Journal on Smart Learning Technologies

Wibawanto, H., & Maulana, I. (2025). Utilization of Augmented Reality in Facilitating Geography Learning to Improve Spatial Ability of Junior High School Students. *Journal on Smart Learning Technologies,* 1 (1), 57-66.

DOI:

The online version of this article can be found at our journal page:

Published by:
Educational Technology Department, Universitas Negeri Surabaya, Indonesia

The Journal on Smart Learning Technologies is a peer-reviewed academic journal that publishes high-quality research articles on innovative topics in education, advancing educational development through scholarly dialogue that bridges theory, practice, and technology. It serves as a platform for interdisciplinary research, exploring the dynamic intersections of pedagogy, curriculum, media, assessment, and Artificial Intelligence (AI). The journal emphasizes AI's integration to facilitate personalized, adaptive, and inclusive learning experiences, encouraging data-driven strategies and equitable educational solutions. It welcomes critical insights and forward-thinking approaches from diverse global perspectives to transform teaching and learning.

Journal on Smart Learning Technologies
Volume 1, No. 1, 2025: 57 - 66
E-ISSN:
DOI:…

Utilization of Augmented Reality in Facilitating Geography Learning to Improve Spatial Ability of Junior High School Students

Hilmawan Wibawano[1*], Iwan Maulana[2]

[1] Educational Sciences, Faculty of Teacher Training and Education, Universitas Sebelas Maret, Surakarta, Indonesia

[2] Educational Technology, PSDKU Magetan, Universitas Negeri Surabaya, Surabaya, Indonesia, 63391

Corresponding author: Rico Eko Andrianto, Email: hilmawan@student.uns.ac.id[1*]

Abstract

Spatial ability is a crucial skill in geography education at the junior high school level; nevertheless, some pupils struggle to comprehend abstract spatial concepts due to the constraints of traditional learning medium. Augmented Reality (AR) serves as a novel solution by offering immersive and contextually interactive 3D visuals. This study seeks to elucidate the application of augmented reality media in geography education and evaluate its impact on enhancing students' spatial skills. The employed research methodology is descriptive qualitative, utilizing a case study approach in two private junior high schools located in Surakarta. Data were gathered via classroom observations, comprehensive interviews with educators and students, and documentation, thereafter analyzed employing the Miles and Huberman framework. The findings indicated that augmented reality was executed in three phases: conceptual inquiry, interactive dialogue, and spatial contemplation. Students demonstrated significant enthusiasm and advancements in spatial orientation, cognitive representation, and comprehension of inter-regional relationships. The challenges encountered comprised insufficient devices, unreliable internet connectivity, and pupils' inadequate early digital literacy. This study suggests that augmented reality is not merely a visual-assistance, but also a potent transformative learning medium for enhancing students' spatial skills. The implication is that the incorporation of AR must be supported by teacher training and infrastructure to ensure its best application in geography education.

Keywords: Augmented Reality, geography learning, spatial ability, interactive media, junior high school students.

Article History:

Received	Review	Accepted	Published
June 2025	July 2025	July 2025	July 2025

INTRODUCTION

Geography education at the Junior High School (SMP) level plays a crucial role in enhancing students' spatial skills, which are essential for comprehending inter-regional relationships and spatial dynamics. Nonetheless, numerous obstacles persist in its application, particularly in instructing

intricate and abstract spatial notions. Educators frequently depend on traditional techniques like lectures, two-dimensional visuals, and static maps, which often fail to accurately depict geographic reality in context. Traditional geographic pedagogy has been demonstrated to constrain students' spatial comprehension due to its reliance on two-dimensional representations and abstract elucidations (Freksa & Barkowsky, 2020). This hinders students' ability to construct precise mental models of the earth's surface, including its shape, location, direction, and inter-regional linkages.

Numerous studies have shown that contextual learning methods—such as educational comics, 3D models, and experiential demonstrations—can significantly enhance spatial thinking (Astawa, 2022; von Reumont & Budke, 2021). The integration of digital technologies, including Geographic Information Systems (GIS) and Augmented Reality (AR), has emerged as a viable solution to the limitations of conventional approaches, offering visual, dynamic, and interactive representations of spatial information (Guryevskikh, 2020; Jo & Hong-Dwyer, 2024). In cross-cultural education, diverse spatial concepts have also been shown to improve students' understanding of place diversity and spatial relationships (Chihab et al., 2020). AR, in particular, facilitates immersive and contextual engagement with spatial content, thereby supporting active, meaningful learning experiences (Pambudi et al., 2022; Szentirmai & Murano, 2024) and bridging abstract map-based learning with complex geographical realities. It enhances cognitive representation and orientation while providing 3D interactive content that boosts both cognitive and emotional learning outcomes (Kozov & Ivanova, 2023), spatial abilities, problem-solving, motivation (Guntur et al., 2020), creativity, and critical thinking (Qamar, 2023). As a technology that merges virtual elements with the physical world, AR fosters immersive learning through didactic, experiential, and kinesthetic modalities (J. et al., 2019; Parashar, 2020), and its use is growing in educational practices through 3D models, virtual simulations, and gamified content (Kshirsagar et al., 2023). However, challenges remain, including technical limitations, infrastructure needs, and the lack of instructional design frameworks (Kozov & Ivanova, 2023). Despite its potential, there is a scarcity of research on AR's application in junior high school geography education, especially in improving students' spatial competence. Most prior studies focus on STEM subjects at the higher education level. Addressing this gap, the present study offers a qualitative, practice-based investigation of how AR can enhance spatial learning in junior high school geography classes, reflecting the needs of 21st-century digital learners and curriculum demands for spatially competent students.

This research is anticipated to yield significant contributions in both theoretical and practical domains. Theoretically, the results of this study can enhance the literature in educational technology, particularly for the application of interactive media like Augmented Reality in spatial learning. This study may serve as a reference for constructing a pedagogical strategy that integrates digital technology with geography education, particularly in establishing a conceptual framework that enhances students' spatial thinking abilities. The findings of this study can serve as a reference for geography educators in developing more engaging, visual, and impactful learning methodologies with augmented reality. This study offers guidance for makers of educational media in designing AR material tailored to the requirements of junior high school pupils, hence facilitating optimal attainment of geography

curriculum competencies. This study seeks to elucidate the application of Augmented Reality (AR) media in geography education at the Junior High School (SMP) level. This study aims to elucidate the utilization of AR media by educators in the geography learning process and to examine students' responses to and interactions with spatial content delivered through this technology. This study intends to investigate the role of augmented reality in enhancing students' spatial abilities, encompassing spatial orientation, mental representation, and comprehension of inter-regional linkages. This study aims to offer a comprehensive overview of the potential and efficacy of augmented reality (AR) in enhancing contextual spatial awareness among junior high school students by examining actual classroom practices and the experiences of learners.

METHODS

This study adopts a descriptive qualitative methodology (Sofaer, 2002) to explore the implementation of Augmented Reality (AR) in junior high school geography education and its influence on students' spatial skills. This approach was chosen for its capacity to provide a contextual and in-depth understanding of phenomena by examining participants' experiences, perceptions, and interactions within AR-integrated learning environments (Gill, 2020). Rather than seeking generalization, the research aims to develop a rich, nuanced interpretation of AR use in specific educational settings. The study was conducted in two private junior high schools in Surakarta City that had integrated AR-based media into their geography instruction. These schools were purposively selected based on their technological readiness and the presence of teachers actively utilizing AR.

Participants consisted of two key groups: five geography teachers employing AR in classroom instruction, and eighth-grade students participating in AR-based geography learning. Participant selection prioritized active involvement to ensure that the data accurately reflected real classroom experiences (Gill, 2020). Data collection employed two strategies: direct observation of AR-mediated geography lessons to capture interaction patterns, instructional methods, and student engagement; and in-depth interviews with teachers and students to explore their perspectives, learning experiences, and perceptions of AR's impact on spatial understanding. Together, these strategies facilitated a comprehensive exploration of the research focus.

Data analysis followed Miles and Huberman's interactive model (Lisa et al., 1967), consisting of three stages: data reduction (sorting and focusing data relevant to research objectives), data presentation (structuring information through thematic narratives and matrices), and conclusion drawing and verification (identifying patterns and ensuring consistency through iterative analysis). To ensure credibility, several validation techniques were employed. Source triangulation (Gill, 2020) was conducted by comparing data from teachers, students, and supporting documents to enrich perspectives and reduce bias. Member checking (Djafar et al., 2021) involved validating preliminary findings with participants to confirm alignment with their experiences. Additionally, an audit trail was maintained through systematic documentation of the research process, enabling transparency and

reproducibility. Together, these techniques strengthened data integrity and enhanced the validity of the study's findings.

RESULTS

Implementation of Augmented Reality in Geography Learning

The results of the study show that geography teachers in two private junior high schools in Surakarta have utilized the GeoAR application as a visual aid in geography learning. This application is used to visualize various spatial concepts that were previously abstract, such as the shape of the earth's surface, topographic maps, and the distribution of geographical phenomena. The implementation of AR-based learning takes place in three main stages. First, at the concept exploration stage, students scan objects using a tablet or smartphone that has the GeoAR application installed. The three-dimensional visualization displayed allows students to observe geographical objects more concretely and contextually. Second, the learning process continues with an interactive discussion, where the teacher facilitates the exchange of ideas and understanding between students based on the visual objects that have been displayed through AR. Third, at the spatial reflection stage, students are asked to compile a mental map or describe a particular location based on visual stimuli from AR media. This process aims to hone spatial representation skills and understanding of geographical relations between locations.

Student Responses to AR Media

The use of Augmented Reality in geography learning has received a very positive response from students. Most students showed enthusiasm and active involvement during the learning process. This is reflected in the students' verbal and nonverbal expressions, as well as their participation in discussion activities and reflective tasks. One student stated that "it is easier to imagine the shape of the earth's surface," indicating an increase in the ability to visualize spatial objects. Another student stated that "it's fun like playing a game, but you can also learn," indicating an integration between entertainment and learning aspects that increases learning motivation. Overall, AR media provides strong visual stimulation and supports the learning process multimodally, both cognitively and affectively. This strengthens the assumption that interactive technologies such as AR can create more meaningful learning experiences, especially in understanding complex spatial concepts.

Table 1. Analysis of AR Implementation and Student Responses

No.	Data Quotes (Verbatim)	Open Code	Category (Axial Code)	Theme
1	"Teachers use the GeoAR application to visualize the shape of the earth's surface."	Utilization of GeoAR	Technology integration in learning	Implementation of AR in Geography Learning
2	"Students scan objects using tablets/smartphones."	Exploration of spatial objects	AR-based exploratory activities	
3	"Teachers facilitate discussions based on visual objects."	Interactive discussion	Visual media-based interactions	

4	"Students create mental maps based on AR stimuli."	Spatial reflection	Spatial representation construction activities	
5	"It's easier to imagine the shape of the earth's surface."	Visualization of spatial concepts	Cognitive impact of AR use	Student Responses to AR Media
6	"Fun like playing a game, but can also be a learning experience."	Fun learning	Affective responses to AR	
7	"Students show active participation in discussions."	Student engagement	Active involvement in the learning process	

Indicators of Enhanced Spatial Proficiency

The utilization of Augmented Reality media in geography education has substantially enhanced students' spatial skills. Observations and interviews revealed that students demonstrated an enhanced comprehension in identifying the relative location of a place, articulating the contours of the earth's surface, and elucidating the interconnections between regions. Indicators of growing spatial abilities encompass geographical orientation, mental representation, and comprehension of geographic relations. During a classroom session, students successfully identified and articulated the river's flow direction and its relationship to the adjacent landscape through AR visualization. Within the realm of mental representation, pupils commenced articulating geographic features in three dimensions, a task that had previously posed challenges when relying on two-dimensional illustrations in textbooks. Moreover, their capacity to elucidate the interconnections across locations improved, as evidenced by their construction of spatial narratives utilizing augmented reality displays. These findings suggest that AR media is both instructive and transformative in enhancing students' spatial reasoning skills.

Table 2. Analysis of Indications of Increased Spatial Ability

No.	Data Quotes (Verbatim)	Open Code	Category (Axial Code)	Theme
1	"Now I can tell the direction of the mountain from the river around it."	Determining relative position	Spatial orientation	Improving Students' Spatial Ability
2	"The image appears in 3D, so I can visualize the shape in my head."	Forming mental images	Mental spatial representation	
3	"From there I can see why flooding often occurs in low areas near rivers."	Explaining relationships between regions	Spatial relations	
4	"If the mountain is here, then the valley is that way."	Spatial reasoning	Geographic orientation and direction	
5	"The AR makes me understand how topographic maps connect to real conditions."	Understanding the relationship between visual data	Integration of spatial concepts	

Obstacles to the Implementation of Augmented Reality

This study found that while Augmented Reality (AR) enhances student involvement and spatial skills in geography learning, some obstacles were encountered throughout its deployment. A primary

difficulty is the restricted availability of gadgets in educational institutions. Not all students can utilize tablet or smartphone devices concurrently; therefore, AR-based learning must be conducted alternately or in groups, which may diminish the efficacy of personalized learning. A significant impediment is an unreliable internet connection, particularly when augmented reality apps necessitate downloading or online data processing. This affects the fluidity of vision and hinders the learning process. Furthermore, it was discovered that not all pupils are familiar with AR-based technology, necessitating additional time for technical acclimatization. Several students exhibited uncertainty initially, particularly in maneuvering the camera or interpreting interactive aspects on the screen. These challenges suggest that the efficacy of AR implementation relies not solely on the medium itself, but also on the preparedness of infrastructure, digital literacy, and sufficient technical support.

Table 3. Barriers to AR Implementation

No.	Data Quotes (Verbatim)	Open Code	Category (Axial Code)	Theme
1	"There are not enough tablets, so we have to wait for our turn."	Device limitations	Limited technology access	Barriers to AR Implementation in Learning
2	"The signal is slow, the application sometimes doesn't work."	Unstable internet	Technical constraints	
3	"I've never used an application like this before."	Lack of digital experience	Low technology literacy	
4	"Some of my friends were confused about how to use it at first."	Initial usage difficulties	User adaptation	
5	"Sometimes we have to repeat it because the image doesn't appear."	Visualization problems	Connection dependency	

DISCUSSION

The incorporation of Augmented Reality (AR) in geography education has demonstrated a significant enhancement of students' spatial skills. This study's findings demonstrate that augmented reality (AR) enables pupils to comprehend abstract geographic ideas via realistic and contextual visuals. This aligns with the ideas of multimodal learning theory, which underscores the significance of conveying knowledge through diverse forms of representation, including visual and interactive modalities. Pambudi et al. (2022) elucidated that augmented reality applications facilitate students in manipulating and visualizing spatial information within an immersive context, hence fostering deeper cognitive links to the learning content.

These findings are consistent with previous research indicating that Augmented Reality (AR) significantly enhances students' spatial abilities. Ho et al. (2022) reported that students perceived higher effectiveness in acquiring spatial information within mixed reality environments compared to traditional methods. Similarly, Yanuarto and Iqbal (2022) found that AR-based instruction in geometric concepts markedly improved students' ability to visualize objects from multiple perspectives. This study also observed that students began to construct mental representations and articulate spatial

relationships between places. Herman et al. (2023) further emphasized that AR's visual and interactive affordances facilitate the comprehension of abstract concepts and their practical applications, thereby supporting spatial visualization development.

The enhancement of spatial reasoning through AR is further supported by Szentirmai and Murano (2024), who found that AR promotes active learning and deepens cognitive understanding of spatial relations in geoscience education. Students in their study exhibited significant improvement in spatial orientation and in interpreting geological data. This parallels the present study's findings, where students effectively identified relative positions, developed mental maps, and explained interregional connections after engaging with AR-based geography content. Likewise, Srivastava et al. (2024) demonstrated that AR media improved students' ability to visualize complex astronomical phenomena—previously difficult to convey through conventional instruction—reinforcing AR's value in supporting abstract spatial learning.

The three-dimensional depiction offered by AR enhances spatial awareness and conceptual understanding, consistent with this study's findings on students' mental representations of geographic objects. This study also affirms the role of interactive media in enhancing a contextual and stimulating learning experience. Wakhungu (2023) emphasized the significance of incorporating geotechnology, such as augmented reality, to foster an active inquiry-based learning environment in geography education. This is evident in the classroom learning, as students participate in discovery and discourse centered on spatial visualization. (Tene et al., 2024) similarly indicated that interactive media can enhance students' motivation for learning and retention of information. In this study, students exhibited much enthusiasm and regarded studying as "fun like playing games," affirming that augmented reality (AR) serves not merely as a visual aid but as a transformative medium that cultivates a more dynamic and meaningful educational experience.

CONCLUSIONS

This study demonstrates that the implementation of Augmented Reality (AR) in junior high school geography education significantly enhances students' spatial skills. The application of augmented reality via interactive 3D visualization enhances students' comprehension of spatial concepts, increases spatial orientation, develops mental representations, and reinforces understanding of inter-regional relationships. Besides promoting experiential learning, AR enhances student motivation and engagement. Nonetheless, some challenges persist in its implementation, including insufficient devices, unreliable internet connectivity, and inadequate student technological proficiency. Consequently, it is advisable that the incorporation of augmented reality in education be facilitated through teacher training, availability of sufficient infrastructure, and creation of adaptive and contextual learning materials. This study aims to serve as a foundation for the advancement of more interactive and effective geography learning innovations to enhance students' spatial thinking skills in the digital age.

Author Contributions:

H.W.: Conceptualization, Methodology, Software, Supervision, Writing – Review & Editing.

I.M.: Validation, Writing – Original Draft, Project Administration, Writing – Review & Editing.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

Informed Consent Statement/Ethics approval: Not applicable.

REFERENCES

Astawa, I. B. M. (2022). Peningkatan Spatial Thinking Skills Siswa dalam Pembelajaran Geografi melalui Metode Demonstrasi Berpendekatan Kontekstual. *Journal of Education Action Research*, *6*(2), 242–251. https://doi.org/10.23887/jear.v6i2.45526

Chihab, L., Herrmann, K., Schlottmann, A., & Nöthen, E. (2020). Of Skyscrapers and Windmills: Enhancing Intercultural Learning by Utilizing Four Key Spatial Concepts. *The Geography Teacher*, *17*(1), 13–27. https://doi.org/10.1080/19338341.2019.1680412

Djafar, H., Yunus, R., DJ Pomalato, S. W., & Rasid, R. (2021). Qualitative and Quantitative Paradigm Constellation In Educational Research Methodology. *International Journal of Educational Research & Social Sciences*, *2*(2). https://doi.org/10.51601/ijersc.v2i2.70

Freksa, C., & Barkowsky, T. (2020). On the Relations between Spatial Concepts and Geographic Objects. In *Geographic Objects with Indeterminate Boundaries* (pp. 109–121). CRC Press. https://doi.org/10.1201/9781003062660-11

Gill, S. L. (2020). Qualitative Sampling Methods. *Journal of Human Lactation*, *36*(4). https://doi.org/10.1177/0890334420949218

Guntur, M. I. S., Setyaningrum, W., Retnawati, H., & Marsigit, M. (2020). Assessing the Potential of Augmented Reality in Education. *Proceedings of the 2020 11th International Conference on E-Education, E-Business, E-Management, and E-Learning*, 93–97. https://doi.org/10.1145/3377571.3377621

Guryevskikh, O. Yu. (2020). Development of Cognitive Geography Ideas in a Digital Educational Environment. *Proceedings of the International Scientific Conference "Digitalization of Education: History, Trends and Prospects" (DETP 2020)*. https://doi.org/10.2991/assehr.k.200509.157

Herman, H., Zalukhu, A., Hulu, D. B. T., Zebua, N. S. A., Manik, E., & Situmorang, A. S. (2023). Augmented Reality (AR) pada Geogebra Meningkatkan Kemampuan Spasial dan Pemecahan Masalah Matematis pada Materi Dimensi Tiga. *Journal on Education*, *5*(3), 6032–6039. https://doi.org/10.31004/joe.v5i3.1368

Ho, S., Liu, P., Palombo, D. J., Handy, T. C., & Krebs, C. (2022). The role of spatial ability in mixed reality learning with the HoloLens. *Anatomical Sciences Education*, *15*(6), 1074–1085. https://doi.org/10.1002/ase.2146

J., B., Conor, F., Andrew, S., D., O., & William, H. (2019). *Augmented Reality for Enhancing Life Science Education*.

Jo, I., & Hong-Dwyer, J. J. (2024). GIS learning and college students' acquisition and understanding of spatial concepts. *Journal of Geography in Higher Education*, *48*(5), 763–774. https://doi.org/10.1080/03098265.2023.2263748

Kozov, V. V., & Ivanova, B. (2023). Augmenting Student Education Using the RealityScan Application for Generating 3D Content. *2023 46th MIPRO ICT and Electronics Convention (MIPRO)*, 619–624. https://doi.org/10.23919/MIPRO57284.2023.10159773

Kshirsagar, N., Pandey, G., Prakash, A., Chauhan, I. S., & Kumar, S. (2023). Educative Reality - Augmented Reality Application for Education. *2023 2nd International Conference for Innovation in Technology (INOCON)*, 1–6. https://doi.org/10.1109/INOCON57975.2023.10101270

Lisa, R., Maschandra, & Iskandar, R. (1967). Analisis Penelitian Kualitatif Model Miles dan Huberman. *Angewandte Chemie International Edition, 6(11), 951–952*.

Pambudi, M. H., Suyitno, A., & Mastur, Z. (2022). Development of Application Based on Augmented Reality to Improve Student's Spatial Ability. *Jurnal Didaktik Matematika*, *9*(2), 314–327. https://doi.org/10.24815/jdm.v9i2.25936

Parashar, V. (2020). AUGMENTED REALITY A NEW ERA IN EDUCATION. *International Journal of Engineering Technologies and Management Research*, *5*(2), 19–29. https://doi.org/10.29121/ijetmr.v5.i2.2018.608

Qamar, T. (2023). *Augmented Reality: A New Tech To Teach And Learn*.

Sofaer, S. (2002). Qualitative research methods. *International Journal for Quality in Health Care*, *14*(4). https://doi.org/10.1093/intqhc/14.4.329

Srivastava, A., Vaidya, V., Murthy, S., & Dasgupta, C. (2024). GeoSolvAR: Scaffolding spatial perspective-taking ability of middle-school students using AR enhanced inquiry learning environment. *British Journal of Educational Technology*, *55*(6), 2617–2638. https://doi.org/10.1111/bjet.13456

Szentirmai, A. B., & Murano, P. (2024). *Enhancing Learning Through Universally Designed Augmented Reality: A Comparative Study of Augmented and Traditional Learning Materials*. https://doi.org/10.3233/SHTI241044

Tene, T., Marcatoma Tixi, J. A., Palacios Robalino, M. de L., Mendoza Salazar, M. J., Vacacela Gomez, C., & Bellucci, S. (2024). Integrating immersive technologies with STEM education: a systematic review. *Frontiers in Education*, *9*. https://doi.org/10.3389/feduc.2024.1410163

von Reumont, F., & Budke, A. (2021). Spatial Thinking With Comics in Geography Education. *Frontiers in Education*, *6*. https://doi.org/10.3389/feduc.2021.702738

Wakhungu, L. N. (2023). Influence of Geo-Technologies Integration on the Learning of Geography among Public Secondary Schools. *Innovare Journal of Education*, 17–21. https://doi.org/10.22159/ijoe.2023v11i5.48825

Yanuarto, W. N., & Iqbal, A. M. (2022). The Augmented Reality Learning Media to Improve Mathematical Spatial Ability in Geometry Concept. *Edumatica : Jurnal Pendidikan Matematika*, *12*(01), 30–40. https://doi.org/10.22437/edumatica.v12i01.17615

Journal on Smart Learning Technologies
Volume 1, No. 1, 2025: 57 - 66
E-ISSN:
DOI:…