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Integrating Google Earth in Problem Based Learning to Improve Spatial Thinking Skills of High School Students in Geography Learning

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ABSTRACT

The initial survey showed that high school students had low spatial thinking skills (STS). This quasi-experimental study aimed to examine the effectiveness of Google Earth in enhancing STS, identifying the most developed spatial thinking component, and exploring students' perceptions of its use in geography learning. The study involved two senior high schools in Central Java, with 36 students in the experimental group and 46 students in the control group selected using Slovin's formula and purposive sampling. Data were collected through observation, STS tests, and document analysis, and analyzed using Gain Score, Independent Sample t-test, and descriptive analysis. Results showed that Google Earth significantly improved STS. The experimental group's average score increased from 40.28 (pre-test) to 86.62 (post-test), while the control group improved only from 40.91 to 67.19. The Independent Sample t-test produced a significance value of 0.0001 < 0.05, rejecting H0. Based on gain score criteria, the improvement in the experimental group was categorized as high, while the control group showed a medium improvement. The most developed component was Condition, where students reported that Google Earth's interactive features enhanced their understanding of geographic situations. In conclusion, Google Earth is effective in improving STS and is recommended for geography learning in senior high schools.

Keywords: google earth, spatial thinking skills, learning geography

INTRODUCTION

Geography is a subject studied from elementary school to high school. The scope of geographical studies is very broad, encompassing all human activities, the physical properties of the earth, the interrelationships between the two through a spatial perspective, and fostering a sense of concern for the environment in which we live. The scope of study provides opportunities for humans to find answers to questions about the world around them, with an emphasis on the spatial and ecological dimensions of their existence [1]. The primary objectives of geography learning are to familiarize students with building conceptual insights, developing character values, and preparing them to face challenges by developing spatial thinking skills encompassed in all the basic competencies of the geography subject matter. Spatial thinking should be a central theme in geography education [2], [3]. Furthermore, geography learning can equip high school students with the skills necessary to face the competition and challenges of the Industrial Revolution 4.0 era [4].

Spatial thinking is a way of thinking that encompasses knowledge, skills, and habits in using spatial concepts, representation tools such as maps and graphs, and reasoning processes to organize and solve problems. Spatial thinking is a combination of spatial concepts, representation methods, and reasoning processes. When combined with critical assessment skills, critical spatial thinking is born, namely the ability to evaluate reasoning processes using spatial concepts and representations [5]. Spatial thinking skills introduce learning with maps and spatial information, enabling students to identify spatial patterns and relationships between data related to various study topics [6]. Critical spatial thinking skills in geography are important because they help students access and understand geographic information to understand the complexity of the various spatial problems facing our world today [7]. Geography learning in senior high schools, spatial thinking concepts are already present in the material on maps, remote sensing, and geographic information systems. However, students' spatial thinking skills (KBS) are not optimal. This occurs because, in learning, educators are only oriented to textbooks provided by the government, which still have minimal spatial concepts and are less effective in improving geographic skills, and prioritize only conceptual aspects. The main deficiency in the spatial conceptual aspect is the lack of analytical sharpness that can be used to accept all spatial problems. Students may have various knowledge about a location, but in another location, these students may not be successful in spatial analysis because the knowledge they learn in class is not in the form of KBS but rather spatial knowledge.

The lack of spatial thinking skills (KBS) in students can also be caused by the lack of educators in using learning media based on spatial data in geography learning. Likewise, in assessments, educators have not used appropriate instruments that refer to KBS. Therefore, educators need accurate instruments that can measure students' KBS in detail. Researchers also encountered this condition in high schools in Temanggung Regency. When researchers conducted an initial survey by interviewing geography teachers/educators who are members of the MGMP Geography SMA throughout Temanggung Regency, most still minimally/have not implemented learning that leads to KBS. Textbooks still use textbooks from the government that are still conceptually oriented, learning media is still limited because educators still predominantly use the lecture method, and assessment tools are also not directed towards KBS. Without changes in methods, media, and assessments that lead to spatial skills, students' KBS will not develop. Therefore, efforts are needed to optimize the learning process, one of which is through the use of Google Earth media. This media is expected to make learning more interesting and easier to understand and encourage students to be more active, because Google Earth, as a 3D media, has high appeal and is able to support the learning process effectively [8], [9].

Google Earth is a digital mapping application that displays images of the Earth's surface using high-resolution satellite imagery. This application allows users to virtually explore various locations, perform spatial analysis, and observe changes in regions over time [10]. In the context of geography learning, the application is useful as a medium that provides opportunities for students. Through Google Earth's features, teachers can organize virtual trips to various historical and cultural sites, allowing students to explore and interact with various locations around the world without having to leave the classroom. This activity not only broadens students' geographical insights but also fosters curiosity and an appreciation for cultural and societal diversity [11]. With the help of Google Earth, students can explore various locations in 3D, making learning more realistic and in-depth, while also facilitating their understanding of the geographic context [12]. This application, which utilizes satellite imagery, provides students with the opportunity to virtually explore the Earth's surface with realistic visualizations [13].

However, the use of Google Earth in education is still very limited and is generally only used at the applied theoretical level to analyze various phenomena [14]. Furthermore, the results of the initial survey related to the use of Google Earth in geography learning are still rarely carried out. From the data obtained that out of 17 educators in 17 schools, there are 2 educators (12%) who never used Google Earth, and 15 educators (88%) who rarely used Google Earth in geography learning activities. Furthermore, interview results revealed that educators rarely use Google Earth in geography lessons. Many remain focused on government-provided textbooks, which emphasize cognitive knowledge and give little attention to developing spatial thinking skills (KBS). Appropriate learning tools such as Google Earth that could foster KBS are seldom employed. Students' critical thinking was also not evident during class activities or discussions, and educators rarely used spatial data–based assessment instruments to enhance KBS. Consequently, students' formative evaluation results remain low. Addressing these issues, this study aims to examine the influence of Google Earth on students' spatial thinking abilities in geography learning.

This research offers a distinctive contribution by integrating Google Earth into the Problem Based Learning (PBL) model to enhance spatial thinking skills in high school geography classes. Previous studies have generally examined the effects of Google Earth as a visualization tool or explored PBL as an independent pedagogical approach. However, few have combined the interactive geospatial capabilities of Google Earth with the inquiry-driven structure of PBL to cultivate higher-order spatial reasoning. This integration not only provides authentic, real-world problem contexts but also enables students to analyze, interpret, and evaluate spatial data directly, thereby bridging the gap between technology use and active, problem-centered learning. The study fills a research gap by demonstrating how digital geospatial tools and PBL can synergistically foster students' spatial thinking a core competency for 21st-century geography education.

RESEARCH METHODS

This study applies a quasi-experimental quantitative research method. In this quasi-experimental research, the smallest experimental unit is placed into an experimental group and a control group and is not carried out using a random/non-random assignment system [15]. This study was conducted in two public schools in Temanggung, namely SMAN 1 Temanggung and SMAN 2 Temanggung. Students of SMAN 1 Temanggung were assigned to the experimental group, and students of SMAN 2 Temanggung were assigned to the control group. The research sample was taken from the population using the Slovin formula with the purposive sampling technique. So, the sample from SMAN 1 Temanggung was 28 students, while the number of samples from SMAN 2 Temanggung was 46 students. Research data collection used observation, KBS (Spatial Thinking Ability) Test, and document study. Research data analysis used validity, reliability, normality, homogeneity, N-Gain, and an independent t-test.

The spatial thinking ability measurement refers to the spatial thinking framework developed by Gersmehl and Gersmehl, which encompasses aspects of spatial representation, pattern recognition, spatial reasoning, and geospatial data interpretation. The test instrument is structured according to these components, and each student's KBS score is calculated based on the total score of the test items.

Table 1. Criteria for N-gain Interpretation

N-gain Score (g)	Category
g ≥ 0.70	High
0.30 ≤ g < 0.70	Medium
g < 0.30	Low

RESULT AND DISCUSSION

Data collection in this study was carried out from April to May 2024. The data collection took place in two locations, namely at SMAN 1 Temanggung and at SMAN 2 Temanggung. Samples from students at SMAN 1 Temanggung served as the experimental group, while samples from students at SMAN 2 Temanggung served as the control group. Both sample groups carried out learning with the same material, namely, landslide disaster mitigation. The main material was chosen because the researcher implemented contextual learning, where the Temanggung Regency area, where the students live, has the potential for landslide disasters. Thus, students were more interested and able to understand the problems of landslide disasters that often occur around their homes. Research data were collected from the results of the pretest and posttest. The pretest and posttest questions contained questions that referred to the KBS based on the opinion of Gersmehl and Gersmehl, which consisted of 11 components.

Table 1. Components of Spatial Thinking Ability [16]

Component	Information
Location	Where?
Condition	What's there?
Connection	How is an object related to/connected to other objects?
Comparison	Are there similarities and differences between spaces?
Aura	How does an object influence the objects around it?
Region	Can a part of the Earth's surface be delineated as a region?
Hierarchi	Are there specific levels of spatial aspects?
Transition	Are there transitional phenomena between spaces?
Analogy	Can situations in one space occur in another space due to similar characteristics?
Pattern	How are objects distributed in a space?
Assosiation	Does an object have a special relationship with another object, such that one object can be recognized by the presence of another object?

Each component consists of 2 questions, so there are 22 questions in total. Before the learning activities were carried out, both the experimental and control groups were given a pretest to determine the initial conditions of students in the KBS with the material on landslide natural disaster mitigation. Next, learning activities were carried out where the experimental group used the Problem-Based Learning (PBL) learning method with the Google Earth Application, while the control group used the Project-Based Learning (PjBL) learning method without using the Google Earth Application. After carrying out the learning activities, in the final learning session, students carried out a posttest activity to find out the KBS.

The KBS test used has been validated by three validators to obtain competent expert judgments in the areas of content, learning, and instruments. The assessment results from the three validators were analyzed using the Aiken Index. The validation results show that all items in the KBS instrument are declared very valid. This is because all items in the instrument obtained analysis results > 0.8. Meanwhile, the reliability of the instrument was analyzed using Cronbach's Alpha analysis with the help of Microsoft Excel. Of the total 22 items in the instrument used, there are 20 questions that are reliable, while the other 2 questions are not reliable. The unreliable questions include questions 11 and 15. However, the results of the total reliability analysis using the Cronbach's Alpha value analysis as a whole show that the instrument used in this study is very reliable, because the calculation result of the Cronbach's Alpha value is 0.908.

Next, a Gain Score calculation was performed to determine the differences or improvements in the KBS of students in both the experimental and control groups. The data used in the gain score calculation was the posttest score minus the pretest score. The results of the gain score calculation for the experimental group are shown in Table 2.

Table 2. Improvement in KBS Results of the Experimental Group (Gain Score)

Improvement Criteria	Score Range	Frequency	Percentage (%)
Very Low	0 – 20	1	2.7
Low	21 – 40	10	28
Medium	41 – 60	21	58.3
High	61 – 80	4	11
Very High	81 - 100	-	0
Total		36	100

Based on the improvement criteria, the distribution of students' spatial thinking scores shows that most students (58.3%) fell into the medium category (41–60). A total of 10 students (28%) were in the low category (21–40), while 4 students (11%) achieved a high category score (61–80). Only 1 student (2.7%) was in the very low category (0–20), and no students reached the very high category (81–100). Overall, these results indicate that the majority of students experienced a moderate level of improvement in spatial thinking skills. Meanwhile, the Gain Score results for students in the control group are listed in Table 3.

Table 3. Improvement in KBS Results of the Control Group (Gain Score)

Improvement Criteria	Score Range	Frequency	Percentage (%)
Very Low	0 – 20	13	28.3
Low	21 – 40	25	54.3
Medium	41 – 60	8	17.4
High	61 – 80	-	0
Very High	81 - 100	-	0
Total		46	100

The increase in KBS in the control group students had the highest frequency in the low range, namely 25 students (54%), while the lowest was in the medium range, namely 8 students or 17.4%. Before testing the hypothesis, it is necessary to conduct a data normality and homogeneity test to ensure that the data distribution is normal and homogeneous [17]. Based on the results of the normality test, the significance value of the experimental group is 0.200 and the control group is 0.051. The significance value of both classes is greater than the significance level, which is 0.05. Thus, the normality of the pretest data is met. Likewise, the significance value of the posttest is 0.087 for the experimental group and 0.090 for the control group. The significance value of both groups is greater than the significance level, which is 0.05. This means that the normality of the posttest data is met. The homogeneity test is also fulfilled and gives the result that both groups are homogeneous. The table shows the distribution of students' spatial thinking ability improvement levels after the learning process. The majority of students were in the low category, namely 25 students (54.3%) with a score range of 21–40. Total of 13 students (28.3%) were in the very low category (0–20), while 8 students (17.4%) were in the medium category (41–60). No students reached the high (61–80) or very high (81–100) categories. These findings indicate that conventional learning has not been able to optimally encourage SBA improvement. An important implication is that the implementation of Google Earth integrated with the Problem-Based Learning (PBL) model can be a relevant alternative learning intervention. The integration of geospatial technology with a problem-based approach allows students to directly analyze spatial data, solve contextual problems, and develop spatial thinking skills at a higher level. Thus, the results of this table reinforce the urgency of technology-based learning innovation and PBL to achieve more significant SBA improvements.To prove the effect of Google Earth utilization on students' KBS in this study, the researcher tested the hypothesis with a t-test (independent sample t-test). The process of calculating the t coefficient in this independent sample t-test uses the help of the SPSS program version 27 for Windows.

Table 4. Results of the t-test of KBS Student Gain Score Data

α	P-value	Interpretation	Conclusion
0.05	0.0001	H_0 is rejected and H_1 is accepted	There was a significant difference in KBS improvement between the two classes.

Table 4 shows that the p-value of the independent sample t-test for both groups is 0.0001. This value is smaller than the significance level of 0.05. Thus, there is strong evidence to reject H_0, and H_1 can be accepted. Based on the results of this analysis, the conclusion obtained is that there is a significant difference in students' KBS between the experimental group and the control group. During the learning activities in the experimental group, the researcher utilized Google Earth as a learning medium. The learning method used was Problem-Based Learning (PBL). In answering questions that have been designed to improve KBS, students are allowed to use mobile phones to download and utilize the Google Earth application. Furthermore, the results of the pretest and posttest are known to have an increase in students' KBS. Of the 11 KBS components that experienced a large increase, the condition, comparison, and hierarchy components were the most notable.

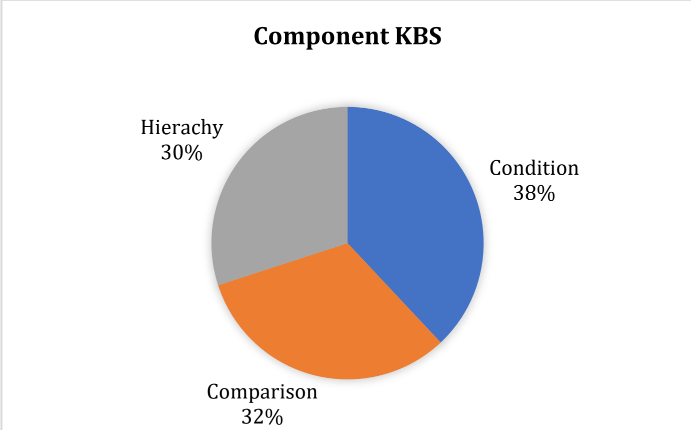

Figure 1. KBS Components that Experienced an Increase

Based on Figure 1, it can be seen that the condition component showed the highest improvement in students' spatial thinking ability (38%), followed by the comparison component (32%) and the hierarchy component (30%). This indicates that the use of Google Earth was most effective in helping students understand the geographic conditions of a region, although improvements in hierarchical and comparative spatial reasoning were relatively lower. The learning activities carried out during the research utilized the Google Earth application as a medium. There were no significant obstacles because Google Earth is easy to download and operate. In addition, Wi-Fi facilities at the school were also available so that educators and students could freely explore all of Google Earth's features. Students were very enthusiastic about completing the Student Worksheet (LKPD) with the help of Google Earth because Google Earth offers visualizations of the earth in the form of satellite images, 3D maps, and other interactive features that allow students to explore various locations virtually. By using this application, students can develop map-reading skills, identify geographical features, and understand the concepts of distance, location, and relationships between places. At the final meeting of the research, educators and students conducted a reflection to determine how students perceive learning using Google Earth as a medium. Educators provided questionnaires for students to fill out. The questions asked about the level of student interest in learning using Google Earth and how students perceived their understanding of the subject matter after learning using Google Earth as a medium.

The results of reflection at the end of the learning stated that 15 students (41.7%) stated that the interactive features in Google Earth made them understand the geographical conditions of an area better. A total of 8 students (22.8%) stated that it was easier to remember locations and geospatial information with Google Earth. A total of 7 students (19%) stated that using Google Earth made the geography material feel more real and relevant, and a total of 6 students (17%) stated that learning with Google Earth made learning more enjoyable.

The use of technology in geography learning is currently increasingly important, especially in improving students' spatial understanding. Google Earth, as one of the geospatial technology-based media, offers various interactive map and earth image visualization features that can support the learning process. This study was conducted to determine the effect of Google Earth utilization on students' KBS. The sample in this study was 36 students at SMAN 1 Temanggung as the experimental group and 46 students at SMAN 2 Temanggung as the control group. In this research process, learning activities in the experimental group used Problem-Based Learning (PBL) learning techniques with Google Earth Application media, while the control group used Project-Based Learning (PjBL) learning techniques without using Google Earth applications. The learning activities of the experimental and control groups began with a pretest, and after the learning process, where the experimental group received treatment in the form of using Google Earth while the control group did not use Google Earth for 6 meetings, at the end of the learning, both groups were given a posttest.

During the learning activities using Google Earth, students were very enthusiastic and active. Using Google Earth is also very easy and practical because all students can easily download Google Earth to their mobile phones and can immediately operate it to work on practice questions in the Student Worksheet (LKPD). The LKPD has been designed using 11 spatial components. The use of Google Earth in learning activities directs students to observe spatial conditions in the Temanggung Regency area, which then allows students to analyze the relationship between spatial conditions and the potential for landslides.

In this study, it was proven that the use of the Google Earth application in geography learning effectively increased students' KBS. In the experimental group, there was a significant increase in the average score of 46.34 from the average pretest score of 40.28 to 86.62 in the posttest. Meanwhile, in the control group, which did not use Google Earth in their learning, the increase in KBS was not as high as the experimental group, namely an increase in the average score of only 26.28 from the average pretest score of 40.91 to 67.19 in the posttest.

Based on the analysis of the independent simple t-test as a tool in hypothesis testing, the results obtained that the p-value of the independent sample t-test for both groups is 0.0001. This value is smaller than the significance level of 0.05, which means that H_0 is rejected and H_1 is accepted. This means that the use of the Google Earth application in geography learning has an effect/effectiveness in improving students' KBS. The use of Google Earth can improve students' KBS in this study, which is in line with the constructivist learning theory (Constructivist Learning Theory), where Google Earth as a learning medium allows students to construct spatial understanding directly through interactive visual exploration. In this study, the use of interactive visual media such as Google Earth can reduce the cognitive load in understanding geographic concepts, making it easier for students to think spatially.

During the study, students utilized Google Earth to solve problems by referring to 11 components of the KBS. There was a significant increase in the pretest and posttest results for each KBS component. The three components with the greatest increase were condition, comparison, and hierarchy. The increase in students' KBS is inseparable from the use of Google Earth, which provides visualizations of the earth in the form of satellite images, 3D maps, and other interactive features that make it easier for students to explore various locations virtually in solving problems in the LKPD and posttest. The interactivity and real-life visualizations provided by Google Earth are considered to help clarify material that was previously difficult to understand only through text or static images in books. Google Earth plays a role in improving students' spatial orientation skills and their ability to interpret geographic information visually. Thus, this media is not only a learning aid but also functions as a cognitive tool that deepens the thinking process [18]. The use of Google Earth media can support the development of students' spatial thinking skills. This is because students are able to analyze an area more realistically, thus gaining their own perspective on the object being studied, observing changes in the area over time, and analyzing the causes, processes, and impacts of a problem. Furthermore, students can compare similar problems in different areas or within the same area over different time periods, ultimately boosting their problem-solving abilities [19]. Google Earth can display satellite imagery in three-dimensional (3D) form, which can stimulate students' brains to respond and store spatial information better [20]. Students' perceptions after learning using Google Earth state that the interactive features in Google Earth help them better understand the geographical conditions of an area, make it easier to remember locations and geospatial information, make geography material feel more real and relevant, and make learning more enjoyable.

CONCLUSION

Based on the results and discussion, it can be concluded that the integration of Google Earth into Problem Based Learning (PBL) is effective in improving the spatial thinking skills of high school students in geography learning. Hypothesis testing using an independent sample t-test obtained a p-value of 0.0001, which is lower than the 0.05 significance level, indicating strong evidence to reject H0 and accept H1. This finding confirms that the integration of Google Earth within the PBL model significantly enhances students' learning outcomes. Among the spatial thinking skill components measured, the condition component showed the greatest improvement with a 24% increase. In addition, students' perceptions revealed that the interactive features of Google Earth within the PBL framework supported a deeper understanding of regional geographic conditions, thereby making the learning process more meaningful, engaging, and aligned with 21st-century learning needs.

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