles. However, in 2023, there was a significant decrease in the number of articles to only two articles. Furthermore, there was a sharp increase in 2024, with the number of articles reaching four. This pattern indicates that research on students' conceptual understanding through GeoGebra-assisted Discovery Learning began to gain renewed attention after experiencing a decline. The increase in 2024 also shows that this topic is still relevant and continues to develop in the field of mathematics education research.

3.2. Study based on journal index

Based on the study of the number of articles analyzed in the journal accreditation classification in the SINTA system, the results show that the majority of articles came from journals indexed in SINTA 4, with a total of seven articles. Meanwhile, there were three articles from SINTA 3 journals, and only two articles were published in SINTA 5 journals, as can be seen in Figure 3.

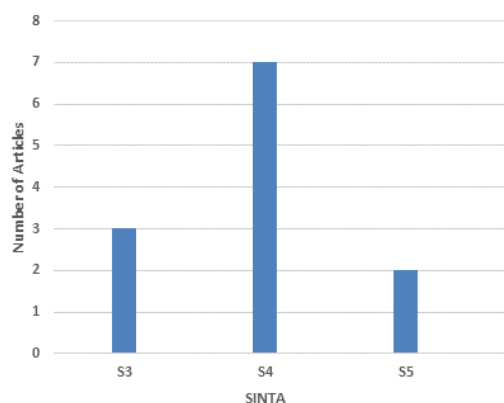


Figure 3. Article Data Based on Journal Index

3.3. Study based on education level

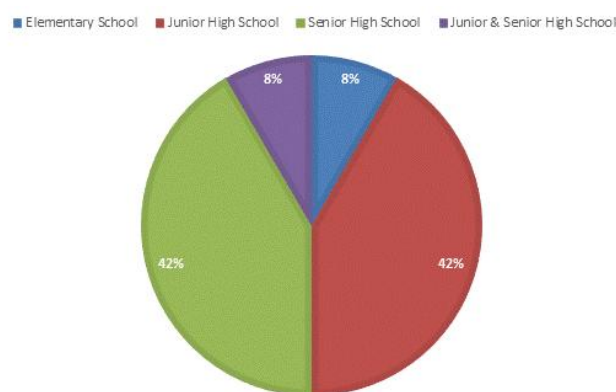


Figure 4. Article Data Based on Education Level

Based on Figure 4, the number of articles analyzed based on education level shows that most of the research was conducted at the junior high school (SMP) and senior high school (SMA) levels. Research with high school students as subjects dominated the largest proportion, followed by research on junior high school students. Meanwhile, only a few studies were conducted at the Elementary School (SD) level, as well as a combination of SMP and SMA levels. This is likely due to the higher complexity of mathematical concepts at these levels, which necessitates more effective visualization, making technology-based and discovery-oriented learning approaches more suitable (Khairani et al., 2024; Laili et al., 2023).

3.4. Studies based on research location

From the research locations in the analyzed articles, it can be seen that research on students' conceptual understanding through GeoGebra-assisted Discovery Learning is spread across various regions of Indonesia. The majority of locations are in West Java and Central Java provinces, each showing a high level of interest in applying this approach. Sumatra and East Nusa Tenggara (NTT) are also listed as research locations, although with fewer numbers. Additionally, there are several articles that do not explicitly mention the research location. As shown in Figure 5. This finding indicates that the GeoGebra-assisted Discovery Learning approach is beginning to be adopted in various regions, but most research remains focused on the island of Java.

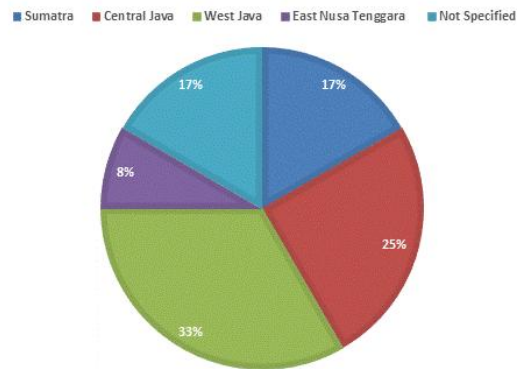


Figure 5. Article Data Based on Research Location

3.5. Study based on lesson materials

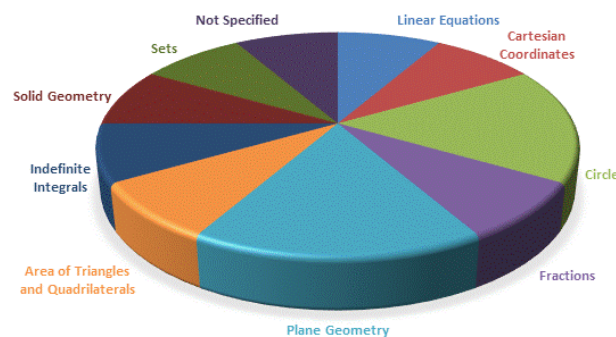


Figure 6. Article Data Based on Lesson Material

Figure 6. These findings indicate that Flat Geometry and Circles tend to be used more in GeoGebra-based research, given GeoGebra's characteristics that greatly support the dynamic visualization of mathematical concepts. Materials that require clear visuals are often used because they can be visualized concretely through interactive simulations, thus supporting the Discovery Learning model that emphasizes student exploration (Rahmi et al., 2024).

3.6. Research findings

The main findings from each article relevant to the focus of this study are presented in Table 2. In general, the studies analyzed reveal that the application of the Discovery Learning model with the assistance of GeoGebra software has a positive impact on improving students' understanding of mathematical concepts. This is due to the exploratory and interactive nature of the learning approach, which makes it easier for students to understand abstract concepts in mathematics.

Based on various research results, the application of the GeoGebra-assisted Discovery Learning model has been proven effective in improving students' mathematical concept comprehension at various levels of education. In general, this model helps students construct concepts independently, visualize mathematical ideas, and increase active involvement in learning. This improvement is not only reflected in quantitative learning outcomes but also in students' ability to understand, construct, and represent mathematical concepts in a more meaningful way. Research Safriati (2021) shows that the application of Discovery Learning assisted by GeoGebra on eighth-grade students at SMP Negeri 2 Peukan Pidie was able to improve conceptual understanding in the very high category. Similar results Fitriani et al. (2022) were also demonstrated by those who developed a learning design for comparing and ordering fractions for seventh-grade students. GeoGebra proved effective in helping students understand the comparison of fraction values visually and concretely through an exploratory approach to learning.

Table 2. Research Findings

Author(s)	Methods	Research Findings
Safriati	Qualitative	The implementation of the Discovery Learning model supported by GeoGebra has proven to be effective in improving the mathematical concept understanding of eighth-grade students in class VIII-A at SMP Negeri 2 Peukan Pidie. This improvement is evident from the results of written tests, where indicators such as the ability to classify objects based on specific properties and restate a concept achieved a very high category. Meanwhile, students' ability to perform mathematical operations and present problems in various mathematical representations falls into the high category.
Rahel B. Sitorus & Yasifati Hia	Qualitative	The results showed an increase in students' mathematical concept comprehension after the implementation of the GeoGebra-assisted Discovery Learning model. This was evidenced by an increase in learning scores from cycle I to cycle II.
Dhea Ika Felisa & Nurul Arfinanti	Quantitative	Based on the results of the study, the LKPD had a validity level of 88.3% (very valid category), a practicality level of 78.75% (practical category), and an effectiveness level of 88% (very good category). Thus, this media is considered capable of facilitating the development of mathematical concept understanding in grade XI students.
Hikmatul Fadhillah Sianipar, Nuranisah, & Trinad Silalahi	Qualitative	Based on a review of ten relevant articles, this study indicates that the use of GeoGebra in Discovery Learning contributes significantly to improving students' understanding of mathematics. In addition, its application is able to increase students' active involvement in the learning process, encourage in-depth exploration of mathematical concepts, and facilitate the visualization of abstract material.
Yuni Fitriani, Dedi Muhtadi, & Depi Setialesmana	Qualitative	Learning material comparing and ordering fractions through the Discovery Learning model, assisted by GeoGebra, enables students to understand the concept of fractions as part of a whole. The success of this learning is also evident from the evaluation results, where the level of student learning achievement reached 90.32%, with 28 out of 31 students declared proficient.
Ambar Tri Wahyuni & Siti Rohayah	Quantitative	The Discovery Learning model, supported by the use of GeoGebra, has been proven to help students understand flat geometry concepts in a more concrete and realistic way. Through this approach, students demonstrate better mastery of the material, increased interest in learning mathematics, and higher ability in solving various mathematical problems.
Niva Ramadhani Putri, Jozua Sabandar, Asep Ikin Sugandi	Quantitative	The use of GeoGebra in the Discovery Learning model is highly effective in improving students' mathematical comprehension skills.
Vevi Hermawan, Agus Dede Anggiana, Taufik Rahman	Quantitative	The results of statistical tests show a significance value of 0.002, which is less than the significance threshold of 0.05. Thus, the alternative hypothesis (H_a) is accepted. These findings indicate that the Discovery Learning model assisted by Geogebra is effective in improving students' understanding of mathematical concepts compared to conventional learning.
Rustam Effendy Simamora & Meryance Viorentina Siagian	Qualitative	The application of the Discovery Learning model, combined with a scientific approach and supported by GeoGebra, has proven effective in improving students' understanding of mathematical concepts in geometry. In addition, students also showed positive responses to the mathematics learning process.
Ayu Rekno Kusuma Dewi, Aflich Yusnita Fitrianna, & M. Afrilianto	Quantitative	The application of the scientific approach through the Discovery Learning model was able to significantly improve the mathematical comprehension skills of seventh-grade students at a junior high school in Bandung Regency. This was reflected in an N-Gain score of 0.76, which is classified as high, indicating that the approach was effective in improving students' understanding of set theory.
Marfin Marlisy Noman, Siprianus Suban Garak, & Magdalena Wangge	Quantitative	The application of the Discovery Learning model with the help of GeoGebra has been proven to improve students' understanding of circle equations. This can be seen from the increase in students' learning completeness before and after the implementation of the intervention. In the pre-cycle stage, only 3.70% of students achieved completeness. This percentage increased to 66.67% in cycle I, and then increased again to 85.19% in cycle II.
Nuroh Difallah, Ali Sunarso, & Barokah Isdaryanti	Quantitative	The use of the Discovery Learning model supported by MEBADA (<i>Media Bangun Datar</i>) based on GeoGebra has been proven effective in improving the mathematical concept comprehension of fifth-grade elementary school students.

This effectiveness is also supported by a significant increase from cycle to cycle after the implementation of this model. At the junior high school level, an increase in learning scores was observed after the intervention, while at the senior high school level, student learning completeness increased dramatically from only 3.70% in the pre-cycle to 66.67% in cycle I and reached 85.19% in cycle II. This confirms the effectiveness of this model in promoting progressive understanding of circle equation concepts

(Noman et al., 2024; Sitorus & Hia, 2022). A quantitative study by Felisa & Arfinanti revealed that the LKPD-based model is highly valid (88.3%), practical (78.75%), and effective (88%) in enhancing students' understanding of mathematical concepts in grade XI (Felisa & Arfinanti, 2024).

Statistically, the effectiveness of this model has also been proven through significant tests. Research by Hermawan, Anggiana, & Rahman shows that there is a significant difference in learning outcomes between students who use the GeoGebra-assisted Discovery Learning model and those who use conventional learning, with a significance value of $p < 0.05$ (Hermawan et al., 2023). Research by Putri, Sabandar, & Sugandi also reinforces these results and concludes that GeoGebra is very effective in supporting exploratory learning processes (Putri et al., 2021).

Unlike previous studies, Sianipar et al. (2024) have conducted a literature review of 10 articles concluded that the integration of GeoGebra in discovery-based learning (Discovery Learning) strengthens understanding of abstract concepts, increases student participation, and expands mathematical exploration. These findings are more conceptual and reflective than experimental. In the field of geometry, the application of this model improves students' ability to understand flat plane concepts through the visualization and interactivity provided by GeoGebra. Students not only find it easier to grasp concepts but also show increased interest and problem-solving skills (Wahyuni & Rohayah, 2022).

At the elementary school level, Difallah, Sunarso, & Isdaryanti examined the effectiveness of using MEBADA (Media Bangun Datar) assisted by GeoGebra in geometry learning. The results showed that the Discovery Learning model assisted by MEBADA based on GeoGebra was effective in improving the understanding of geometry concepts among fifth-grade students. This supports previous findings that this model can be adapted to various levels of education and subject matter, including elementary school (Difallah et al., 2024). In another study, the scientific approach was combined with Discovery Learning assisted by GeoGebra to strengthen mathematical concept understanding. Simamora & Siagian (2021) showed that this combination encouraged students to be active in discovering concepts and created a fun learning atmosphere. Meanwhile, Dewi et al. (2023) was reported that this approach was able to improve concept understanding of set material with an N-Gain value of 0.76 (high category).

In their research, Putri et al. (2021) suggested that the development of teaching materials using the GeoGebra-assisted Discovery Learning approach be carried out on a wider range of learning materials. Further development on other topics is also important to encourage increased motivation and interest among students in active and participatory learning. In addition, future research is expected to further explore the development of GeoGebra Class-based learning media as a supporting tool in mathematics learning. Innovations that can be implemented include the creation of interactive teaching materials, such as e-books or online modules, designed to be accessed and used independently by students (Sianipar et al., 2024).

4. CONCLUSION

Based on the results of a systematic literature review, the ability of students to understand concepts through Discovery Learning assisted by GeoGebra has been proven to improve students' mathematical concept understanding at various levels of education and mathematics subjects. This approach enhances visualization, promotes active engagement, and improves learning outcomes. For future development, it is recommended that GeoGebra-based learning media, such as GeoGebra Class, be further developed into interactive instructional materials that can be accessed independently and applied to other subjects to enhance students' motivation and interest in learning comprehensively.

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