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RESEARCH ARTICLE

The Influence of Geospatial Technology-Based Learning Media on Students' Spatial Thinking Ability

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ABSTRACT

The ability to think spatially is an essential competency in geography learning because it is directly related to the understanding of spatial phenomena. However, the practice of learning geography in high school is still dominated by conventional methods that do not support the development of these abilities. This study aims to analyze the influence of geospatial technology-based learning media on students' spatial thinking ability. The study used a quantitative approach with a quasi-experimental non-equivalent control group design. The research subject consists of 2 classes, namely the experimental class that obtains learning using geospatial technology (ArcGIS Online) and the control class that obtains conventional learning. The research instrument is in the form of the Spatial Thinking Ability Test (STAT) which is compiled based on spatial thinking indicators according to Bednarz and Lee. Data analysis was carried out using normality test, homogeneity test, t-test, Size effect test (Cohen's d) and N-Gain test. The results showed a significant difference between the experimental class and the control class. The improvement of students' spatial thinking ability in the experimental class was in the higher category than the control class. Thus, geospatial technology-based learning media has a positive effect on improving students' spatial thinking ability. This study recommends the use of geospatial technology as an alternative geography learning media to improve the quality of room-based learning.

Keywords: Geospatial Technology; Spatial Thinking Ability; Geography Education; Learning Media

1. INTRODUCTION

Spatial thinking ability are an essential competency in geography learning because they are the foundation for understanding the structure, patterns, and interactions of geospherical phenomena in the spatial dimension (Sabihi et al., 2024). From a geographical perspective, space is not only interpreted as a location, but as an analytical framework to explain the relationships between phenomena in a systematic and contextual manner (Aulia, 2024). Therefore, the development of spatial thinking ability is the main requirement so that students are able to comprehensively interpret distribution patterns, regional dynamics, and the relationships between geographical elements (Adzani et al., 2023). Spatial thinking is not only related to the ability to read maps, but also includes the ability to understand spatial relationships, patterns of phenomenon distribution, as well as representations of space in various forms (Bednarz & Lee, 2019).

However, the reality in the field shows that the spatial thinking ability of high school students in Indonesia is still relatively low. The geography learning process tends to be verbal, teacher-centered, and has minimal use of visual-interactive media, so that students have difficulty understanding geography and spatial concepts (Bana et al., 2025). This condition was also found at SMA Negeri 13 Bandar Lampung. Based on the results of interviews with geography teachers on May 21, 2025, information was obtained that the use of geospatial technology-based learning media is still limited and has not been optimally integrated in the learning process. Although teachers have experience in using digital maps, their implementation has not been done consistently. As a result, students tend to be passive, have low motivation to learn, and spatial thinking ability have not been developed optimally (Ansarullah et al., 2023).

These qualitative findings are strengthened by quantitative data on student learning outcomes. Based on the data of documentation of learning outcomes obtained from preliminary research at SMA Negeri 13 Bandar Lampung on the material block test of Indonesia's strategic position and the potential of natural resources in the odd semester of the 2024/2025 school year, it is known that many have not reached the Minimum Completeness Criteria (KKM).

Table 1. Geography Daily Exam Score on the Material Indonesia's Strategic Position and Natural Resource Potential Class XI State High School 13 Bandar Lampung

Classes	Qty	Finished ≥70	%	Incomplete <70	%	Total
XI F.7	31	4	12.9%	27	87.1%	31
XI F.8	32	4	12.5%	28	87.5%	32
Total	63	8	12.7%	55	87.3%	63

Source: SMA Negeri 13 Bandar Lampung Academic Year 2024/2025

Table 1 shows that the level of completeness of Geography learning outcomes of grade XI students still has not reached optimal results. Although there are a number of students who have met the Minimum Completeness Criteria (KKM), the percentage is still much lower than the percentage of students who have not completed it. This condition indicates that the achievement of student learning outcomes in general still needs to be improved through more effective and directed learning efforts.

Therefore, innovation in learning methods and media is needed so that students can more easily understand Geography concepts that require spatial thinking ability, and are able to significantly increase student motivation and learning outcomes. One of the solutions that can be pursued is the use of learning media based on geospatial technology, such as Google Earth, WebGIS, ArcGIS Online, WinMap, and other mapping applications. These media can help students visualize spatial concepts that have been difficult to understand in the abstract, so that they have the potential to improve students' spatial thinking ability (Wijaya et al., 2023).

In general, geospatial technology is a technology used to collect, store, analyze, and display geographic data in the form of location, shape, and characteristics of an object or place (Aulia & Aji, 2024). Geospatial technology presents spatial and regional information, so it is very relevant for studying various geosphere phenomena in geography learning. Geospatial technology is able to answer questions about what, where, when, how, and why related to geosphere dynamics and their distribution (Sejati, 2021). Its use is able to improve the quality of learning because students not only receive information passively, but also actively engage in space exploration. This research is in line with the findings of Khairurraziq (2024) regarding the application of geospatial technology-based learning media in improving the spatial thinking ability of grade XI social studies students at SMA Negeri 5 Sigi; the results were obtained that as many as 90% of students stated that it was easier to understand the material when learning was delivered using geospatial technology.

In this study, the geography material used will utilize geospatial technology-based learning media, especially on the distribution of flora and fauna in Indonesia and the world, which is included in the realm of biosphere dynamics. The scope of biosphere dynamics material is very interesting, starting from the material on the distribution of plants and animals in the world and Indonesia to the material on conservation efforts for the distribution of flora and fauna in Indonesia and the World (Fadlan, 2023). Thus, the use of geospatial technology-based learning media is very important and relevant to overcome problems in spatial thinking ability, as well as encourage the achievement of geography learning goals optimally. This, at the same time, emphasizes the position of this research in the realm of geography learning methodology, because it places spatial thinking ability as the center of analysis in understanding geosphere phenomena.

Therefore, this research is expected to make a positive contribution to the world of education, especially in the teaching of geography at SMA Negeri 13 Bandar Lampung. The results of the study will provide insight into how much the use of geospatial technology-based learning media affects students' spatial abilities. In addition, this research is also expected to be a consideration for policymakers in developing a more innovative and effective curriculum, as well as encouraging the use of technology in a wider learning process in schools in Indonesia. Based on the description above, the researcher decided to take the title "The Influence of Geospatial Technology-Based Learning Media on Students' Spatial Thinking Ability at SMA Negeri 13 Bandar Lampung".

2. LITERATURE REVIEW

2.1 Spatial Thinking Ability in Geography Education

Spatial thinking is a fundamental cognitive ability that encompasses understanding of space, representation, and reasoning. According to the National Research Council (2006), spatial thinking involves three elements: space, representation, and reasoning, all of which are closely interrelated in understanding geographic phenomena. In the context of geography education, spatial thinking enables students to interpret the distribution of phenomena, analyze relationships between locations, and understand the dynamics of geosphere interactions (Bednarz & Lee, 2019). These abilities are considered essential in geography learning because geography as a discipline relies heavily on the ability to read, interpret, and analyze spatial information (Sabihi et al., 2024).

Spatial thinking ability is not an innate fixed trait but can be developed through appropriate learning interventions. Research by Uttal et al. (2013) demonstrated that spatial skills are malleable and can be improved through targeted training, including the use of spatial technology tools. In geography learning, the development of spatial thinking is closely linked to the use of maps, Geographic Information Systems (GIS), and other geospatial technologies (Jo et al., 2016). The ability to visualize, analyze, and interpret spatial data is particularly relevant for understanding complex geographic phenomena such as biome distribution, climate patterns, and natural resource potential (Furqan et al., 2021).

Bednarz and Lee (2019) developed a comprehensive framework for measuring spatial thinking ability through the Spatial Thinking Ability Test (STAT), which includes eight core indicators: orientation and direction understanding, distinguishing map information from graphical information, choosing optimal locations based on spatial factors, visualizing slope profiles from topographic maps, correlating spatial phenomena distributions, visualizing three-dimensional images from two-dimensional information, overlaying and merging multiple map layers, and understanding spatial object representations. These indicators reflect a progression from basic to advanced spatial reasoning and provide a structured approach for assessing students' spatial competencies (Thayaseelan et al., 2024).

Despite the importance of spatial thinking in geography learning, empirical evidence consistently shows that the spatial thinking abilities of high school students in Indonesia remain at a relatively low level. Adzani et al. (2023) found that spatial thinking abilities of public high school students in Balikpapan City were generally below the expected benchmark, particularly in aspects requiring advanced spatial reasoning such as three-dimensional visualization and multi-layer spatial analysis. Furqan et al. (2021) similarly reported that geography education students at Syiah Kuala University demonstrated limited spatial thinking skills, especially in tasks requiring integration of multiple spatial data sources. These findings highlight a persistent gap between the spatial competencies required for meaningful geography learning and those actually possessed by Indonesian students.

2.2 Geospatial Technology as a Learning Medium

Geospatial technology encompasses a broad range of tools used to collect, store, analyze, and visualize geographic data in relation to location, shape, and spatial characteristics. Key geospatial technologies include Geographic Information Systems (GIS), Global Positioning Systems (GPS), remote sensing, and web-based mapping platforms such as Google Earth, ArcGIS Online, WebGIS, and Ina Geoportal (Aulia & Aji, 2024). These technologies enable users to interact with spatial data dynamically, explore geographic patterns, and derive meaningful insights from spatial relationships. In educational contexts, geospatial technologies transform abstract geographic concepts into interactive, visual experiences that promote deeper understanding (Sejati, 2021).

The integration of geospatial technology in geography learning aligns with constructivist pedagogical principles, wherein students actively construct knowledge through direct interaction with the learning environment. Jo et al. (2016) demonstrated that the use of GIS in geography classrooms significantly facilitated spatial thinking development, particularly in tasks requiring spatial analysis and interpretation of geographic data. ArcGIS Online, specifically, provides a cloud-based platform that allows students to access, analyze, and visualize spatial datasets without requiring advanced technical installation, making it particularly suitable for high school learning contexts (Wijaya et al., 2023). The interactive nature of these platforms encourages students to explore geographic distributions, test spatial hypotheses, and draw evidence-based conclusions about spatial phenomena.

Several studies have affirmed the effectiveness of geospatial technology in improving students' spatial capabilities. Kartadireja et al. (2024) found that GIS-based media significantly enhanced spatial intelligence among high school students, particularly in aspects related to map reading, spatial analysis, and geographic reasoning. Research by Medani et al. (2022) demonstrated that a guided discovery learning model assisted by Google My Maps positively influenced the spatial thinking ability of high school students at SMAN 1 Singosari. Furthermore, Vallentiza and Wijayanto (2024) reported that the application of techno-geospatial media—including Google Earth and Ina Geoportal—produced a notable increase in the average posttest score of the experimental class from 37.03 to 73.94, with a significance value of 0.001, confirming the statistically significant positive effect of geospatial technology on spatial thinking development.

2.3 Quasi-Experimental Approach in Geography Education Research

Quasi-experimental research designs are widely employed in educational research when random assignment of participants to treatment conditions is not feasible. The non-equivalent control group design, a common form of quasi-experimental design, involves comparing pretest and posttest scores between an experimental group receiving the intervention and a control group receiving conventional instruction (Abraham & Supriyati, 2022). This design provides a practical framework for evaluating the causal effects of educational interventions in authentic classroom settings, where factors such as class scheduling and institutional constraints limit the possibility of true random assignment (Scott, 2020).

In geography education research, quasi-experimental designs have been extensively used to assess the effectiveness of technology-based learning interventions. For example, Medani et al. (2022) employed a quasi-experimental design to study the effect of Google My Maps-assisted discovery learning on spatial thinking ability, while Vallentiza and Wijayanto (2024) used a similar design to evaluate the influence of techno-geospatial media on spatial thinking development. The N-Gain score, developed by Hake (1998), is commonly used in such designs to quantify the relative improvement between pretest and posttest scores, with scores categorized as high ($g \geq 0.70$), medium ($0.30 \leq g < 0.70$), and low ($g < 0.30$). Cohen's d is additionally employed to quantify the practical significance of observed differences between groups, with values of 0.2, 0.5, and 0.8 representing small, medium, and large effect sizes respectively.

The use of Rasch modeling for instrument validation represents an advanced approach to ensuring measurement quality in educational research. Thayaseelan et al. (2024) applied Rasch modeling to revalidate the Spatial Thinking Ability Test (STAT), confirming its unidimensionality and reliability. This approach provides a more rigorous and objective basis for measuring spatial thinking ability compared to classical test theory, as it separates person ability estimates from item difficulty parameters (Thayaseelan et al., 2024). The application of this validated instrument in the present study ensures that the measurement of spatial thinking ability is both reliable and valid, providing a sound basis for drawing conclusions about the effectiveness of geospatial technology-based learning media.

3. METHOD

3.1 Research Methods and Design

This study uses a quantitative approach with a pseudo-experiment method (Quasi Experimental Design). Quasi Experimental Design is a development of true experimental design. This design has a control group, but it cannot fully function to control the external variables that affect the execution of the experiment because the subjects are not randomly selected (Scott, 2020). The research design used is quasi-experimental type of non-equivalent control group design, which involved two groups, namely the experimental group and the control group.

Before being given treatment, experimental classes and control classes are first given Pretest to find out the initial ability of students before treatment is given. The experimental group obtained learning using geospatial technology-based media (ArcGIS Online), while the control group acquired conventional learning. After the treatment was given, both groups were given Posttest to measure changes in students' spatial thinking ability (Abraham & Supriyati, 2022). Schematically, the design is as follows: O1 X O2 / O3 — O4, where O1 and O3 are pretests, X is the treatment (geospatial technology media), and O2 and O4 are posttests.

01 X 02

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03 X 04

Figure 1. Non-equivalent control group design

3.2 Population and Sample

The population in this study is all students of grade XI of SMA Negeri 13 Bandar Lampung who take Geography subjects. The sampling technique used is nonprobability sampling with the purposive sampling method. Nonprobability sampling is a sampling technique that does not provide the same opportunity for each member of the population to be selected as a sample. Meanwhile, purposive sampling is a sample determination technique based on certain considerations adjusted to the research criteria. The sample in this study consisted of class XI F7 (31 students) and class XI F8 (32 students).

The independent variable in this study is geospatial technology-based learning media. The level of student involvement was measured using a questionnaire with a four-level Likert scale (1–4), which included aspects of attention, active participation, learning interests, and student interaction. The dependent variable is the spatial thinking ability of students, measured using multiple-choice test instruments compiled based on the Spatial Thinking Ability Test (STAT) given before and after treatment (pretest and posttest).

3.3 Research Instruments

The main instrument in this study is the Spatial Thinking Ability Test (STAT) compiled based on the indicators put forward by Bednarz and Lee. The test is multiple-choice and is given as a pretest and posttest. Indicators of spatial thinking ability measured can be seen on table 2.

The selection of this indicator was based on the consideration that Robert Bednarz and Jongwon Lee's indicators were more comprehensive and appropriate to the context of geography learning at the high school level. The indicators emphasize basic skills relevant to classroom learning practices, such as understanding orientation and direction, differentiating map information, choosing locations based on spatial factors, and visualizing spatial data in 2D and 3D form. Thus, this indicator is considered the most representative to measure students' spatial thinking ability as a whole as well as practical to be applied in this study.

Table 2. Spatial Thinking Ability Test (STAT)

No	Indicator
1	Have an understanding of orientation and directions
2	Distinguishing map information from graphical information
3	Choosing the best location based on spatial factors
4	Visualize slope profiles based on topographic maps
5	Correlating the distribution of spatial phenomena
6	Visualize 3D images based on 2D information
7	Overlay and merge multiple map shapes
8	Understand the representation of spatial objects in the form of points, lines, areas

Sources: (Safriani et al., 2024)

The STAT instrument used in this study has gone through a revalidation process using Rasch modeling referring to the analysis conducted by Thayaseelan et al. (2024). Based on the results using Winsteps, the Person Reliability value was 0.81 (good category) and Reliability Item 0.92 (very good category). Person Separation Index was 2.05 and Item Separation Index was 3.44. All question items met Rasch model eligibility criteria with Infit and Outfit MNSQ values within the acceptable range of 0.5–1.5. Unidimensionality analysis confirmed the instrument measures one main construct, namely spatial thinking ability (Thayaseelan et al., 2024).

3.4 Data Analysis Techniques

The data obtained in this study was analyzed through several stages of statistical testing: (1) normality testing using Shapiro-Wilk method to verify normal distribution as a prerequisite for parametric analysis; (2) homogeneity test to ensure the similarity of variance between the experimental group and the control group; (3) Independent Samples T-Test to test the difference in average spatial thinking ability between the two groups; (4) effect size calculation using Cohen's d formula to determine the extent of influence; and (5) N-Gain test to determine the level of learning effectiveness in each group.

4. RESULTS AND DISCUSSION

4.1 Descriptive Analysis of Learning Statistics in Experimental Classrooms

The implementation of learning in the experimental class was carried out during three meetings by applying geospatial technology-based Geography learning using ArcGIS Online. Before the treatment was given, students first took a pretest to measure initial spatial thinking ability. In the first meeting, learning was focused on the introduction of the basic concept of the distribution of biomes and their geographical characteristics. Students explore digital maps through ArcGIS Online to identify the distribution of the world's biomes, determine latitude positions, and measure the distance of certain biomes to the territory of Indonesia with the help of the Student Worksheet (LKPD).

In the second meeting, learning was directed at strengthening spatial analysis skills. Students analyzed the orientation of the biome distribution based on the cardinal direction, average air temperature, rainfall level, and vegetation characteristics through the use of spatial data in ArcGIS Online. In the third meeting, students received reinforcement of material regarding the distribution of flora and fauna and their preservation efforts. After the entire learning series was completed, students were given a posttest to measure the improvement of spatial thinking ability.

Based on the statistical analysis of the spatial thinking ability test (pretest and posttest) in the experimental class, the average score (mean) increased from 30 (pretest) to 38 (posttest), while the minimum value increased from 6 to 12. The standard deviation in the posttest was 14, showing that despite the general increase in achievement, variation in ability between students remained relatively stable. The increase in average and minimum grades shows that geospatial technology-based learning not only impacts students with high ability, but is also able to improve the spatial thinking ability of students with low achievements.

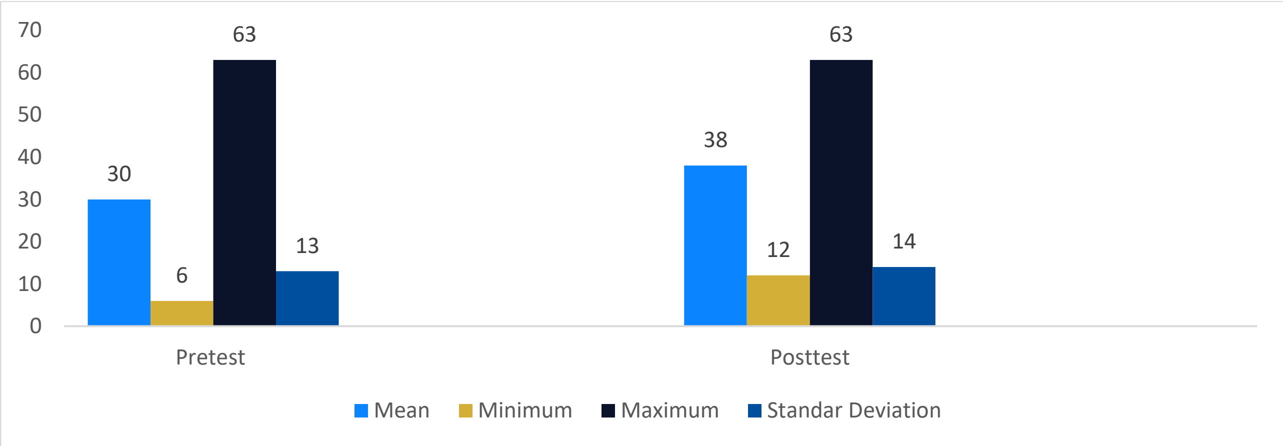

Figure 2. Comparison of descriptive statistics of the pretest and posttest of the experimental class

[Bar chart: Experimental class pretest vs posttest descriptive statistics – Mean, Min, Max, SD]

Further analysis based on the achievement of each item of the Spatial Thinking Ability Test (STAT) shows that geospatial technology-based learning has a different impact on each aspect of students' spatial thinking ability. After the implementation of geospatial technology-based learning, the posttest results showed an increase in achievement in almost all question items, especially in directional orientation skills, visual interpretation of maps, correlation of spatial phenomena, and simple spatial overlays. This increase shows that the use of geospatial media is able to help students understand spatial relationships more concretely through visualization and exploration of spatial data.

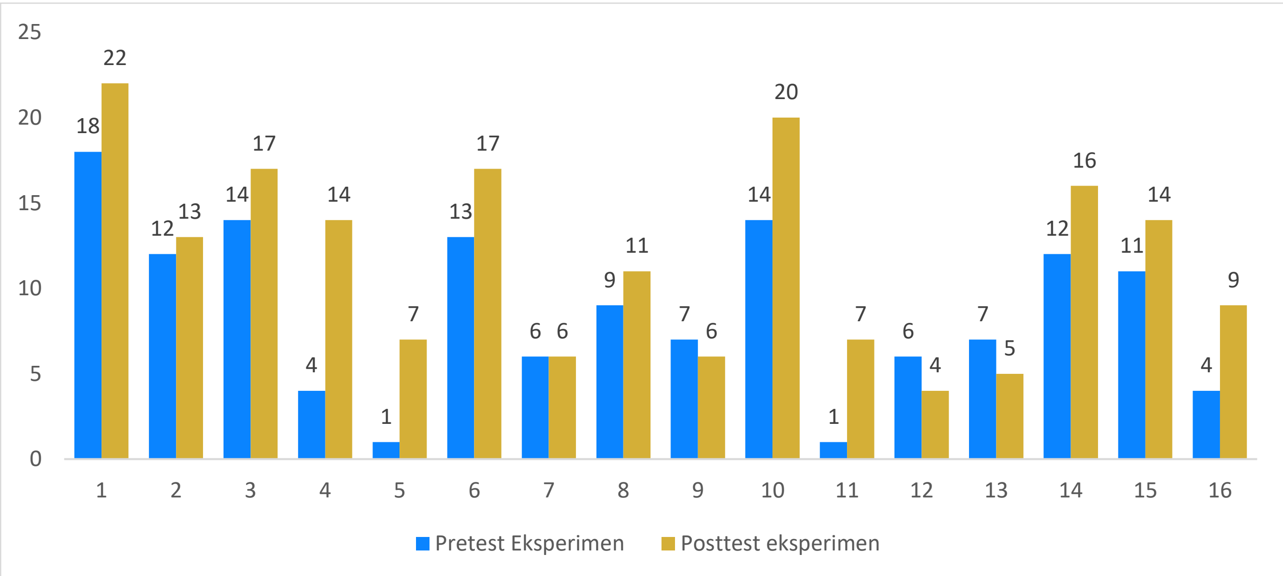

Figure 3. Comparison of achievement per STAT item of the experimental class (pretest and posttest)

[Bar chart: Per-item STAT comparison – experimental class]

4.2 Descriptive Analysis of Learning Statistics in Conventional Classrooms

Based on the statistical analysis of the spatial thinking ability test in the control class, students' spatial thinking ability does not show a significant improvement after the application of conventional learning. The average score remained fixed at 31 and the minimum score was unchanged. The maximum value decreased from 63 to 50, accompanied by a decrease in the standard deviation to 12. These findings indicate that conventional learning in control classes has not been effective in improving students' spatial thinking ability, and even tends to reduce the achievement of high-ability students without providing a significant improvement in low-ability students.

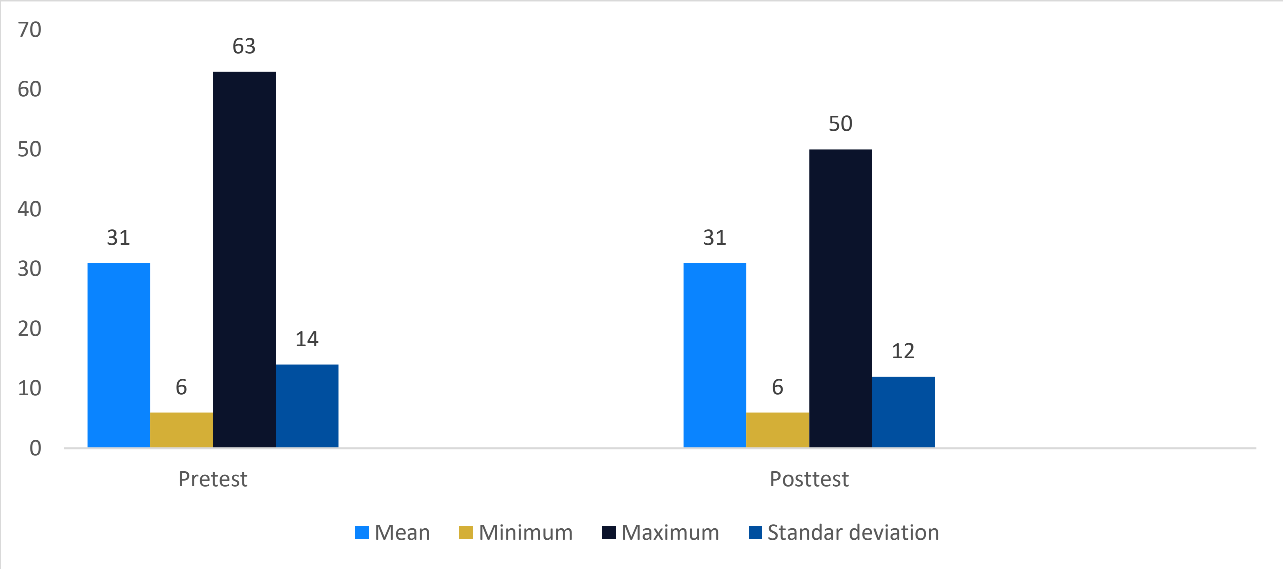

Figure 4. Descriptive analysis diagram of the pretest and posttest of the control class

[Bar chart: Control class pretest vs posttest descriptive statistics]

The analysis of the achievement of each item of the STAT question in the control class showed variations in students' spatial thinking ability in various aspects. After the application of conventional learning, the posttest results showed improvement in some question items related to directional orientation and basic spatial representation. However, these improvements did not occur evenly and tend to be limited to basic to intermediate spatial abilities. Overall, conventional learning has not been able to develop advanced spatial thinking ability optimally.

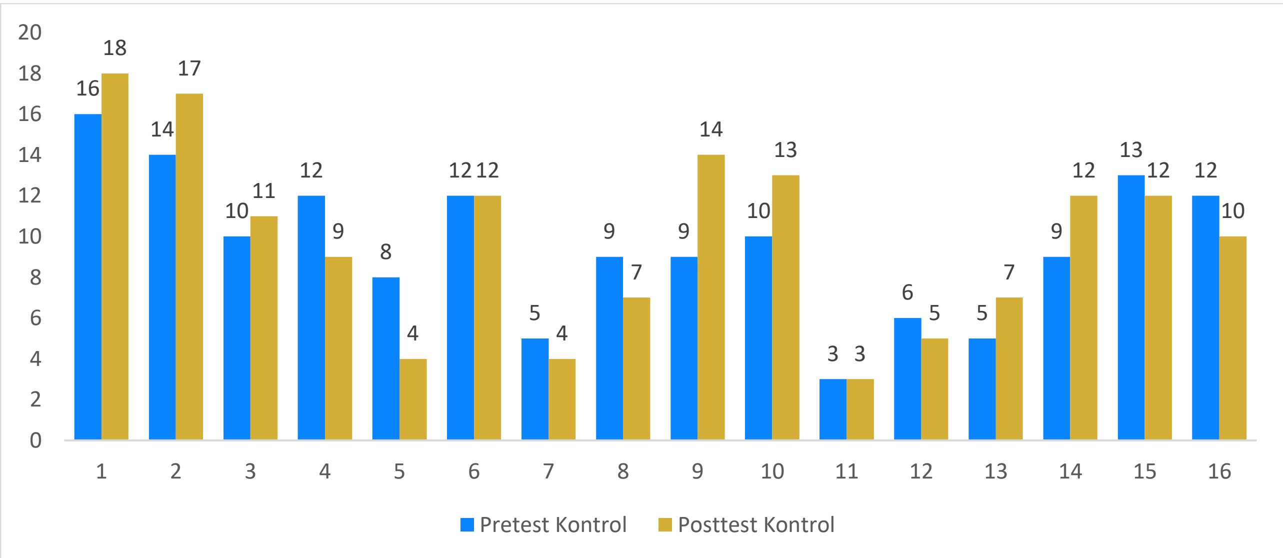

Figure 5. Comparison of descriptive statistics of the pretest and posttest of the control class

[Bar chart: Per-item STAT comparison – control class]

4.3 Data Analysis Prerequisite Test Results

Before conducting a hypothesis test, normality and homogeneity tests were performed. For the normality test, the Shapiro-Wilk method was used (sample < 50). The significance value for the pretest data in the experimental class was 0.107 and in the control class 0.106; both above 0.05, confirming normal distribution. For posttest data, significance values were 0.173 (experimental) and 0.061 (control), also above 0.05.

Table 3. Results of the normality test of the experimental and control class pretest data

Class	KS Statistic	Df	KS Sig.	SW Statistic	Df	SW Sig.	Ket.
XI.F7	.163	29	.048	.941	29	.107	Normal
XI.F8	.172	30	.023	.943	30	.106	Normal

Source: Research Results, 2026

Table 4. Results of the normality test of the posttest data

Class	KS Statistic	Df	KS Sig.	SW Statistic	Df	SW Sig.	Ket.
XI.F7	.159	29	.060	.949	29	.173	Normal
XI.F8	.208	30	.002	.934	30	.061	Normal

Source: Research Results, 2026

The homogeneity test pretest data yielded significance value 0.730 (> 0.05) confirming homogeneous variance. The posttest homogeneity test yielded significance value 0.266 (> 0.05), also confirming homogeneous variance. Both assumptions are met, making the data eligible for parametric statistical analysis.

Table 5. Results of the homogeneity test of the pretest data

Levene Statistic	Df1	Df2	Sig.
0.121	1	57	.730

Source: Research Results, 2026

Table 6. Results of the homogeneity test of the posttest data

Levene Statistic	Df1	Df2	Sig.
1.261	1	57	.266

Source: Research Results, 2026

4.4 Hypothesis Test Results

Based on the results of the Independent Samples t-test on the pretest values, a significance value of 0.653 was obtained (> 0.05), confirming no significant difference between the pretest score of the experimental and control classes. Thus, before treatment, both classes had relatively similar initial spatial thinking ability.

Table 7. Independent samples test results (posttest)

Test		Equal Variances Assumed	Equal Variances Not Assumed
t-test	T	2.151	2.146
	Df	57	55.727
	Sig. (2-tailed)	.036	.036
	Mean Difference	7.164	7.164
	Std. Error Difference	3.331	3.338
	95% CI Lower	.494	.477
	95% CI Upper	13.835	13.852

Source: Research Results, 2026

Based on the results of the effect size calculation using Cohen's d, an effect size value of -0.557 was obtained on students' spatial thinking ability. The absolute value of 0.557 is categorized as a moderate effect. This was strengthened by the increase in average score from the pretest of 29.59 to 37.93 in the posttest.

Table 8. Independent Samples Effect Size

		Pretest	Posttest
Mean		29.59	37.93
Standard Deviation		13.378	13.533
95% CI	Lower	-0.944	
	Upper	-0.161	
Effect Size (Cohen's d)		-0.557	

Source: Research Results, 2026

The N-Gain test was carried out to find out the magnitude of the increase in students' spatial thinking ability after participating in the learning process.

Table 9. Differences in Students' N-Gain Scores

No	Class	Learning Methods	Average N-Gain Score
1	XI-F7	Geospatial Technology-Based Learning Media	0.0984
2	XI-F8	Conventional	-0.0518

Source: Research Results, 2026

Based on the N-Gain analysis using SPSS version 27, the experimental class obtained an N-Gain value of 0.0984 or equivalent to 9.84%. Referring to the learning effectiveness criteria according to Hake (1998), the score is included in the low category ($0.00 \leq g < 0.30$), but still shows an increase in student learning outcomes. The low N-Gain value is suspected to be influenced by the limited duration of the implementation of technology-based media and the process of student adaptation. In contrast, the control class obtained an N-Gain value of -0.0518 (-5.18%), which indicates a decrease in student learning outcomes.

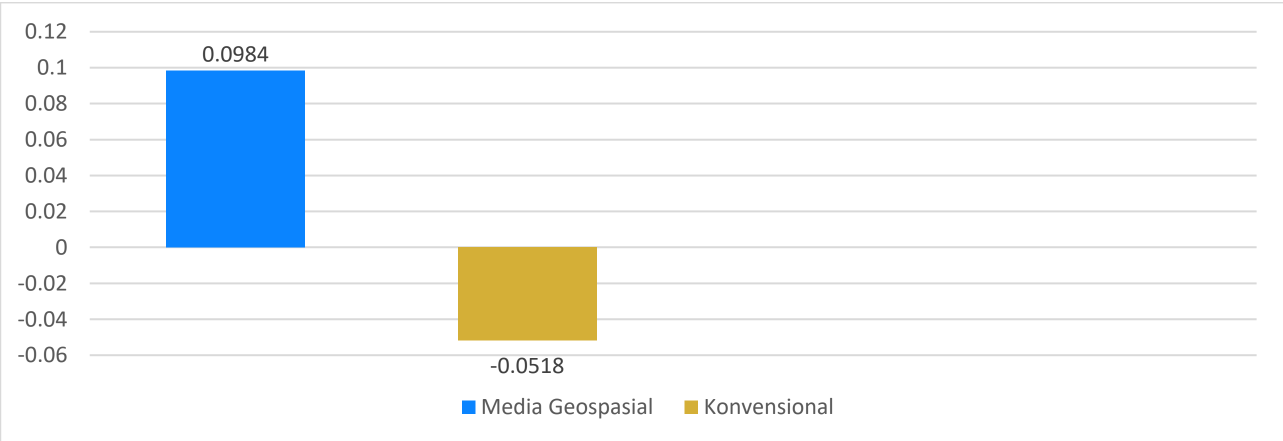

Figure 6. Comparison histogram of Student N-Gain average score

[Bar chart: N-Gain comparison – experimental vs control class]

The low N-Gain category in the experimental class indicates that the improvement has not been practically optimal, although statistically significant differences are shown. This can be due to the limitations of the duration of treatment as well as the characteristics of spatial thinking ability which are high-level cognitive abilities and require continuous practice to develop optimally (Bednarz & Lee, 2019). In addition, the process of student adaptation to the use of geospatial technology also has the potential to affect the effectiveness of early learning.

4.5 Discussion

The results of the analysis showed that there were differences in students' spatial thinking ability before and after the application of geospatial technology-based learning media. These findings show that the use of geospatial technology makes a positive contribution to the development of spatial thinking ability of grade XI students at SMA Negeri 13 Bandar Lampung. The application of this media puts students in direct interaction with spatial representation through digital maps and spatial data visualization, so that geography learning becomes more contextual and meaningful than conventional methods that are verbal and abstract.

This finding is in line with previous research conducted by Khairurraziq (2024) regarding the application of geospatial technology-based learning media in improving the spatial thinking ability of grade XI students at SMA Negeri 5 Sigi; as many as 90% of students stated that it was easier to understand the material when learning was delivered using geospatial technology. Similar research was also conducted by Vallentiza & Wijayanto (2024) which confirmed the effectiveness of techno-geospatial (including Google Earth and Ina Geoportal) in high school students, showing an increase in average posttest score from 37.03 to 73.94 with significance value of 0.001 based on the paired t-test. In addition, research by Kartadireja et al. (2024) found that the use of GIS-based media was able to significantly increase students' spatial intelligence. Research by Wijaya et al. (2023) also shows that the use of Web-GIS as a geography learning medium affects students' spatial thinking ability, especially in understanding spatial relationships, distribution patterns, and analysis of geographical phenomena.

The results of this study show that the use of geospatial technology-based learning media has a real influence on improving students' spatial thinking ability. The independent samples t-test produced a significance value of 0.036 (< 0.05), confirming a significant difference between the two groups. Prior to treatment, both groups had relatively similar initial ability (Sig. pretest = 0.653 > 0.05).

The effectiveness of geospatial technology-based learning media is due to several factors. First, the media presents spatial information visually, dynamically, and contextually according to the characteristics of geographical material that emphasizes spatial aspects (Aulia & Aji, 2024). Second, direct interaction with digital maps and interactive visualizations helps students understand location relationships, distribution patterns, and regional characteristics more concretely. Third, this media encourages active student involvement through spatial data observation and analysis activities, which play an important role in training spatial thinking ability. In contrast, conventional learning methods tend to rely on verbal and textual explanations, so students have to imagine for themselves the forms and spatial relationships between phenomena.

In addition, geospatial technology-based learning media is able to encourage active involvement of students in the learning process. In line with this, Wijayanto stated that the use of technology-based learning media in geography subjects has a high level of urgency because students need to understand material more effectively, actively and enjoyably (Azzukhruf & Suharto, 2025). Thus, the use of geospatial technology-based learning media is more effective than conventional methods because it is more in line with the characteristics of geography learning that emphasizes spatial aspects.

5. CONCLUSION

Based on research conducted on grade XI students of SMA Negeri 13 Bandar Lampung, it can be concluded that the use of learning media based on geospatial technology has a significant influence on students' spatial thinking skills. Learning with geospatial technology such as ArcGIS Online makes the learning process more interactive and helps students understand the concept of space more clearly. The improvement in spatial thinking skills can be seen from the difference in pretest and posttest results between the experimental class and the control class. The experimental class showed high improvement in orientation indicators, spatial analysis, visualization, and map interpretation. Thus, the research hypothesis that states the influence of geospatial technology-based learning media on students' spatial thinking skills is accepted. Overall, geospatial technology has proven to be effective and feasible as an alternative geography learning media because it is able to increase students' understanding of spatial phenomena and their distribution patterns.

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