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GeoGebra AR in Mathematics Learning: Students' Perceptions from Indonesian Junior High Schools

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Abstract

It is becoming more and more necessary for educational practices to use digital technologies that can facilitate efficient and meaningful learning in the age of rapid technology advancement. Digital technology is crucial in mathematics education because it helps pupils envision and comprehend abstract ideas that are frequently challenging to learn through traditional teaching methods. The purpose of this study is to examine students' views on the use of GeoGebra Augmented Reality (AR) in mathematics classes at public junior high schools in Palangka Raya. Twenty questions covering five areas—knowledge and awareness, usefulness and application, obstacles and restrictions, support and facilities, and interest and attitude—were answered by 248 students using a survey method with a descriptive quantitative approach. The findings indicate that students' overall perceptions of GeoGebra AR are high, especially regarding its usefulness, their interest in it, and the support from their schools. They still have to deal with issues like device availability and restricted internet access, though. In conclusion, GeoGebra AR has great potential as an innovative learning tool to boost students' motivation and understanding of math, in line with the Merdeka Curriculum.

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INTRODUCTION

In the twenty-first century, the rapid advancement of technology has fundamentally altered the nature of education. It is widely acknowledged that technology literacy can enhance learning quality, expand information access, and foster critical thinking, creativity, teamwork, and communication—all essential 21st-century skills (Adnyana et al., 2025; Patriasih et al., 2025; Ramadhan et al., 2025; Suhendri & Retnowati, 2024). Therefore, in order to thrive in the digital age, students need to have both a theoretical grasp of topics and the ability to use technology to support and facilitate learning (Adnyana et al., 2025; Patriasih et al., 2025; Ramadhan et al., 2025; Suhendri & Retnowati, 2024). In order to improve student learning and promote the development of essential digital-age skills, it is now strategically required to incorporate technology into the classroom.

Furthermore, students' propensity to use smartphones for entertainment rather than education is frequently made worse by differences in device availability and a lack of digital monitoring. Furthermore, since students primarily use digital tools for amusement, owning digital gadgets does not necessarily transfer into academic use (Fauziddin & Adha, 2024; Rachmawati, 2022). Actually, with the right educational applications, these gadgets have a great deal of potential to enhance mathematical comprehension (Fauziddin & Adha, 2024). The disparity between students' access to digital devices and the best use of technology in the classroom is demonstrated by this circumstance. These circumstances underscore the necessity of a methodical shift away from media-based technology use and toward academically focused and productive engagement.

A comparable situation can be seen in Palangka Raya's public junior high schools, where most students already own Android smartphones but rarely use them for educational purposes. Through suitable educational applications, these devices actually have a great deal of potential to enhance mathematical understanding (Fauziddin & Adha, 2024). One such application is GeoGebra, which enables the visualization of mathematical concepts and is equipped with Augmented Reality (AR) features that support interactive three-dimensional graphics, thereby facilitating more accessible and meaningful learning experiences (Permana, 2025; Wati et al., 2024). The disparity between students' access to digital devices and the best use of technology in the classroom is evident in this situation.

Prior research has shown that the use of augmented reality (AR) in GeoGebra can serve as interactive educational materials that help students understand abstract mathematical ideas (Abdullah et al., 2025; Ali et al., 2024; Koparan et al., 2023; Siregar, 2025). Additionally, studies reveal that AR can improve students' mental grasp of subjects including three-dimensional function graphs, solid geometry, and geometric transformations (Sampurno, 2024; Walkington et al., 2026). However, the integration of GeoGebra AR into mathematics learning is still in its infancy and has not yet been widely accepted as a standard classroom practice, despite growing evidence of its educational effectiveness (İslim et al., 2024).. More significantly, there is currently no empirical data on students' acceptance, attitudes, and preparedness to use GeoGebra AR, especially at the junior high school level in the Indonesian context. Instead, the majority of previous research has concentrated on learning results or instructional effectiveness.

The current study intends to close this gap by examining how students in public junior high schools in Palangka Raya perceive the usage of GeoGebra Augmented Reality in mathematics instruction. The research issue of how students view the usage of GeoGebra AR in mathematics education in this setting serves as the basis for this investigation. It is anticipated that the results will offer empirical data that will help educators, educational institutions, and legislators create more engaging and technologically advanced approaches to teaching mathematics. In keeping with the goals of the Merdeka Curriculum, technology can serve as a valuable teaching tool that fosters meaningful and outcome-driven learning if students' current digital tools are used to their fullest potential.

RESEARCH METHODS

This research used a descriptive quantitative method with study design called survey. This design was chosen as the study intended to examine students' perceptions of possible use of GeoGebra AR in mathematics learning and that this research did not have specific hypotheses (Creswell, 2014, 2016). The use of the survey facilitated a relatively large, objective collection of the data.

Participants were 248 students enrolled at public junior high schools in Palangka Raya, Indonesia. A convenience sampling technique based on participant availability and accessibility was used. The selection process used this sampling technique because there is considerable variation between schools regarding technological readiness, digital device availability, and previous experiences using technology to learn. There may be some issues with representation using the convenience sampling technique; however, the exploratory and context-specific nature of this study makes this an appropriate sampling method. Therefore, the results of this study are not intended to generalize outside of the context of the research site, but rather to provide empirical evidence of the conditions present in the research site for future study.

Respondents had 127 males and 121 females. Respondent grade levels included Grade VII with 88 respondents, Grade VIII with 98 respondents, and Grade IX with 62 respondents; therefore, respondents were generally representative of student perspectives at the junior high school level based on their current grade.

Data were collected using a questionnaire adapted from (Maghfiroh et al., 2024). The instrument had previously undergone content validity and reliability evaluation, with content validity assessed by experts in mathematics education and reliability demonstrating acceptable internal consistency, indicated by a Cronbach's Alpha coefficient above 0.70. In the present study, the adaptation involved only contextual adjustments to align the instrument with the GeoGebra AR learning environment, without altering the core structure or constructs of the questionnaire. Therefore, additional validity testing was not conducted.

The questionnaire consisted of 20 closed-ended items measured on a five-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree) (Likert, 1932; Robinson, 2024), complemented by several open-ended questions to capture students' qualitative experiences with GeoGebra AR. The instrument measured five main dimensions: knowledge and familiarity, usefulness and application, challenges and constraints, support and facilities, and engagement, motivation, and future use, as summarized in Table 1.

The survey links were circulated on official school communication channels and was conducted online through Google Forms. Before starting the study, students were told about the aim of the study, that participation was voluntary and that their answers would be confidential. Analyses were restricted to those students who provided consent.

Data analysis was conducted using descriptive statistical techniques, including percentages, mean scores, and categorical interpretations, to identify patterns and trends in students' perceptions of GeoGebra AR. The findings were presented in tables, figures, and narrative descriptions to provide a comprehensive overview of students' responses. Since this study focused on descriptive exploration rather than inferential comparison, advanced statistical analyses were not applied.

Table 1. Aspect the questionnaire

Aspect	Description	Example Item
1. Knowledge and Familiarity	Evaluates students' prior knowledge, awareness, and recognition of GeoGebra AR before using it.	I have heard about or used GeoGebra before.
2. Usefulness and Application	Evaluates whether GeoGebra AR aids in the comprehension of mathematical ideas, particularly those that are abstract or spatial.	GeoGebra AR helps me understand abstract mathematical concepts more easily.
3. Challenges and Constraints	Assesses perceived usability, technical limitations, and possible challenges with augmented reality.	GeoGebra AR is easy to operate and does not cause significant difficulties during learning.
4. Support and Facilities	Evaluates the infrastructure, devices, teachers' and students' preparedness for implementation, and the availability of school support.	Not all students have devices that support GeoGebra AR.
5. Engagement, Motivation, and Future Use	Assesses the motivation, interest, enjoyment, and willingness of students to use augmented reality in subsequent lessons.	I am interested in using GeoGebra AR again in mathematics learning.

In addition, basic reliability information from the original instrument was used as a reference to support the consistency of the data, while the descriptive results were interpreted cautiously within the scope and limitations of the sampling method.

RESULTS AND DISCUSSION

The analysis and evaluation results may be accounted in comparative forms, figures, tables or etc. Avoid extended descriptive accounts without discussion. as The points that need explanation, re-ferences to figures, diagrams, or charts will be preferred supported by very brief interpretations. The analysis also offered explanations, value adding and benefits based on the research problems and objectives. The discussion should be brief, to the point and not recapitulate material already presented in the results section. References should be provided when contrasting results with earlier or analogous work are presented.

Students' Perceptions Across Five Aspects of GeoGebra AR Implementation

The results of this study are that the students' perceptions towards using GeoGebra AR in learning mathematics is included in the 'good' category at State Junior High Schools in Palangka Raya Analysis was performed for 20 items of the questionnaire classified into five domains: knowledge and familiarity, usefulness and application, challenges and constraints, support and facilities, interest of students to use this application.

In the aspect of knowing and familiarizing with it, students in overall they showed high popularity in this Geogebra application itself. They had heard and known about GeoGebra as a technology-assisted mathematics learning tool, but the application was not present in all schools as part of the formal work with mathematics.

Table 2. Knowledge and familiarity aspect

Statement	Mean	Interpretation
1. I have heard of the GeoGebra application before	3.77	High
2. My school has introduced or used GeoGebra in learning activities	3.78	High
Average	3.77	High

Students' high preparedness levels (cognition and technology) enable them to comprehend GeoGebra AR without developing an additional cognitive burden (Mayer, 2005; Moreno & Mayer, 1999). This means that in local contexts, the implementation of AR will no longer be limited or constrained by basic digital literacy. Local implementations should now shift focus from simply getting students ready for AR to how they can apply AR pedagogically. In addition, students' high preparedness levels enable them to have a similar level of prior AR experience as students in higher income countries with higher levels of technology; students' previous knowledge will, also, be a predictor of how successfully they are able to use AR (Anugrah et al., 2023a; Davis, 1989). Conversely, if students have low preparedness, they will increase the amount of extraneous cognitive load placed on them and limit the amount of positive learning gains they can expect to make with AR, as reported frequently in studies that implement AR (Nurwijaya & Sukaria, 2025). Therefore, high preparedness reflects not only an acceptance of technology but also has the potential for sustainable learning.

Table 3. Usefulness and application aspect

Statement	Mean	Interpretation
1. GeoGebra AR can be applied in my school	4.37	Very High
2. GeoGebra AR makes mathematics learning more interesting	3.94	High
3. GeoGebra AR helps me understand abstract mathematical concepts more easily	3.93	High
4. GeoGebra AR encourages me to be more active in learning	3.82	High
5. GeoGebra AR helps me learn independently outside the classroom	3.89	High
6. GeoGebra AR can improve my learning outcomes	3.90	High
7. GeoGebra AR helps teachers explain difficult mathematical concepts	4.30	Very High
8. GeoGebra AR can be combined with other learning methods	3.85	High
Average	3.97	High

Table 3 shows that GeoGebra AR is highly rated by students on usefulness to assist their understanding of abstract mathematical ideas while not burdening them with excessive cognitive load (Mayer, 2005; Mayer & Moreno, 1998). Because AR is no longer seen just as a novel technology for teaching in the local context, it has come to be seen as a valuable tool for teaching. Globally, these findings are also supported by previous studies which have demonstrated that AR works best for students with enough prior knowledge and digital readiness (Bacca et al., 2014; Billinghurst & Duenser, 2012). Inversely, if they had lower levels of usefulness, it might reflect a minimal pedagogical impact and risk of a low level of engagement.

Table 4. Challenges and constraints aspect

Statement	Mean	Interpretation
1. GeoGebra AR is too difficult for students to understand	2.33	Low
2. GeoGebra AR made learning more complicated rather than easier	2.34	Low
3. Not all students have devices that support GeoGebra AR	1.77	Very Low
4. Using GeoGebra AR will consume too much learning time	2.30	Low
5. GeoGebra AR is not suitable for schools with limited facilities	2.33	Low
6. GeoGebra AR causes students to play more than learn	2.34	Low
Average	2.24	Low

GeoGebra AR's average challenge/constraint score (2.24) reflects the fact that there are no significant technical or cognitive challenges associated with its use by students; thus, it can be used seamlessly in a classroom without additional cognitive load or distraction. In addition, the average low district level scores for challenge and distraction demonstrate that by using AR, educators can effectively integrate AR into their classroom instruction and routines (which is beyond just the novel aspect of it) as low level challenges/constraints will not create significant added burden to the students' cognitive processes or learning focus during the application of AR. Globally, AR is effective when devices are available and there is adequate basic digital infrastructure (Bulut & Borromeo Ferri, 2023; Ersen & Alp, 2024), which results in lower implementation risk. If AR use results in higher challenge/constraint scores, it indicates inequitable infrastructure, as well as insufficient support for teachers—the key challenges faced across numerous K–12 systems. Therefore, GeoGebra AR's feasibility for wider implementation depends upon maintaining a minimum level of technical preparedness and instructional support.

Table 5 shows a very high average score (3.37) indicating strong agreement by students about the value of institutional support for implementing GeoGebra AR. In the case being examined, this indicates that students understand that the effectiveness of AR depends not only on an individual's ability, but also on how prepared the school is (in terms of infrastructure, technical support and teacher readiness). Thus, at the local level, AR integration has gone beyond being dependent upon student acceptance to being dependent on the capacity of the institutions involved.

Table 5. Support and facilities aspect

Statement	Mean	Interpretation
The school needs to provide adequate support and facilities for the implementation of GeoGebra AR	3.37	High

Globally, these high scores align with international research identifying Institutional Readiness as a key enabler/disabler of successful AR implementation and fragmented or unsustainable use (Bulut & Borromeo Ferri, 2023; Ersen & Alp, 2024). Comparatively, low scores in this area indicate systemic limitations (eg, lack of adequate infrastructure; lack of policy support) slowing the development of AR across many educational systems globally. Thus, the high scores demonstrate that sustainable use of GeoGebra's AR requires both coordinated institutional planning and the readiness of learners; therefore, institutional support is the essential link from local implementation to global best practices.

Table 6. Aspects of interest and attitude

Statement	Mean	Interpretation
1. I am interested in using GeoGebra AR in mathematics learning	4,45	Very High
2. I am more interested in learning mathematics using GeoGebra AR than through conventional methods	3,89	High
3. If given the opportunity, I am willing to try GeoGebra AR in class	3,97	High
Average	4,10	High

Table 6 shows high student interest/positive attitudes in their use of GeoGebra AR as a tool for learning math. In the local context, positive results from affective scores indicate that AR is well suited for student-centered and exploratory learning, as it encourages active engagement and reduces negative emotion towards abstract maths. This suggests that motivation is no longer a constraint at the classroom level and that there will be no impediments to using AR in the classroom.

On a global level; the students' high interest levels were found to be consistent with the international literature on the role of motivation as a key enabler for successful AR technology adoption and continued technology use (Bacca et al., 2014; Nasution, 2022). With lower attitude scores would indicate that risk exists in short-term participation delivered through novelty, as opposed to significant learning experiences, are known to be a concern found in instances of AR being used without supporting pedagogy. Therefore, the high interest scores in this particular study indicate that GeoGebra AR is more than just a cognitive support mechanism in supporting sustainable and internationally applicable methods of learning mathematics.

Students' Technological Readiness and Perceptions of GeoGebra AR

Overall, survey results indicate that most students possess Android-based smartphones capable of running the GeoGebra AR application and perceive the tool as user-friendly. This indicates that students have the necessary technological readiness. Although some technical problems were experienced, they were not major enough to act as barriers to using the technology. In addition to technical availability, the students also showed positive psychological and pedagogical readiness. The high scores in interest and attitude indicate alignment with the Merdeka Curriculum, which focuses on student agency, experiential learning, and appropriate use of technology. The results indicate favorable conditions for the implementation of technology-supported exploratory learning. Additionally, the attitudes of the students indicate motivation to engage with technology-supported learning tasks.

From a pedagogical perspective, the results challenge assumptions about digital divides between metropolitan and non-metropolitan regions. Students in Palangka Raya demonstrate levels of technological acceptance and familiarity comparable to those reported in more urbanized contexts. This indicates that readiness is shaped not only by geographic factors but also by students' digital habits and adaptive responses to instructional innovation. Consequently, geographic location alone may not be a reliable predictor of students' technological preparedness.

Consistent with previous studies, the use of GeoGebra AR has the potential to support mathematical abstraction and spatial reasoning through three-dimensional visualization. This can reduce cognitive load when learning complex mathematical concepts studies (Azuma, 2015; Ibáñez & Delgado-Kloos, 2018; Zulyanty et al., 2024). The results also show that students' perceptions were generally consistent and positive across five measured aspects: technological readiness and familiarity, perceived ease of use, perceived usefulness, learning engagement, and learning effectiveness. Although advanced statistical analyses, such as comparisons between student groups, were not conducted, these findings are reinforced by similar studies in various educational contexts.

In the case of the technological readiness and familiarity of the students, the high scores suggest that the students were technologically ready and had the required digital literacy and understanding of the technology, which are the pre-requisites to the successful implementation of the augmented reality technology in the learning environment (Anugrah et al., 2023a, 2023b; Murwaningsih, 2024; Nurwijaya & Sukaria, 2025). This is consistent with the earlier literature, which emphasized the importance of the readiness of the user in the successful implementation of the augmented reality technology, especially in managing the cognitive load of the user (Bacca et al., 2014; Billinghurst & Duenser, 2012).

With regard to perceived ease of use and perceived usefulness, the positive responses of the students indicated that the GeoGebra AR tool was perceived to be useful in facilitating mathematics concepts to the students, which is in line with previous studies that found that perceived ease of use and perceived usefulness of a tool can significantly affect the acceptance of technology (Alenezi et al., 2023; Ali et al., 2024; Fischer et al., 2023; Hardhienata et al., 2021). However, previous research has also shown that sometimes students tend to be more concerned with the technology itself, which may cause them to be distracted from the concepts (Bacca et al., 2014; Mufit et al., 2023).

In terms of the level of student engagement in the process of learning, the study findings are consistent with the literature indicating the potential of augmented reality to improve the interest, attention, and engagement of students in the process of learning (Oktaviana, 2025; Pradita et al., 2024; Vani, 2025). Nevertheless, the literature highlights the need to be cautious with the assumption that improved student engagement will automatically lead to improved student outcomes, as this is also influenced by the level of cognitive readiness and the instructional design (Nadzri et al., 2024; Tiarani et al., 2024).

With regard to the aspect of learning effectiveness, a number of research studies have shown that the positive impact of AR on conceptual understanding is significantly influenced by the spatial ability of students, as well as their prior knowledge, especially in terms of geometry-related concepts (Bulut & Borromeo Ferri, 2023; Ersen & Alp, 2024; Nadzri et al., 2024) These research findings are reinforced by a number of studies conducted in Indonesian educational contexts, which emphasize that the effectiveness of AR-based learning is highly contextual in nature, relying more on pedagogical rather than technological readiness (Hidayati et al., 2024; Judijanto et al., 2025; Nurhayati et al., 2025). In this regard, it can be noted that even in the absence of additional statistical analysis, the comparison of the research findings with those of previous studies reveals that the variations in terms of students' perceptions and learning effectiveness with regard to the five aspects are primarily influenced by the differences in cognitive, pedagogical, and technological readiness in specific educational contexts.

CONCLUSION

According to the study's findings, pupils in Palangka Raya's public junior high schools had favorable opinions on the possible application of GeoGebra Augmented Reality (AR) in mathematics education. According to the results, GeoGebra AR is thought to be practical, interesting, and successful at assisting pupils in comprehending abstract mathematical ideas through interactive three-dimensional representations. Along with showing a strong desire to employ GeoGebra AR in upcoming educational activities, students also showed a low level of perceived difficulty and technological limitations. Overall, the findings indicate that students are psychologically and cognitively prepared to use GeoGebra AR as a cutting-edge teaching tool to enhance mathematics instruction in accordance with the Merdeka Curriculum.

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