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INTEGRATING GEOGEBRA IN LEARNING RIGHT TRIANGLE GEOMETRY: A DESCRIPTIVE STUDY OF FIRST-YEAR UNIVERSITY STUDENTS' RESPONSES

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ABSTRACT

The rapid development of digital technology has significantly influenced instructional practices in mathematics education, particularly in the teaching of abstract and conceptually demanding topics such as geometry and trigonometry. One foundational topic that frequently presents learning challenges is right triangle geometry, which underpins students' understanding of trigonometric ratios and their applications. This study aims to describe university students' responses to the use of GeoGebra as a technology-assisted learning tool in right triangle geometry instruction. Employing a descriptive survey research design, the study involved 30 first-year students enrolled in a Mathematics Education program at Universitas PGRI Palembang. Data were collected through a structured student response questionnaire administered after a GeoGebra-assisted learning session. The questionnaire examined four aspects: perceived conceptual understanding, learning motivation, interactivity, and ease of problem solving. Data were analyzed using descriptive statistics in the form of percentage distributions. The findings indicate that students demonstrated positive to very positive responses across all assessed aspects, particularly in learning motivation and perceived conceptual clarity supported by visual representations. While the results do not claim instructional effectiveness or learning gains, they suggest that GeoGebra is perceived as a supportive and engaging tool for learning right triangle geometry. The study contributes descriptive evidence regarding students' perceptions of GeoGebra-based instruction and provides pedagogical insights for mathematics educators integrating digital tools in geometry learning.

ABSTRAK

Perkembangan teknologi digital yang pesat telah memberikan pengaruh signifikan terhadap praktik pembelajaran dalam pendidikan matematika, khususnya dalam pengajaran materi-materi yang bersifat abstrak dan menuntut pemahaman konseptual tinggi, seperti geometri dan trigonometri. Salah satu materi dasar yang sering menimbulkan kesulitan belajar adalah

geometri segitiga siku-siku, yang menjadi landasan pemahaman mahasiswa terhadap konsep perbandingan trigonometri serta penerapannya. Penelitian ini bertujuan untuk mendeskripsikan respons mahasiswa terhadap penggunaan GeoGebra sebagai media pembelajaran berbantuan teknologi dalam pembelajaran geometri segitiga siku-siku. Penelitian ini menggunakan desain survei deskriptif dengan melibatkan 30 mahasiswa semester pertama Program Studi Pendidikan Matematika di Universitas PGRI Palembang. Data dikumpulkan melalui angket respons mahasiswa yang terstruktur dan diberikan setelah pelaksanaan pembelajaran berbantuan GeoGebra. Angket tersebut mengkaji empat aspek, yaitu persepsi terhadap pemahaman konsep, motivasi belajar, interaktivitas pembelajaran, dan persepsi kemudahan dalam menyelesaikan masalah. Data dianalisis menggunakan statistik deskriptif dalam bentuk persentase. Hasil penelitian menunjukkan bahwa mahasiswa memberikan respons positif hingga sangat positif pada seluruh aspek yang dikaji, terutama pada aspek motivasi belajar dan kejelasan konsep yang didukung oleh representasi visual. Meskipun hasil penelitian ini tidak mengklaim adanya efektivitas pembelajaran atau peningkatan hasil belajar, temuan ini menunjukkan bahwa GeoGebra dipersepsikan sebagai media pembelajaran yang mendukung dan menarik dalam pembelajaran geometri segitiga siku-siku. Penelitian ini memberikan bukti deskriptif mengenai persepsi mahasiswa terhadap pembelajaran berbasis GeoGebra serta menawarkan wawasan pedagogis bagi pendidik matematika dalam mengintegrasikan perangkat digital ke dalam pembelajaran geometri.

Introduction

The integration of digital technology into mathematics education has become an increasingly prominent focus in response to the evolving demands of twenty-first-century learning, including efforts to enhance visualization, interactivity, and student engagement in mathematical tasks (Saat et al., 2024; Suparman et al., 2024). Advances in educational technology have expanded opportunities for designing instructional environments that emphasize visualization and conceptual exploration, moving beyond traditional lecture-based instruction (Zbiek et al., 2007).

Geometry is one of the core domains of mathematics that plays a crucial role in developing students' spatial reasoning, logical thinking, and conceptual understanding (Battista, 2007; Battista et al., 2018; Medina Herrera et al., 2024). Within geometry, right triangle geometry serves as a foundational topic that forms the basis for learning trigonometry, analytic geometry, and various applied mathematical concepts (Aprizal Bintara & Prabawanto, 2024; Gurmu et al., 2024).

A sound understanding of right triangle properties, including the relationships between sides and angles, is essential for students' progression to more advanced mathematical topics (Van de Walle et al., 2022).

Despite its foundational importance, numerous studies have reported that students experience persistent difficulties in learning right triangle geometry and trigonometry. These difficulties include misunderstanding trigonometric ratios, confusion in identifying relevant sides relative to angles, and challenges in applying concepts to contextual or non-routine problems (Khairunnisa, 2023; Nurjanah et al., 2022; Weber, 2005). Such learning obstacles are often attributed to students' limited conceptual understanding and the abstract nature of trigonometric relationships, which are frequently introduced through symbolic representations without sufficient visual or experiential support (Suparman et al., 2024; Weber, 2005).

Traditional instructional practices in geometry tend to emphasize procedural problem solving and the application of memorized formulas. While such approaches may enable students to solve routine exercises, they often fail to promote deep conceptual understanding and meaningful reasoning (Hiebert, 2007; Skemp, 2006). As a consequence, students may struggle to interpret geometric relationships flexibly or to transfer their knowledge to unfamiliar problem contexts. These challenges highlight the need for instructional approaches that support conceptual visualization and active mathematical exploration (Suparman et al., 2024).

In response to these pedagogical challenges, technology-enhanced learning tools have been increasingly adopted in mathematics education. One such tool is GeoGebra, a dynamic mathematics software that integrates geometry, algebra, and graphical representations within an interactive digital environment (Hohenwarter & Jones, 2007). GeoGebra allows users to construct and manipulate geometric objects dynamically, enabling real-time visualization of mathematical relationships. Through dragging, measuring, and adjusting parameters, students can observe how changes in geometric configurations influence related mathematical properties.

In the context of right triangle geometry, GeoGebra offers opportunities for students to explore the relationships between side lengths, angle measures, and trigonometric ratios such as sine, cosine, and tangent. By manipulating triangle elements directly, students can move beyond static textbook diagrams and engage in exploratory learning that may support conceptual understanding (Bekene Bedada & Machaba, 2022). Prior research has suggested that such dynamic

visualizations can enhance students' engagement, motivation, and conceptual reasoning in mathematics learning (Batiibwe, 2024).

However, much of the existing research on GeoGebra has focused on experimental designs aimed at measuring learning outcomes or comparing instructional effectiveness (Juandi et al., 2021; Siregar et al., n.d.; Zutaah et al., 2023). While these studies provide valuable evidence, they often overlook students' subjective experiences and perceptions during GeoGebra-assisted learning. Understanding how students perceive the use of GeoGebra—whether they find it helpful, motivating, or engaging—represents an important complementary perspective, particularly for educators considering the practical integration of technology into classroom instruction.

Moreover, in many educational contexts, especially at the early stages of technology adoption, instructors conduct small-scale or exploratory implementations before engaging in large experimental studies. In such contexts, descriptive evidence of students' responses can provide meaningful insights into the feasibility and pedagogical value of technology-assisted instruction. Despite its importance, descriptive research examining students' responses to GeoGebra in right triangle geometry learning remains relatively limited, particularly at the university level (Gurmu et al., 2024).

Therefore, this study aims to address this gap by conducting a descriptive investigation of first-year university students' responses to GeoGebra-assisted learning in right triangle geometry. Rather than evaluating instructional effectiveness or learning gains, the study focuses on students' perceptions across four dimensions: conceptual understanding, learning motivation, interactivity, and perceived ease of problem solving. By adopting a descriptive approach, the study seeks to provide nuanced insights into how students experience GeoGebra-based instruction and to inform mathematics educators about the potential role of GeoGebra as a supportive learning tool in geometry education.

Method

This study employed a descriptive survey research design aimed at examining students' responses to GeoGebra-assisted learning in right triangle geometry. A descriptive approach was selected because the primary objective of the study was not to measure learning effectiveness or causal relationships, but rather to describe students' perceptions and experiences after participating in a technology-assisted learning activity.

Descriptive research is particularly appropriate in exploratory or early-stage instructional implementations, where the focus is on understanding how learners

respond to new instructional tools or environments. In the context of this study, GeoGebra was introduced as a supplementary learning tool to support conceptual visualization, and students' responses were examined across multiple perceptual dimensions.

The GeoGebra-assisted learning activity was conducted in a structured instructional session lasting approximately two hours. The learning procedure consisted of the following stages: (1) Introduction to GeoGebra; Students were introduced to the basic interface and functions of GeoGebra, including tools for constructing points, line segments, angles, and right triangles. Basic navigation and manipulation features were demonstrated by the instructor. (2) Construction of Right Triangles; Students were guided to construct right triangles using GeoGebra and to label side lengths and angle measures. Emphasis was placed on identifying the hypotenuse, opposite side, and adjacent side relative to a given angle. (3) Exploration of Trigonometric Ratios; Students explored the relationships between side lengths and trigonometric ratios (sine, cosine, and tangent). By dragging vertices and adjusting angle measures, students observed how trigonometric values changed dynamically. (4) Guided Problem Solving; Students worked on a set of guided geometry and trigonometry problems using GeoGebra. These problems focused on conceptual understanding rather than computational complexity. (5) Reflection and Discussion; The session concluded with a brief discussion in which students reflected on their learning experiences and challenges encountered while using GeoGebra. This learning procedure was designed to encourage active exploration while providing sufficient instructional guidance to prevent cognitive overload.

Data were collected using a student response questionnaire developed to capture students' perceptions of GeoGebra-assisted learning. The questionnaire consisted of 11 statements grouped into four aspects: (1) Perceived Conceptual Understanding (4 items); Statements in this aspect focused on students' perceptions of how GeoGebra supported their understanding of right triangle geometry concepts and trigonometric relationships. (2) Learning Motivation and Interest (3 items); This aspect examined students' interest, enthusiasm, and motivation when learning with GeoGebra. (3) Interactivity (2 items); Statements addressed the extent to which students perceived the learning process as interactive and engaging. (4) Perceived Ease of Problem Solving (2 items). This aspect focused on students' perceptions of how GeoGebra facilitated the process of solving geometry problems.

The questionnaire employed a four-point Likert scale ranging from Strongly Agree (4) to Strongly Disagree (1) for positive statements, with reverse scoring

applied to negative statements. The use of a four-point scale was intended to reduce neutral responses and encourage more decisive feedback. Prior to administration, the questionnaire was reviewed by two mathematics education lecturers to ensure content clarity and relevance. Although formal validity and reliability testing was not conducted, this expert review helped establish face and content validity appropriate for descriptive research.

Data analysis was conducted using descriptive statistical methods. For each questionnaire item and aspect, percentage scores were calculated based on students' responses. The percentage results were then interpreted using predefined response categories, as shown in Table 1.

Table 1.
Student Response Categories

Percentage (%)	Category
Less than 21	Very Negative
21-40	Negative
41-60	Fair
61-80	Positive
81-100	Very Positive

Results and Discussion

The overall results of the student response questionnaire indicate that students responded positively to the use of GeoGebra in learning right triangle geometry. The mean percentage score across all aspects was 82.6%, which falls within the Very Positive category. Table 2 presents a summary of students' responses for each assessed aspect.

Table 2.
The student response

Aspect	Number of statement	Percentage	Category
Conceptual understanding	4	85%	Very Positive
Interest and motivation	3	90%	Very Positive
Interactivity	2	80%	Positive
Ease of problem solving	2	90%	Very Positive
Mean Score		86,2	Very Positive

Responses related to conceptual understanding showed that most students perceived GeoGebra as helpful in clarifying the relationships among sides and angles in right triangles. Students reported that dynamic visualizations made it easier to identify the hypotenuse, opposite side, and adjacent side relative to a given angle.

The ability to manipulate triangle configurations was perceived as particularly beneficial in understanding how trigonometric ratios are formed. Rather than viewing sine, cosine, and tangent as abstract formulas, students indicated that GeoGebra helped them see these ratios as relationships between side lengths.

The highest response percentages were observed in the learning motivation and interest aspect. Many students reported that learning with GeoGebra was more engaging than traditional instruction. The interactive features of the software appeared to increase students' curiosity and willingness to explore mathematical concepts independently. Learning motivation emerged as the most positively perceived aspect in this study. Students reported that GeoGebra-assisted learning was more engaging and enjoyable than conventional instruction. This finding is consistent with research suggesting that interactive digital tools can enhance students' affective responses to mathematics learning.

Students also indicated that the visual and interactive nature of GeoGebra reduced feelings of anxiety commonly associated with learning trigonometry. This finding suggests that GeoGebra may contribute to a more positive learning atmosphere, particularly for students who previously perceived trigonometry as difficult. Responses related to interactivity were generally positive, although slightly lower than other aspects. While students appreciated the opportunity to interact with geometric objects, some reported initial difficulties in navigating the GeoGebra interface. These difficulties were primarily related to unfamiliarity with specific tools and commands.

Despite these challenges, most students agreed that GeoGebra promoted active participation and reduced passivity during the learning process. This suggests that with additional practice or instructional support, the perceived level of interactivity may increase further. In terms of problem solving, students generally perceived GeoGebra as a helpful tool for solving right triangle geometry problems. The ability to adjust parameters and immediately observe outcomes was reported to support reasoning and reduce computational errors.

Students noted that GeoGebra was particularly useful for checking solutions and exploring alternative approaches to problems. However, some students emphasized that GeoGebra should be used as a supportive tool rather than a replacement for understanding underlying concepts. The results indicate that students responded positively to GeoGebra-assisted learning across all assessed aspects. The findings suggest that GeoGebra is perceived as a supportive, engaging, and visually informative tool for learning right triangle geometry. Nevertheless, the results should be interpreted within the descriptive scope of the

study and in light of its methodological limitations. The example of GeoGebra worksheet can be seen in Figure 1.

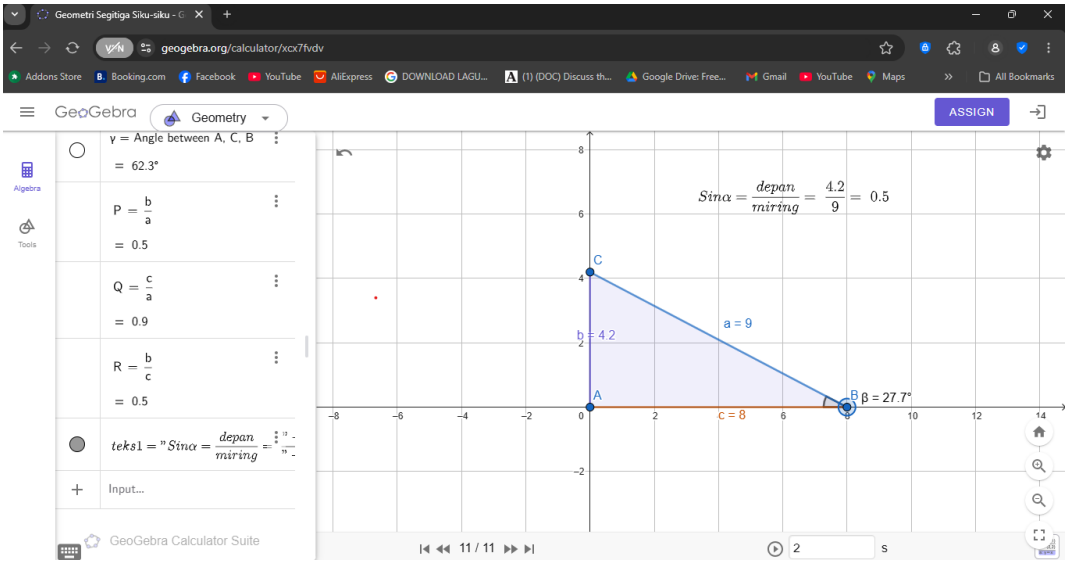

Figure 1. GeoGebra worksheet

Students' responses regarding perceived ease of problem solving indicate that GeoGebra was viewed as a helpful aid in solving right triangle geometry problems. The ability to adjust parameters and visualize outcomes allowed students to check their reasoning and explore alternative solution strategies. However, several students noted that GeoGebra should not replace conceptual understanding or analytical reasoning. This perception reflects a mature understanding of the role of technology in learning mathematics. Rather than serving as a shortcut, GeoGebra was perceived as a tool that supports reasoning and verification. This finding reinforces the notion that technology integration should aim to augment, rather than substitute, mathematical thinking. When used appropriately, GeoGebra can function as a cognitive tool that supports exploration, reflection, and conceptual clarity (Bache et al., 2023; Nzaramyimana et al., 2021; Septian & Monariska, 2021; Zakaria et al., 2024).

Several limitations should be acknowledged when interpreting the findings of this study. First, the study employed a descriptive design and relied solely on students' self-reported responses. As such, the results do not provide evidence of learning effectiveness or cognitive improvement. Second, the study involved a single group of first-year students from one institution, which limits the generalizability of the findings. Students' responses may be influenced by contextual factors such as instructional style, prior knowledge, or technological familiarity. Third, the questionnaire used in this study was not subjected to formal

statistical validation. While expert review was conducted to ensure content clarity, future studies may benefit from more rigorous instrument development procedures.

Future research could build upon the findings of this descriptive study by employing experimental or mixed-method designs to examine the impact of GeoGebra on students' learning outcomes. Studies involving larger and more diverse samples would also enhance the generalizability of findings.

Additionally, qualitative approaches such as interviews or classroom observations could provide deeper insights into students' learning processes and challenges when using GeoGebra. Longitudinal studies may further explore how sustained exposure to GeoGebra influences students' conceptual development and attitudes toward mathematics.

Conclusion

This study examined first-year university students' responses to the use of GeoGebra in learning right triangle geometry through a descriptive survey approach. The findings indicate that students generally perceived GeoGebra as a supportive and engaging learning tool, particularly in terms of motivation, conceptual visualization, and perceived ease of problem solving. While the study does not claim instructional effectiveness, it provides descriptive evidence that GeoGebra is positively received by students and may serve as a valuable component of technology-enhanced geometry instruction. By focusing on students' perceptions, this study contributes to a more nuanced understanding of GeoGebra-assisted learning and offers practical insights for educators seeking to integrate digital tools into mathematics education.

Declarations

Author contribution. AS: resources, visualization, collecting and analyzing data, writing–original draft; YLN: conceptualization, project administration, validating, editing; All authors agreed with the results and conclusions.
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