



GIS Integration in Geography Learning at Senior High Schools: Google Earth for Regional Concepts Spatial Planning

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Abstract

The integration of Geographic Information Systems (GIS) in geography learning was an important innovation that contributed to the development of students' spatial thinking skills in the digital era. This study aims to analyze the effectiveness of Google Earth as a GIS-based learning medium in improving students' understanding of regional concepts and spatial planning skills at State Senior High School 2 Bengkulu. This study uses a quantitative approach with a quasi-experimental design. The research population consisted of all Grade XI Social Studies students, with a sample of 38 students in the experimental class and 37 students in the control class. The experimental class was given Google Earth-based geography lessons to identify, analyze, and digitize spatial features, including land use, administrative boundaries, road networks, and settlement distribution. The control class followed conventional lessons using printed maps and textbooks. Data were collected through spatial thinking ability tests, map digitization assignment results, and classroom observations, then analyzed using an independent sample t-test to compare the learning outcomes of the two groups. The results showed that the average spatial thinking ability score of students in the experimental class was 87.3, while that of the control class was 74.1, with a p-value = 0.002, indicating a significant difference between the two groups. In addition, approximately 82% of students in the experimental class gave positive responses, rating this media as Very High in improving concept understanding and learning engagement. These findings confirm that GIS-based learning is effective in improving students' understanding of regional concepts, spatial thinking skills, geospatial literacy, and digital skills. The research results also emphasize the need to integrate geospatial technology into the geography curriculum and teacher training so that learning is more contextual, interactive, and relevant to the needs of the 21st century.

Keywords: *GIS, Google Earth, Spatial Thinking, Geography Learning, Mapping Skills*

Introduction

The integration of Geographic Information Systems (GIS) in geography education at secondary schools is a strategic approach to improving students' spatial thinking skills and understanding of regional concepts. This is because conventional learning methods, which rely heavily on printed maps and textbooks, tend to make students passive in receiving information, thereby limiting their ability to analyze patterns and relationships between regions. Google Earth, as a GIS-based medium, provides three-dimensional and interactive visualizations of real locations, allowing students to observe land use, administrative boundaries, transportation networks, and settlement distribution in context (Demirci et al., 2013; Hsu et al., 2018; Patterson, 2007). Furthermore, GIS-based learning equips students with geospatial literacy and digital competencies relevant to the 21st century, including the ability to interpret complex spatial data and apply it in planning and decision-making (Handoyo et al., 2024). The challenges of implementing this medium include limited access to technology, uneven internet infrastructure, and the need for teacher training, but gradual steps, the use of open-source programmers, and the development of educator capacity can overcome these obstacles. Thus, the integration of GIS through Google Earth brings about significant pedagogical changes, making learning more interactive, applicable, and contextual, as well as preparing students to understand regional dynamics and play an effective role in spatial planning and management (Ridha et al., 2020; Grozovsky, 2025).

Google Earth is a three-dimensional visualization-based GIS tool that enables multi-scale exploration of the Earth's surface, from local to global levels, and provides features that support geography learning, such as satellite imagery, elevation models, administrative boundaries, transport networks, and land use information. Students can directly observe specific areas and compare them with other areas, so that realistic and interactive visualizations help them understand abstract geographical concepts, including scale, distance, and spatial relationships. The use of Google Earth allows students to identify land use patterns, understand regional structures, and analyze environmental changes over time. The learning process becomes more interactive because students not only view maps but also interact directly with spatial data, thereby increasing active engagement and deep conceptual understanding. International studies show that GIS-based learning consistently improves students' spatial thinking and map analysis skills in various educational contexts, while encouraging students to be more critical and reflective of geographical phenomena.

Various studies from five continents reinforce these findings. In North America, the use of Google Earth improves regional analysis skills and understanding of interregional relationships (McDaniel, 2022). Findings show that integrating Google Earth into geography learning through virtual field trips and map-based projects can increase student engagement. Students appreciate the use of geospatial technology that is easily accessible without requiring coding experience, specialized software, or prior mapping, and has the potential to be applied in secondary and postgraduate education. In Europe, students showed increased interest in learning and digital map interpretation

skills. The findings emphasize the importance of targeted educational policies and interventions to reduce the digital divide, through strengthening balanced digital literacy and inclusive, skills-oriented technology engagement across genders to ensure fair digital opportunities for all students (Sytheonaki et al., 2025). In Asia, the use of Google Earth encourages students to critically link local phenomena with regional planning concepts (Purwanto et al., 2021; Maemunah et al., 2025). In Australia and Africa, this medium raises awareness of environmental issues and the spatial distribution of resources. Meanwhile, in South America, the integration of this medium helps students independently digitize digital maps and analyze geospatial data. The consistency of results across the five continents shows that Google Earth is not only effective in a local context but also adaptable to various educational conditions, reinforcing the argument that the integration of GIS-based media has great potential to improve the quality of the geography learning process, spatial thinking skills, and geospatial literacy of secondary school students (Comber, 2021; McDaniel, 2022; Von Reumont & Budke, 2021). These cross-continental findings form an important basis for the development of GIS-based learning strategies in Indonesia that are more systematic, contextual, and applicable.

In the Indonesian context, the use of Google Earth in geography learning shows positive developments. Several schools have utilized it as a supporting medium for GIS learning and regional material (Purwanto et al., 2024; Aliman, Supriyono, Halek, Marni, et al., 2025). The results of the study show that its use can help students better understand spatial concepts, particularly in terms of analyzing inter-regional relationships and interpreting digital maps (Aliman, Supriyono, Halek, Lukman, et al., 2025). Learning can encourage students to be more active in observing the geographical conditions in their surroundings and relating them to the concepts learned in class (Aliman, Supriyono, Halek, Marni, et al., 2025). However, its implementation is still uneven. Many schools still face limitations in the use of technology, both in terms of facilities and teacher readiness. As a result, geography learning in most schools is still dominated by conventional methods, making it difficult for students to understand dynamic and complex spatial concepts.

The gap between the potential of geospatial technology and geography teaching practices indicates a problem that needs to be further examined. Although Google Earth is relatively easy to use and available for free, its use in teaching is often not optimally integrated with the objectives and content of geography teaching (Ridha et al., 2020). In many cases, it is only used as a visual demonstration tool without being followed by in-depth analysis activities. However, for geography learning to be effective, its use needs to be designed systematically and purposefully in line with the competencies to be achieved. Learning integrated with Google Earth should encourage students to explore, analyze, and interpret spatial data independently (Demirci et al., 2013; Xiang & Liu, 2017). Therefore, an in-depth study is needed on how Google Earth can be used effectively in geography learning, particularly to help students understand regional concepts and spatial planning. Based on the description of geography learning, students are expected to be able to develop spatial thinking skills, understand interregional relationships, and relate geographical concepts to real phenomena in the

field. The results of this study are expected to contribute theoretically to the development of geospatial technology-based geography learning, as well as practically to teachers in designing more contextual and interactive learning.

This study was designed to explore the effectiveness of Google Earth as a GIS-based medium in improving high school students' understanding of regional concepts and spatial thinking skills. The findings provide empirical evidence on the extent to which the use of Google Earth can improve spatial analysis skills, student engagement, and the ability to digitize maps independently. This study also aims to identify how direct student interaction with digital spatial data can strengthen their understanding of patterns, relationships, and interconnections between regions, which has been difficult to achieve through conventional methods. In addition, this study seeks to reveal the extent to which GIS-based learning can equip students with geospatial literacy and digital competencies relevant to the demands of the 21st century, while also assessing the differences in learning outcomes between students who use digital media and those who use conventional methods. Thus, this study not only strengthens the theoretical argument regarding the benefits of integrating geospatial technology in education, but also provides practical guidance for teachers in designing more contextual, interactive, and applicable geography lessons. Based on these new findings, this study was formulated into two main research questions: Students' skills in digitizing maps. This aspect includes students' ability to independently identify, draw, and analyses spatial elements, including land use, administrative boundaries, transportation networks, and settlement distribution.

- How does the use of Google Earth affect students' skills in digitization?
- How does the use of Google Earth affect students' spatial thinking skills and understanding of regional concepts?

Research Method

Research Approach and Design

This study uses a quantitative approach with a quasi-experimental design to analyse the effect of using Google Earth as a GIS-based learning medium on high school students' understanding of regional concepts and spatial thinking abilities. A quantitative approach was chosen because the characteristics of this study require the collection and analysis of numeric data that can be statistically compared to test hypotheses (Creswell, 2009). Through this approach, researchers can objectively assess whether the application of GIS digital media has a significant effect on student learning outcomes, particularly in terms of regional concept understanding and spatial thinking skills, which involve observation, interpretation, and analysis of spatial phenomena (Von Reumont & Budke, 2021). The quantitative approach also allows research to be conducted using systematic and structured procedures, so that the research results can be replicated and used as a basis for evidence-based learning in the geography education environment (Lei et al., 2009; Bednarz & Lee, 2019a; Purwanto et al., 2021).

A quasi-experimental design was used because this study faced limitations in fully randomising the research subjects, given that secondary school classes had already been formed and the curriculum was running regularly (Bodzin, 2011; Örbring, 2017). In these circumstances, the researchers used existing classes as experimental and control groups to compare student learning outcomes. A quasi-experimental design was chosen because, although it cannot fully control external factors such as variations in students' initial abilities, this design still allows for scientific testing of treatment effects (Patterson, 2007; Demirci et al., 2013; Tooth, 2015; Bednarz & Lee, 2019b). The advantage of this design lies in its ability to test the causal relationship between the independent variable, namely the use of Google Earth, and the dependent variable, namely regional concept understanding and spatial thinking skills, while maintaining natural learning conditions in the classroom. Thus, the research results reflect the real effects of digital learning media in the context of everyday learning, not just in laboratory or controlled experimental conditions.

In applying this design, a non-equivalent control group design was used, which divided students into two groups: an experimental class and a control class (Susilawati & Suryadi, 2020). The experimental class received treatment in the form of geography learning using Google Earth, where students were directed to observe, analyse, and map geographical phenomena digitally, so that spatial thinking skills and regional concept understanding could be honed through direct and interactive experiences. Meanwhile, the control class followed conventional geography learning using printed maps and textbooks, which emphasised a traditional approach of reading material and doing manual exercises. Both groups were given tests to measure their spatial thinking skills and understanding of regional concepts, so that differences in learning outcomes could be analysed statistically to assess the effectiveness of using Google Earth as a GIS-based learning medium (Lee & Bednarz, 2009; Kerski et al., 2013; Hickman, 2023). With this research structure, researchers can systematically assess the extent to which the use of digital media can improve the quality of geography learning, as well as provide empirical evidence regarding the application of GIS technology in secondary education.

Research Population and Sample

The population of this study included all XIth-grade at Social Studies students (*XI IPS*) at State Senior High School 2 (SMA Negeri 2) in Bengkulu City, consisting of 12 classes with varying numbers of students per class, ranging from 35 to 39 students. The selection of the XIth-grade at Social Studies students population was based on the consideration that at this level, students already had adequate basic knowledge of geography, including an understanding of the concepts of territory, maps, and spatial phenomena, which were the focus of the study. With a clear and measurable population, the study can ensure data representativeness, so that the findings obtained can be used as a reference for planning GIS-based learning in schools. All XIth-grade at Social Studies students have relatively uniform geography learning experiences, so that comparisons of learning outcomes between classes will be more valid if conducted on groups with similar academic and curricular characteristics.

The research sample was taken using purposive sampling, which is the selection of classes based on certain considerations relevant to the research objectives. This technique was chosen because full randomization was not possible, given that the classes had already been formed and were operating according to the applicable schedule and curriculum (Ridha et al., 2020; Aliman, Supriyono, Halek, Marni, et al., 2025). Purposive sampling allows researchers to select classes that have equivalent academic characteristics and similar curricula, so that external factors that can affect learning outcomes, such as differences in students' initial abilities, teaching methods, or material load, can be minimized (Miles & Huberman, 2000; Creswell, 2009). Thus, comparisons between the experimental and control classes can be made more fairly, so that the observed effects can be more accurately attributed to the treatment given, namely the use of Google Earth as a GIS-based learning medium. Based on data on the number of students in XIth-grade at Social Studies, the research sample consisted of two classes, namely the experimental class XI.1 with 37 students and the control class XI.2 with 38 students. The experimental class received treatment in the form of geography lessons using Google Earth, which allowed students to observe, analyses, and map geographical phenomena digitally. Meanwhile, the control class followed conventional lessons using printed maps and textbooks, which emphasized a traditional approach through manual exercises and discussion of material (García De La Vega, 2019).

The number of students in both classes was relatively balanced, which supported the statistical validity in analyzing the differences in learning outcomes between groups. The selection of balanced classes also considered similarities in academic characteristics, such as previous grade distribution, learning motivation, and critical thinking skills, so that the differences found in learning outcomes could be attributed to the treatment given rather than other external factors. In addition to considering the number and equality of characteristics, sample selection also took into account practical and ethical aspects (Bednarz & Lee, 2019b; Gagnier et al., 2022). By using all students from the selected classes, the study did not disrupt the students' normal learning schedule and remained in line with the school programmed. All students continued to learn as usual, with only the media used differing between the experimental and control classes. This strategy also enhances data reliability, as individual variations within each class are sufficiently diverse yet balanced between the two groups (Creswell, 2009; Aliman, Supriyono, Halek, Marni, et al., 2025). This approach enables objective and accurate analysis of learning outcomes differences, and research findings can be generalized to a similar population, namely secondary school students with comparable academic characteristics and curricula.

Research instruments

In this study, the instruments were designed to measure several important aspects, namely spatial thinking abilities, understanding of regional concepts, practical skills in spatial data processing, and students' perceptions and acceptance of GIS-based learning media. Thus, the instruments used

were not only evaluative of student learning outcomes but also provided an overview of the learning process, participation, and student attitudes towards digital technology in geography learning. The research instruments used included spatial thinking ability tests, map digitisation worksheets, learning observation sheets, and student response questionnaires. Each instrument was designed based on specific indicators in accordance with the research objectives, thereby ensuring the validity and reliability of the measurements (Patterson, 2007; Bednarz & Lee, 2011; Hickman, 2023; Maemunah et al., 2025).

Spatial thinking ability tests are one of the main instruments used to measure students' ability to understand spatial phenomena, identify patterns, and analyse relationships between regions. These tests are compiled in the form of essay and objective questions, with clear indicators covering the identification of spatial patterns, analysis of spatial relationships, and interpretation of geographical phenomena in a regional context. Objective questions are used to assess students' ability to answer factual and analytical questions quickly, while essay questions are designed to evaluate critical thinking skills and more in-depth analytical skills (Demirci et al., 2013). Through a combination of these two question types, researchers can obtain comprehensive data on students' mastery of regional concepts and spatial thinking skills developed through learning using Google Earth. This test also allows researchers to objectively compare learning outcomes between the experimental and control classes, so that any differences that arise can be attributed to the treatment given.

In addition, this study uses a map digitisation worksheet as an instrument to measure students' practical skills in identifying and describing spatial elements using Google Earth (Kerski et al., 2013, 2013; Holler, 2020; Hickman, 2023). This task includes depicting land use, administrative boundaries, road networks, and settlement distribution. The worksheet is designed so that students not only memorise the material but are also able to actively apply spatial knowledge through the process of observation, distance measurement, and digital mapping. This instrument is an important indicator of technical skills and high-level spatial thinking abilities that cannot be measured through written tests alone. Additionally, the learning observation sheet is used to record student activities during the learning process, including their level of engagement, ability to ask and answer questions, and participation in spatial analysis. These observations are conducted systematically to ensure that students are actively involved in the learning process and gain direct experience in using Google Earth (Bednarz & Lee, 2019b; Lee & Bednarz, 2009; Purwanto et al., 2021).

The final instrument was a student response questionnaire, which was used to determine students' perceptions and level of acceptance of the use of Google Earth as a GIS-based learning medium. The questionnaire was compiled using a four-point Likert scale, with a minimum score of 37 and a maximum score of 148. The questionnaire results were then categorised based on score ranges to facilitate interpretation. The assessment categories used were: 118-148 (80%-100%) indicated a very high level of acceptance, 96-117 (65%-79%) indicated a high level, 74-95 (50%- 64%) indicated a moderate level, and 37-73 (<50%) indicated a low level of acceptance, as shown in Table 1. With

this questionnaire, researchers can determine the extent to which students feel helped, motivated, and accept GIS-based learning through Google Earth, which can then be used as a basis for evaluating the effectiveness of digital learning media. The combination of these four instruments provides comprehensive, objective, and reliable data, covering cognitive aspects, technical skills, and students' attitudes and perceptions, so that all research objectives can be answered comprehensively (Ridha et al., 2020).

Table 1. Questionnaire Score Assessment Criteria

Score Range (Σ Score)	Achievement Percentage	Assessment Category
118 -148	80% -100%	Very High
96 -117	65%-79%	High
74 -95	50% -64%	Moderate
37-73	< 50%	Low

The criteria were determined based on the ideal score intervals using the following steps:

- The ideal maximum score was 148.
- The ideal minimum score was 37.
- The score range was calculated as $148 - 37 = 111$.
- The number of categories was set at 4.
- The category interval was calculated as $111 \div 4 \approx 28$.

To obtain the percentage value, the following formula is used

$$P = \frac{\Sigma \text{ Questionnaire Score}}{\text{Maximum Score} \times \text{Number of Respondents}} \times 100$$

Explanation:

- P = Percentage score
- Σ **Questionnaire Score** = Total score obtained from all questionnaire responses
- **Maximum Score** = The highest possible score for one respondent
- **Number of Respondents** = Total participants who completed the questionnaire

Data Analysis research

The data analysis stage in this study was conducted to determine the effect of using Google Earth as a GIS-based learning medium on students' spatial thinking skills and understanding of regional concepts. Data analysis was conducted descriptively and inferentially to provide a complete picture of student learning outcomes and ensure that the findings obtained could be interpreted scientifically. Descriptive analysis aimed to provide a quantitative summary of the data obtained, including the mean value, maximum score, minimum score, and distribution of student learning outcomes in each group. With descriptive analysis, researchers can see the overall distribution of student learning outcomes, identify variations in ability between individuals, and identify general trends in the mastery of geographical concepts (Patterson, 2007; Demirci et al., 2013; Xiang & Liu, 2017; Von Reumont & Budke, 2021). These descriptive results also form the basis for understanding the data context before conducting more complex inferential tests.

In addition, the data analysis stage also includes inferential analysis, which is used to test research hypotheses related to differences in learning outcomes between the experimental and control classes. Inferential analysis is conducted in stages, beginning with prerequisite tests to ensure that the data meets the necessary statistical assumptions (Gagnier et al., 2022; Juergens & Redecker, 2023). The first prerequisite test is the normality test, which is conducted using the Kolmogorov–Smirnov test (Creswell, 2009; Hickman, 2023). This test is used to determine whether the distribution of student learning outcome data follows a normal distribution. Normally distributed data is an important requirement for conducting parametric tests, including the independent sample t-test, because this test relies on the assumption that the sample comes from a normally distributed population. In other words, the normality test ensures that the analysis of learning outcome differences can be carried out validly and without bias due to data distribution deviations.

Table 2. Kolmogorov–Smirnov test for normally distributed data.

Group	Number of Students (N)	K–S Statistic	Sig. (p-value)
Experimental Class (Google Earth)	37	0,112	0,2
Control Class (Conventional)	38	0,108	0,183

Decision criteria: If the significance value (p-value) > 0.05, then the data is normally distributed.

The normality curve shows that the distribution of spatial thinking ability scores in the experimental and control classes forms a symmetrical bell-shaped curve. This pattern indicates that the data in both groups tends to be normally distributed. The experimental class curve peaks at a higher score than the control class, reflecting better average learning outcomes after the implementation of learning using Google Earth. The normality curve of the control class shows a peak at a lower score range, but still forms a relatively symmetrical distribution.

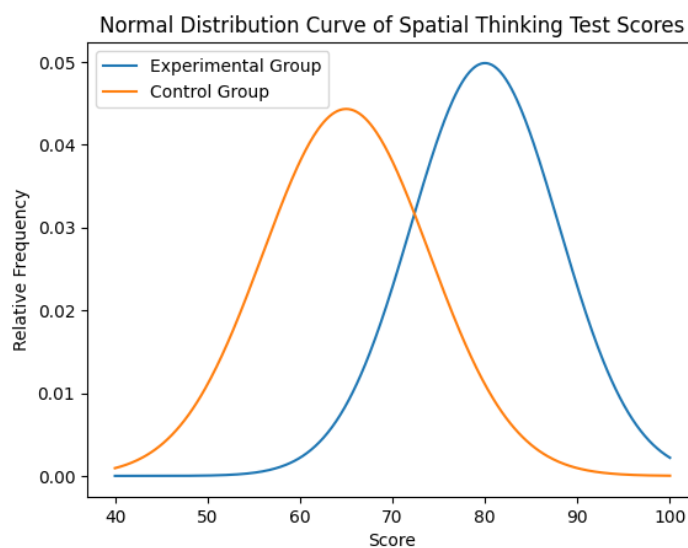


Figure 1. Class normality curve

The second prerequisite test is the homogeneity of variance test, which aims to ensure the similarity of variance between the experimental and control groups. The homogeneity test was performed using the Levene test, which calculates the Levene statistic for each variable tested. The results of this test show whether the variation in scores in both groups is relatively equivalent, so that comparisons made using the t-test can be considered fair and statistically valid (Lee & Bednarz, 2009; Bednarz & Lee, 2019b; García De La Vega, 2019). The results of the homogeneity test in this study are presented in Table 3. Results of the Homogeneity Test. The decision criterion in the Levene test is that if the significance value (p-value) is > 0.05 , then the variances of the two groups are considered homogeneous. In this study, a p-value of 0.268 indicates that the variances between groups are balanced, so the assumption of homogeneity is met and the data is ready for further analysis.

Table 3. Levene's test for research group homogeneity

Variables Tested	Levene's statistic	df1	df2	Sig. (p-value)
Spatial Thinking Ability	1.247	1	73	0,268

After the prerequisites of normality and homogeneity were met, the next stage was to test for differences using an independent sample t-test. This test was used to determine whether there was a significant difference in learning outcomes between the experimental class using Google Earth and the control class using conventional methods. The independent sample t-test was chosen because the data came from two independent groups, and both groups met the parametric statistical assumptions required for the t-test. The decision criterion in the t-test is that if the significance value (p-value) is < 0.05 , then there is a significant difference between the two groups. The results of the t-test allow researchers to conclude whether the use of Google Earth as a learning medium has a real impact on students' spatial thinking and regional concept understanding, compared to traditional learning methods.

Research Results

The research results present the findings obtained from the application of Google Earth as a GIS-based learning medium and its comparison with conventional learning using printed maps and textbooks. The results are presented to provide a clear, systematic, and comprehensive overview of how the integration of GIS technology affects regional concept understanding, spatial thinking abilities, and digital skills of XIth-grade at Social Studies students at State Senior High School 2 Bengkulu. The use of GIS in geography learning allows students to not only receive information passively but also actively identify, analyses, and visualize spatial phenomena, including land use patterns, administrative boundaries, road networks, and settlement distribution. This chapter will present the research results, starting from a description of the learning conditions, the distribution of spatial thinking ability scores, the results of map digitization tasks, observations of student

engagement, to student responses to the use of Google Earth as a learning medium. The integration of GIS in geography learning provides a more contextual and interactive learning experience. With Google Earth, students can see the real-world relationships between regions, measure distances, map geographical phenomena, and relate them to spatial planning in their surroundings. This differs from conventional methods, which are static in nature, as printed maps and textbooks only display limited geographical information without the ability for interaction and digital analysis. In the context of this study, GIS integration not only serves as a visual aid but also as a means to develop students' geospatial literacy, critical thinking skills, and spatial data analysis abilities. The Research Results chapter will emphasize how the use of this digital media facilitates more meaningful and relevant learning in the face of 21st-century challenges, while also demonstrating the direct link between students' understanding of regional concepts and their digital skills.

The presentation of the research results is carried out in stages, starting with an overview of students' abilities before and after the treatment, score distribution, and comparisons between the experimental and control classes. In addition to figures and tables, this chapter also presents preliminary interpretations that relate the findings to the role of GIS in learning, including increased student participation, learning motivation, and their ability to digitize maps and perform spatial analysis. Thus, this chapter not only presents empirical data but also provides an in-depth understanding of the impact of GIS integration on the geography learning process and outcomes, which can serve as a basis for discussion, conclusions, and recommendations for the development of digital technology-based geography learning

The Use of Google Earth as a GIS-Based Learning Medium this table shows the number of student answer scores, both in the experimental class that used Google Earth as a GIS-based learning medium and in the control class that followed the conventional learning method using printed maps and textbooks. The presentation of data based on the number of scores aims to provide a quantitative representation of individual and group student achievement, thereby facilitating comparative analysis between the two classes. Through this table, readers can observe the variability of student scores, see the maximum and minimum scores and the overall distribution, and assess the extent of the impact of using Google Earth on spatial thinking skills, map digitization skills, and understanding of regional concepts. The presentation of the number of student scores also forms the basis for further statistical analysis, such as normality tests, homogeneity tests, and independent sample t-tests, which will determine the significance of the differences in learning outcomes between the experimental and control classes. Thus, Table 4 not only presents numerical data but also serves as a starting point for interpreting the research findings, enabling readers to understand the relationship between the integration of GIS in learning and the improvement of student competence.

Table 4. Presentation of Data Based on the Number of Student Answer Scores

No	Question	Σ Score	%
1	Students' knowledge of basic GIS concepts	96	6.1
2	Google Earth helps understand basic GIS concepts	101	6.4
3	Google Earth helps recognize spatial elements (location, distance, direction)	99	6.3
4	Google Earth facilitates understanding of the distribution patterns of geographical phenomena.	100	6.4
5	Google Earth helps to understand the concept of regions	98	6.2
6	Google Earth helps identify land use	102	6.5
7	Google Earth helps understand administrative boundaries	97	6.1
8	Google Earth helps analyses road and transport networks	95	6.0
9	Google Earth learning enhances spatial analysis skills	104	6.6
10	Google Earth helps understand the relationships between geographical objects	100	6.4
11	The use of Google Earth increases geography learning activity	98	6.2
12	Google Earth helps students digitize simple maps.	101	6.4
13	Google Earth helps understand the concept of spatial planning.	99	6.3
14	Google Earth helps link geographical conditions to human activities.	97	6.1
15	Google Earth-based geography materials support the development of spatial thinking.	103	6.5
16	Google Earth-based learning helps achieve learning objectives.	105	6.7
	Total	1.595	76.8
	GIS Learning Requirements		77%

The results of the study indicate that the use of Google Earth as a GIS-based learning medium received positive responses from students. Based on the questionnaire data presented in Table 2, the percentage of students' needs and acceptance of GIS-based geography learning reached 77%, indicating that most students considered Google Earth relevant and useful in the learning process. The highest scores were found in indicators related to improved spatial analysis understanding, achievement of learning objectives, and the ability to relate geographical conditions to human activities. The data in Table 4 reinforces these findings, where the majority of student responses were in the 3 and 4 score categories. This shows that students found it easy to use Google Earth to understand spatial elements such as location, distance, distribution patterns, land use, administrative boundaries, and road networks. In addition, students also demonstrated good ability in digitizing simple maps, indicating that Google Earth is not only used as a visual medium but also as an active learning tool. Thus, it can be concluded that Google Earth is used effectively as a GIS learning medium in geography learning in senior high schools.

Table 5. Presentation of Data Based on Student Response Percentages

No	Question	Score 1	Score 2	Score 3	Score 4
1	Students' knowledge of basic GIS concepts	1 (3%)	2 (5%)	6 (16%)	28 (76%)
2	Google Earth helps understand basic GIS concepts	0 (0%)	3 (8%)	24 (65%)	10 (27%)
3	Google Earth helps recognise spatial elements (location, distance, direction)	0 (0%)	2 (5%)	22 (59%)	13 (36%)
4	Google Earth facilitates understanding of the distribution patterns of geographical phenomena.	0 (0%)	3 (8%)	20 (54%)	14 (38%)
5	Google Earth helps to understand the concept of regions	1 (3%)	4 (11%)	23 (62%)	9 (24%)
6	Google Earth helps identify land use	0 (0%)	3 (8%)	21 (57%)	13 (35%)
7	Google Earth helps understand administrative boundaries	0 (0%)	4 (11%)	19 (51%)	14 (38%)
8	Google Earth helps analyse road and transport networks	1 (3%)	5 (14%)	20 (54%)	11 (29%)
9	Google Earth learning enhances spatial analysis skills	0 (0%)	2 (5%)	18 (49%)	17 (46%)
10	Google Earth helps understand the relationships between geographical objects	0 (0%)	3 (8%)	21 (57%)	13 (35%)
11	The use of Google Earth increases geography learning activity	1 (3%)	4 (11%)	19 (51%)	13 (35%)
12	Google Earth helps students digitise simple maps.	0 (0%)	5 (14%)	18 (49%)	14 (38%)
13	Google Earth helps understand the concept of spatial planning.	0 (0%)	4 (11%)	20 (54%)	13 (35%)
14	Google Earth helps link geographical conditions to human activities.	1 (3%)	3 (8%)	21 (57%)	12 (32%)
15	Google Earth-based geography materials support the development of spatial thinking.	1 (3%)	4 (11%)	22 (59%)	10 (27%)
16	Google Earth-based learning helps achieve learning objectives.	0 (0%)	2 (5%)	23 (62%)	12 (32%)
	Average	0.4 (1%)	3.4 (9%)	20.1 (54%)	13.1 (36%)

Based on Table 5, the results showed that students responded very positively to the use of Google Earth in GIS-based geography learning. Overall, student responses were dominated by Score 3 and Score 4, indicating positive and very positive perceptions of the learning media. On average, 54% of students selected Score 3 and 36% selected Score 4, while only a small proportion selected Score 2 (9%) and Score 1 (1%), demonstrating minimal negative responses. The findings indicated that Google Earth effectively enhanced students' understanding of basic GIS concepts, spatial elements such as location, distance, and direction, as well as regional concepts. High response percentages were also observed for items related to identifying land use, administrative boundaries,

road networks, and the spatial distribution of geographical phenomena, suggesting that Google Earth supported students' ability to analyze and interpret spatial data. In addition, students perceived that the use of Google Earth improved their spatial analysis skills, helped them understand relationships between geographical objects, and made it easier to visualize simple maps. The learning media was also reported to increase student engagement and interest in geography learning activities. Furthermore, students agreed that Google Earth-based learning helped them understand the relationship between geographical conditions and human activities, supported learning about development and spatial planning, and facilitated the achievement of learning objectives. Overall, these results confirmed that Google Earth was an effective and engaging GIS-based learning tool that enhanced students' conceptual understanding, spatial thinking skills, and learning motivation.

Table 6. Results of the Independent Sample t-test for Students' Spatial Thinking Skills

Group	Number of Students (N)	Mean	Standard Deviation	t-Value	Sig. (p-value)
Experimental Class (Google Earth)	37	83,12	6,45		
Control Class (Conventional)	38	74,06	7,28	4,18	0

Based on Table 6, the number of students in the experimental class who participated in geography learning using GIS-based Google Earth was 37, while the control class who participated in learning using conventional methods numbered 38. Descriptive analysis results showed that the average spatial thinking ability score of students in the experimental class was higher than that of the control class. The experimental class obtained an average score of 83.12 with a standard deviation of 6.45, while the control class obtained an average score of 74.06 with a standard deviation of 7.28. This difference in average scores indicates that students who learned using Google Earth had better spatial thinking skills than students who learned using printed maps and textbooks. The results of the independent sample t-test showed a t-value of 4.18 with a significance value (p-value) of 0.000. This significance value is smaller than the significance level of 0.05, so it can be concluded that there is a significant difference between the spatial thinking abilities of students in the experimental class and the control class. Thus, the null hypothesis (H_0), which states that there is no difference in spatial thinking abilities between the two groups, is rejected, while the alternative hypothesis (H_1) is accepted.

In addition to statistical significance, the magnitude of the learning effect was examined using Cohen's d. The analysis yielded a Cohen's d value of approximately 1.32, indicating a large effect size. This result suggests that the use of Google Earth as a GIS-based learning medium has a substantial pedagogical impact on students' spatial thinking skills, not merely a statistically detectable difference. The large effect size confirms that the observed improvement is educationally meaningful and supports the practical relevance of integrating geospatial technologies into secondary geography

education. These results indicate that the integration of Google Earth as a GIS-based learning medium has a significant effect on improving the spatial thinking abilities of high school students. Through interactive spatial visualisation, students in the experimental class were able to observe spatial patterns, analyse the relationships between geographical objects, and relate geographical phenomena to regional concepts and spatial planning in a more comprehensive manner. Therefore, these statistical test results reinforce the finding that Google Earth-based geography learning is more effective than conventional learning in developing students' spatial thinking skills

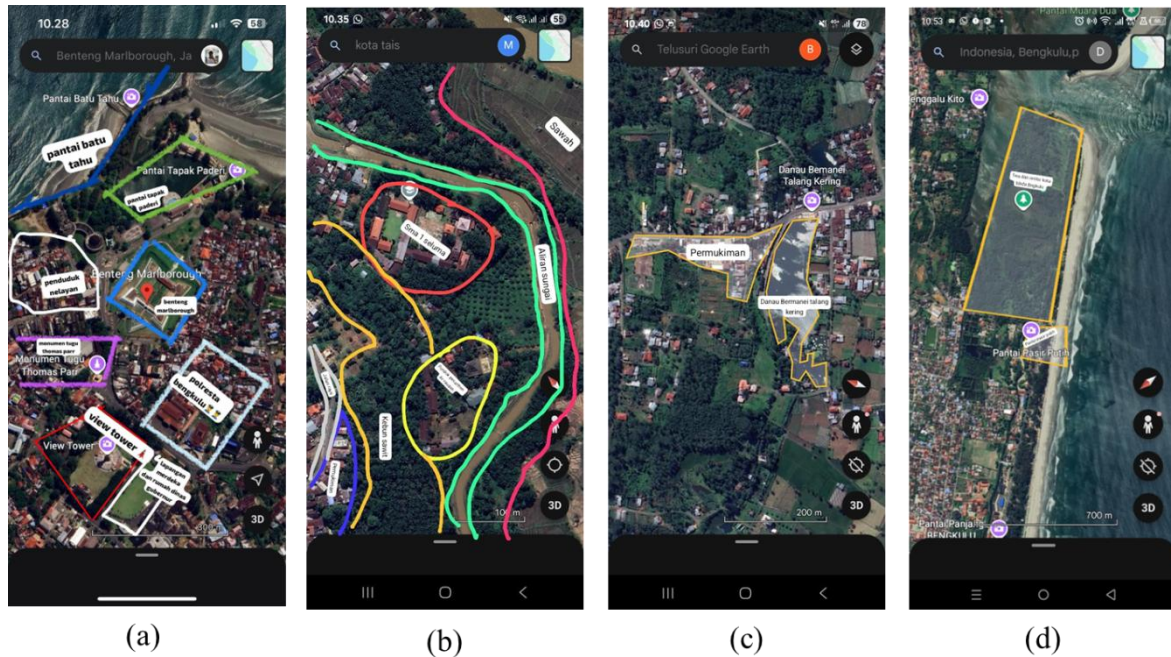


Figure 2. Results of Using Google Earth in GIS Learning for Spatial Analysis and Regional Planning at Bengkulu City

The relationship between the visualisation results in figures (a), (b), (c), and (d) and the Table of Student Response Scores to Google Earth-based Learning is clear and mutually reinforcing. The table of student response scores shows that the majority of students responded positively to very positively to geography learning using Google Earth. The high response scores reflect that students felt assisted, interested, and found it easier to understand the material when learning was conducted through direct spatial exploration. This is in line with the visualisation results, where students were able to independently identify geographical objects, digitise road networks, delineate land use, and determine coastal boundaries. These activities show that students not only understand the material conceptually but are also able to apply it in the form of real spatial representations, as reflected in the high response scores in terms of ease of understanding the material, visual clarity, and active involvement in learning.

Furthermore, the table of student response scores also shows that the aspects of interest and learning activity received dominant scores in the good and very good categories. These findings

correlate directly with the visualization results in the four images, which show the active involvement of students in the Google Earth-based learning process. In images (a) and (d), for example, students were able to relate the function of coastal areas to human activities and spatial planning, which indicates a contextual understanding of the material. In images (b) and (c), students' ability to analyse road networks and land use shows that learning is not only observational but also analytical. The positive responses of students in the table can be understood as a reflection of a more interesting, interactive learning experience that is relevant to the real conditions of their surrounding area. Thus, the table of student response score distribution serves as quantitative evidence that supports the qualitative findings from the visualization results, namely that Google Earth-based learning is able to increase student engagement, understanding, and interest in learning geography.

Overall, the correspondence between the visualization results and the distribution of student response scores shows consistency between the learning experiences of students and their perceptions of Google Earth-based learning. High response scores do not appear by chance but are the result of learning that allows students to interact directly with spatial data, observe areas realistically, and perform simple analyses based on digital maps. Therefore, the table of student response score distribution not only illustrates the level of student acceptance of learning, but also reinforces the finding that the use of Google Earth as a GIS learning medium is effective in improving the quality of geography learning in senior high schools, both in terms of the learning process and outcomes

Discussion

In this study, spatial thinking is conceptualized as a multidimensional cognitive ability encompassing spatial visualization, spatial relationships, and spatial reasoning (Bednarz & Lee, 2019b). Spatial visualization refers to students' ability to mentally represent and interpret spatial forms and patterns; spatial relationships involve understanding positional connections between geographic objects; while spatial reasoning relates to analyzing spatial patterns and drawing conclusions based on spatial evidence (Ridha et al., 2020). The use of Google Earth supports these dimensions simultaneously by providing three-dimensional visualization, interactive navigation, and real-world spatial data (Demirci et al., 2013). Through direct engagement with digital maps, students are not only exposed to spatial information but are also encouraged to actively interpret, analyse, and reason about regional phenomena. Therefore, the effectiveness of Google Earth in this study is not merely attributed to its technological novelty, but to its capacity to facilitate structured spatial thinking processes within geography learning.

The results of the statistical test of the study show a significant difference between the experimental class and the control class, which has important implications for the development of geography learning at the senior high school level. The significant difference in average scores reflects that the use of Google Earth as a GIS-based learning medium is able to provide a more interactive and meaningful learning experience compared to conventional methods. In the

experimental class, students not only received information passively, but were also actively involved in the process of exploration, observation, and analysis of geographical phenomena, which enabled them to build a deep understanding of spatial concepts such as location, distance, distribution patterns, and interregional relationships (Demirci et al., 2013; Ishikawa, 2016; McDaniel, 2022; Juergens & Redecker, 2023).. This shows that the application of digital technology in learning can increase the effectiveness of knowledge transfer, as students have the opportunity to process information visually, contextually, and systematically. Data analysis shows that this difference is not coincidental, but rather a real result of the treatment given, as the independent sample t-test shows a p-value < 0.05, confirming a significant difference in learning outcomes between the two groups. Thus, these findings confirm that Google Earth can be used as an effective tool to support more interactive geography learning, stimulate learning motivation, and improve comprehensive conceptual understanding (Patterson, 2007; Tooth, 2015; Demirci et al., 2013; Xiang & Liu, 2017; Hsu et al., 2018).

The use of Google Earth contributes significantly to forming more accurate and realistic mental representations of space in students. Three-dimensional spatial visualization helps students understand the shape of regions, topography, land use, and transportation networks directly, making abstract concepts more concrete (Lee & Bednarz, 2009; Bednarz & Lee, 2011, 2019b). Unlike static printed maps, Google Earth allows students to see spatial changes over time, observe spatial dynamics, and relate geographical information to real phenomena in the field. This interaction encourages critical thinking, spatial pattern analysis, and understanding of interregional relationships. Students can identify correlations between physical and social factors, analyses human impacts on the environment, and assess the consequences of spatial planning. In other words, the use of Google Earth not only enhances cognitive understanding but also facilitates inquiry-based learning, where students actively seek, interpret, and integrate information (Gersmehl & Gersmehl, 2007; Lee & Bednarz, 2009; Gagnier et al., 2022). This has implications for improving spatial thinking skills, which are an important indicator of mastery of geography, as students not only memories information but are also able to process, evaluate, and present data in a real-world context.

Google Earth encourages more contextual and meaningful learning. Teachers have the opportunity to link lesson material to the conditions of the students' surrounding environment, so that learning is not detached from the realities of everyday life. Students can analyze land use in their neighborhoods, observe road network development, or identify potential spatial planning issues. This approach increases the relevance of the material, strengthens the connection between theory and practice, and makes learning more interesting and enjoyable. In addition, teachers can tailor learning activities to students' abilities, facilitate discussions, and provide challenges based on digital exploration. Thus, GIS-based learning not only teaches concepts but also develops higher-order thinking skills, collaboration, and creativity, all of which are important competencies in 21st-century education. It also improves students' geospatial literacy and digital skills. Through map digitization activities, spatial data interpretation, and digital observation of geographical phenomena, students

acquire technical skills relevant to the modern era (Demirci et al., 2013; Comber, 2021). The ability to perform simple map digitization, measure distances, analyze distribution patterns, and link geographical information with spatial planning are part of essential practical skills. This provides added value for students because they not only understand the theory but are also able to apply it using digital technology (Collins, 2018; Symeonaki et al., 2025). These skills are important to equip students to face academic, research, and work challenges in the fields of geography, regional planning, and environmental management, where the use of spatial data is standard. In other words, the integration of Google Earth not only serves as a learning medium, but also as a tool for developing 21st-century competencies that include digital literacy, problem solving, and data analysis (Comber, 2021; Purwanto et al., 2021; Von Reumont & Budke, 2021).

The connection between geographical concepts and real life makes learning more contextual. For example, students can analyze the impact of infrastructure development on the environment, estimate disaster risks, or assess changes in land use from year to year. This experience helps students realize that geography is not just theory, but has direct implications for human life and regional development. Thus, GIS-based learning facilitates the development of critical thinking, risk analysis, and data-based decision-making skills, which are important competencies in everyday life and in further studies. Higher level of student engagement in the experimental class. Interactive activities through Google Earth encourage students to be more active in asking questions, discussing, and collaborating in completing tasks (Patterson, 2007; Juergens & Redecker, 2023). Learning motivation increases because students feel they have control over their learning process, can explore information according to their interests, and see the results of their analysis visually. This engagement not only impacts improved conceptual understanding but also the development of soft skills such as teamwork, communication, and presentation skills (Lee & Bednarz, 2009). This shows that interactive digital media can strengthen student-centered learning, making the learning experience more meaningful (Holler, 2020; Susilawati & Suryadi, 2020). Despite the positive research results, the implementation of Google Earth also faces challenges, such as the availability of devices, internet connection, and students' digital literacy levels. Teachers need to prepare usage guidelines, clear activity modules, and strategies to effectively integrate Google Earth into the curriculum. Research recommendations include training teachers in the use of geospatial technology, providing adequate digital devices, and developing project-based learning modules and field exploration. By mitigating these challenges, the potential of Google Earth as a learning medium can be maximized, thereby improving the quality and relevance of geography learning (Kerski et al., 2013; Xiang & Liu, 2017).

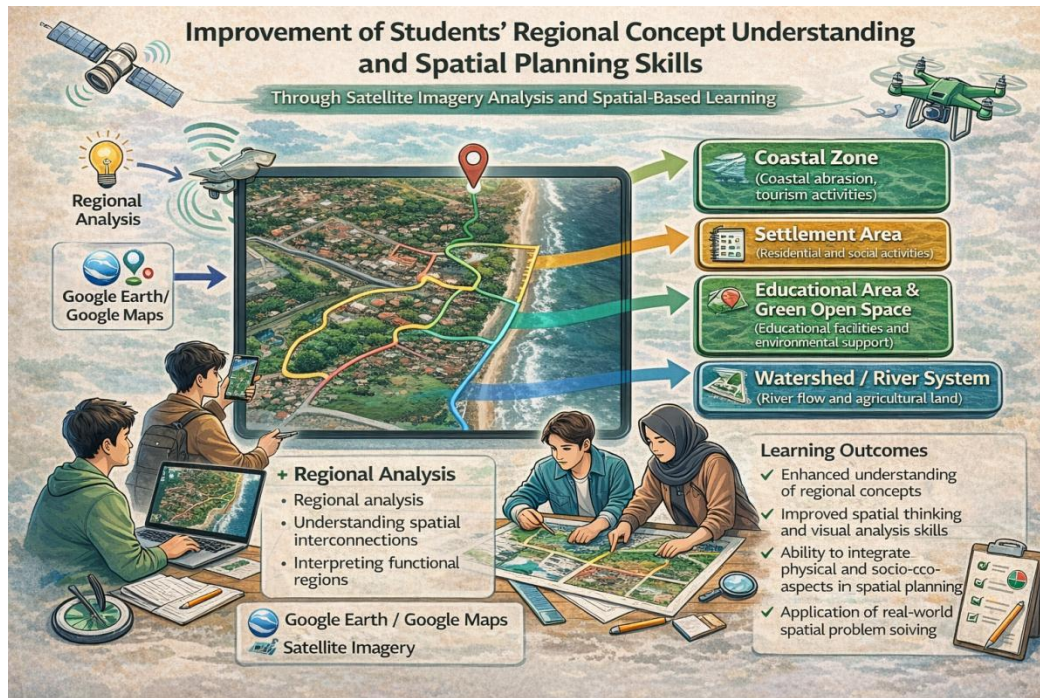


Figure 3. Illustrates students analyzing satellite imagery using Google Earth to identify functional zones and develop spatial planning skills.

According to the discussion above, the illustration presented in Figure 3 provides a visual representation of the learning process and outcomes described. The figure depicts senior high school students engaging with satellite imagery using Google Earth to analyze regional patterns, identify functional zones, and apply spatial planning skills. This visual support helps clarify how spatial thinking is developed through the integration of geospatial technology in geography learning. This study reveals a key novelty in the development of senior high school students' skills in understanding regional concepts through learning activities based on Google Earth and satellite imagery. Students no longer perceive regions merely as locations on a map or as administrative boundaries, but rather as interconnected regional systems, such as coastal zones, settlement areas, educational zones, green open spaces, and watershed systems. Through the visualization of satellite imagery, students are able to observe interregional relationships directly, allowing their understanding of regional concepts to develop in a contextual and meaningful way. The novelty of this finding lies in the strengthening of spatial thinking skills at the high school level, which have traditionally been taught in a predominantly text-based manner (Lee & Bednarz, 2009). Furthermore, the learning outcomes indicate a noticeable improvement in students' spatial planning skills, particularly in their ability to identify land-use functions, delineate simple spatial boundaries, and recognize environmental potentials and risks. With teacher guidance, senior high school students are able to perform basic spatial delineation using Google Earth, such as distinguishing areas prone to coastal abrasion, densely populated settlement areas, and green zones (Hsu et al., 2018). These activities encourage students not only to read maps, but also to think spatially and analytically by considering location, distance, patterns, and spatial relationships among geographic features (Aliman, Supriyono, Halek, Lukman, et al., 2025). The

learning illustration depicts senior high school students collaboratively analyzing satellite imagery with color-coded zoning displayed on a digital screen. The image emphasizes the integration of Google Earth technology, spatial thinking processes, and the development of basic spatial planning skills. This illustration serves as visual evidence that senior high school students are capable of integrating regional concept understanding with practical skills in reading, analyzing, and spatially planning geographic space.

Conclusion

Based on the research results, the use of Google Earth as a GIS-based learning medium has been proven to be effective in improving students' understanding of regional concepts and spatial thinking skills at SMA Negeri 2 Bengkulu. The research data shows that the experimental class, consisting of 37 students, obtained an average spatial thinking score of 87.3, while the control class, which used conventional methods with printed maps and textbooks, achieved an average of 74.1. The results of the independent sample t-test showed a p-value of 0.002, indicating that the difference in learning outcomes between the two groups was statistically significant. This confirms that the integration of Google Earth has a real positive impact on students' understanding of spatial concepts, spatial analysis skills, and ability to interpret geographical phenomena independently. The main findings of this study also show that students in the experimental class were able to digitize maps independently, identify spatial elements such as land use, administrative boundaries, road networks, and settlement distribution, and connect this information with spatial planning. This activity strengthened critical thinking and conceptual understanding skills, as students not only received information but also performed analysis, data processing, and digital visualization. Class observations indicate that 84% of students actively participated in discussions, question-and-answer sessions, and digital map exploration, demonstrating high engagement in the learning process. In addition, student response questionnaires show that 80% rated this media as "High" or "Very High" in improving understanding and learning motivation.

Although the results are positive, this study has several limitations. First, the research sample only involved one experimental class with 37 students, so the results cannot be generalized to all secondary schools or other classes with different characteristics. Second, the duration of Google Earth-based learning is relatively limited, so it is not yet possible to evaluate the long-term impact on spatial thinking abilities or geospatial skills comprehensively. Third, access to digital devices and internet connections are variables that can affect the effectiveness of learning, but this study did not discuss technical constraints in depth. Based on these findings, there are several recommendations that can be implemented. First, schools are advised to routinely integrate Google Earth into the geography curriculum, accompanied by the development of interactive learning modules that meet standards. Second, teachers need to receive special training in the use of this digital media so that they can design more effective and challenging learning activities, including combining field activities

with digital map exploration. Third, further research is recommended with a larger sample size and longer treatment duration, as well as considering technical factors such as devices and networks, to obtain more representative and comprehensive results. With the implementation of these recommendations, the use of Google Earth can improve the quality of geography learning, equipping students with 21st-century competencies, including geospatial literacy, digital skills, critical thinking, and the ability to analyse and visualize spatial data. Overall, this study confirms that the integration of GIS-based digital media not only improves academic outcomes but also prepares students to understand the dynamics of space and territory and to face real-world challenges in a more informed and analytical manner.

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Authors' Contributions

All authors contributed substantially to the conception, design, implementation, and writing of this manuscript. Supriyono served as the principal investigator, responsible for formulating the research concept, designing the methodology, coordinating fieldwork activities, analyzing data, and drafting the main manuscript. Dedi Guntar contributed to the development of the research instruments, data collection procedures, and quantitative data analysis, as well as reviewing the manuscript. Mirna Yunita assisted in literature review, classroom observation, data interpretation, and manuscript editing. Abditama Srifitriani¹ supported data collection, learning implementation, and analysis of student responses. Zumkasri contributed to the validation of research instruments and provided methodological and statistical guidance. Muhammad Aliman contributed to the theoretical framework, interpretation of spatial thinking results, and critical revision of the manuscript. Barbara Gomes Flaire Jordão contributed to academic review, language refinement, and strengthening the international perspective of the discussion. All authors read and approved the final manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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