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THE EFFECT OF THE GUIDED INQUIRY LEARNING MODEL ON SPATIAL THINKING SKILLS VIEWED FROM STUDENTS GEOLITERACY

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Abstrat. The guided inquiry (GI) model is one of the scientific learning models that is student centered and designed to stimulate spatial thinking skills through discovery activities under the guidance and direction of the teacher. In addition to the learning model, geoliteracy is another factor that influences students spatial thinking skills. This study aims to determine the effect of the GI model on spatial thinking skills and to examine the effect of the GI learning model on spatial thinking skills in terms of students geoliteracy. The research method is a quasi experimental design with a post test only design. The population of this study consists of eleventh grade students at SMAN 5 Malang and SMAN 6 Malang, with purposive sampling used to determine the control and experimental classes at each school. Data were collected using a test instrument to obtain spatial thinking ability scores and geoliteracy scores. Data analysis was carried out using independent sample t tests and two way anova. The results show that the GI model can affect the spatial thinking skills possessed by students, even though both experimental classes received the GI model treatment. Further results indicate that the GI model can affect spatial thinking skills in terms of students geoliteracy. However, there is a significant difference in spatial thinking skills based on geoliteracy between students at SMAN 6 Malang and students at SMAN 5 Malang, even though both experimental classes received the GI model treatment.

Keywords: guided inquiry, spatial thinking, students geoliteracy

Introduction

Learning in the 21st century has undergone various changes. These changes are marked by the development of new literacies, such as digital literacy, information literacy, and media literacy (Anugraheni, 2020). 21st century learning focuses on activities aimed at enhancing students skills through learning processes that utilize modern technology (Jannah & Atmojo, 2022). The learning system in the 21st century is no longer teacher centered learning but student centered learning (Mardiyah et al. 2021). The goal of this approach is for students to face increasingly complex 21st century challenges. 21st century students are required to master knowledge, metacognitive skills, critical and creative thinking, as well as communicate and collaborate effectively

(Rahayu, Iskandar, & Abidin, 2022). Thus 21st century competencies are essential for students to support the learning process and adapt to ongoing changes.

Spatial thinking ability is one of the important competencies that students must possess in the 21st century. This ability is needed to solve problems and think critically. Spatial thinking ability is the capacity to understand, manipulate, and mentally visualize objects and space. 21st century education not only demands mastery of information but also skills to solve increasingly complex problems. In facing various 21st century challenges, students with spatial thinking ability have an advantage in addressing intellectual demands. Learning processes that encourage spatial thinking help develop problem solving skills by viewing issues from a spatial perspective. In addition, spatial thinking ability contributes to the development of creativity and innovation, as it enables students to consider various perspectives and generate new solutions for increasingly diverse problems. Thus spatial thinking ability is highly needed by students to meet 21st century challenges.

However spatial thinking ability in Indonesia still faces various challenges and requires special attention in educational development. In general this ability has not received adequate representation in the national curriculum, despite its importance having been recognized in various studies. Many schools still focus on traditional teaching methods that do not optimally support the development of spatial skills. Teachers continue to use conventional methods such as lectures or teacher centered learning (Lathifah 2020). The lack of appropriate learning models aligned with student characteristics and modern developments results in reduced student interest, which affects the ability to think spatially. Given these issues, it can be concluded that improvements in learning quality are needed to enhance students spatial thinking ability in Indonesia.

The Guided Inquiry model is one of the scientific learning models that is student centered and designed to stimulate spatial thinking ability. The GI learning model encourages students to actively engage in the discovery process under the guidance and direction of the teacher (Orosz et al. 2022). In this model, the process begins with posing relevant questions or problems, followed by student investigations to collect and analyze data, and drawing conclusions based on findings (Nurhuwaida et al. 2022). This process encourages students to develop spatial, critical, and creative thinking skills, as well as deepen their understanding of the subject matter (Ranti and Dwi Kurino 2023). In addition, the model emphasizes collaboration and communication among students, which supports team based learning (Pranata 2023). With GI, students become more active and responsible for their learning process, ultimately increasing motivation and independence in learning.

In addition to learning models, geoliteracy is another factor that influences students spatial thinking ability. Geoliteracy is the capacity to understand, interpret, and use geospatial information effectively to make decisions (Husniyah and Prihadi 2022). Students geoliteracy affects their sensitivity to observe phenomena from a spatial perspective. The relationship between geoliteracy and spatial thinking ability is strong because geoliteracy directly involves activities that require visualization and mental manipulation of objects in space. These activities strengthen students spatial thinking skills, helping them mentally visualize and manipulate objects and understand spatial relationships and patterns. Thus it can be concluded that geoliteracy is a factor influencing spatial thinking ability.

Previous studies have explored the effectiveness of the GI model. Siregar (2020) found that GI improved critical thinking and learning outcomes. Asmania (2021) reported that GI enhanced students' creative abilities. Furthermore, Quluk (2022) concluded that GI significantly influenced spatial thinking skills. However, these studies primarily focused on the direct effect of GI on learning outcomes or creative thinking without considering moderator variables that might influence these effects.

This research presents a novelty by introducing geoliteracy as a moderator variable. Geoliteracy—the ability to use geographic understanding to make decisions—is closely linked to spatial thinking as it involves visualizing and manipulating spatial objects. While previous research by Quluk (2022) examined GI and spatial thinking, it did not account for students' geoliteracy levels. This study fills that gap by analyzing whether the effectiveness of the GI model on spatial thinking differs based on students' geoliteracy levels. Therefore, this study aims to determine the effect of the GI model on spatial thinking skills and examine the interaction between the model and students' geoliteracy.

The research problem statements are as follows:

1. Is there an effect of the Guided Inquiry (GI) model on students spatial thinking ability at SMAN 6 Malang?
2. Is there an effect of the Guided Inquiry (GI) model on students spatial thinking ability at SMAN 5 Malang?
3. Is there a difference in the effect of the Guided Inquiry (GI) model on students spatial thinking ability between SMAN 6 Malang and SMAN 5 Malang?
4. Is there an effect of the Guided Inquiry (GI) model on students spatial thinking ability in terms of geoliteracy at SMAN 6 Malang?
5. Is there an effect of the Guided Inquiry (GI) model on students spatial thinking ability in terms of geoliteracy at SMAN 5 Malang?
6. Is there a difference in the effect of the Guided Inquiry (GI) model on students spatial thinking ability in terms of geoliteracy between SMAN 6 Malang and SMAN 5 Malang?

Method

This study employed a quasi-experimental research design with a non-equivalent control group design (pretest-posttest). The population comprised 11th-grade Social Science students at SMAN 5 Malang and SMAN 6 Malang. The sample was selected using purposive sampling based on equivalent academic abilities. At SMAN 5, class XI IPS B was the experimental group and XI IPS A was the control group. Similarly, at SMAN 6, class XI IPS A was the experimental group and XI IPS B was the control group.

Data collection techniques involved tests and questionnaires. The instrument for spatial thinking ability was an essay test developed based on indicators: location, region, map visualization, causality, prediction, and planning. Geoliteracy was measured using a questionnaire covering core content, geographic tools skills, and geographic perspective. Both instruments underwent validity (Product Moment) and reliability (Cronbach's Alpha) testing, resulting in valid and reliable scores (Alpha > 0.6).

Data analysis was performed using SPSS 22. The prerequisite tests included the Kolmogorov-Smirnov test for normality and Levene's test for homogeneity. Hypothesis testing used the Independent Sample t-test and Mann-Whitney U test to determine the effect of the GI model on spatial thinking. Meanwhile, Two-Way ANOVA and the Friedman test were utilized to analyze the interaction between the learning model and geoliteracy levels on spatial thinking skills.

Research Result

The distribution of spatial-thinking ability scores among SMAN 6 Malang students was as follows. In the control class, the most frequent category was medium, with 15 students (58 %). In the experimental class, the most frequent category was high, with 15 students (48 %). The control class's least frequent category was low, whereas the experimental class's least frequent category was medium. At SMAN 5 Malang, in the control class the highest frequency occurred in the high category, with 23 students (68 %), while in the experimental class it was in the very high category, with 17 students (57 %). In both classes the second-lowest frequency fell in the medium category.

Geoliteracy scores at SMAN 6 Malang showed that both control and experimental classes had their highest frequencies in the medium categorycontrol: 14 students (48 %) experimental: 17 students (55 %). The control class's lowest frequency was in the high category (3 students, 10 %), while the experimental class's lowest frequency was in the low category (5 students, 16 %). At SMAN 5 Malang, geoliteracy scores in the control class were most often medium (23 students, 68 %), whereas in the experimental class the highest frequency was high (14 students, 47 %). The control class's smallest frequency was in the high category (5 students, 15 %), and the experimental class's smallest frequency was in the low category (3 students, 10 %). When spatial-thinking ability was examined by geoliteracy level at SMAN 6 Malang, both control and experimental classes most frequently fell into the medium categorycontrol: 14 students (48 %) experimental: 17 students (55 %). The control class's lowest frequency was in the high category (3 students, 10 %), and the experimental class's lowest was in the low category (5 students, 16 %). At SMAN 5 Malang, for both control and experimental groups, the most frequent category was mediumcontrol: 23 students (68 %) experimental: 15 students (50 %)while the smallest frequency in the control class was high (5 students, 15 %) and in the experimental class was low (3 students, 10 %).

Analysis of individual spatial-thinking indicators at SMAN 6 Malang showed that, in the control class, the highest mean score (71.26) belonged to the indicators determining location and visualizing data on a map, whereas the lowest mean score (70.11) applied to identifying regions, analyzing cause-effect, predicting regional conditions, and planning problem prevention. In the experimental class, the highest mean scores (71.26) were recorded for visualizing data on a map, analyzing cause-effect, and planning prevention measures, while the lowest mean score (81.72) was for identifying regions. Overall, the experimental class's average spatial-thinking score exceeded that of the control class. At SMAN 5 Malang, in the control class the highest mean indicator score (80.39) was for identifying regions, and the lowest (76.47) was for visualizing data on a map. In the experimental class, the highest mean scores (92.22) were for predicting regional conditions and determining location, while the lowest mean scores (87.78) were for identifying regions and visualizing data on a map. Again, on average the experimental class outperformed the control class.

Geoliteracy indicator analysis at SMAN 5 Malang showed that, in the control class, core content and geographic perspective had the highest mean scores (73.56), while skill in using geographic tools had the lowest mean score (72.41). In the experimental class at SMAN 6 Malang, geographic perspective had the highest mean (82.26), and both core content and skill using geographic tools shared the lowest mean (79.57). Overall, experimental-class geoliteracy means were higher than control-class means. Further breakdown revealed that at SMAN 5 Malang, core content had the highest control-class mean (81.86) and geographic perspective the lowest (75.49), while at SMAN 6 Malang the experimental class's core content mean was highest (90.00) and geographic perspective lowest (85.56). In all cases, experimental classes geoliteracy averages surpassed those of control classes. Finally, when comparing spatial-thinking ability by geoliteracy level at SMAN 5 Malang, students in the experimental class with low and medium geoliteracy outscored their control-class peers at the high-geoliteracy level, the control class had a higher average than the experimental class. Overall, however, the experimental class achieved higher spatial-thinking scores than the control class. Results of the Hypothesis Test of the Effect of the Guided Inquiry Model on Spatial Thinking Ability

Table 1 Result of the Independent Sample T Test for Spatial Thinking at SMAN 6 Malang

Independent Samples Test								
		t-test for Equality of Means						
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
							Lower	Upper
Spatial Thinking	Equal variances assumed	-4.563	58	0.000	-13.11592	2.87441	-18.86967	-7.36217
	Equal variances not assumed	-4.555	57.202	0.000	-13.11592	2.87932	-18.88122	-7.35062

The results of the independent-samples t test for spatial thinking ability at SMAN 6 Malang (Table 1) show a significance value < 0.05, indicating that the guided inquiry model has an effect on spatial thinking ability at SMAN 6 Malang.

Table 2 Result of the Mann Whitney U Test for Spatial Thinking at SMAN 5 Malang

Test Statistics[a]	
	Spatial Thinking
Mann-Whitney U	183.500
Wilcoxon W	778.500
Z	-4.504
Asymp. Sig. (2-tailed)	0.000

The results of the Mann–Whitney U test for spatial thinking ability at SMAN 5 Malang (Table 2) show a significance value < 0.05, indicating that the guided inquiry model has an effect on spatial thinking ability at SMAN 5 Malang.

Table 3 Result of the Mann Whitney U Test for Spatial Thinking at SMAN 5 Malang and SMAN 6 Malang

Test Statistics[a]	
	Spatial Thinking
Mann-Whitney U	311.000
Wilcoxon W	807.000
Z	-2.305
Asymp. Sig. (2-tailed)	0.021

The results of the Mann–Whitney U test comparing spatial thinking ability at SMAN 6 Malang and SMAN 5 Malang (Table 3) show a significance value < 0.05, indicating that there is a difference in the guided inquiry model's effect on spatial thinking ability between SMAN 6 Malang and SMAN 5 Malang. Results of the Hypothesis Test of the Effect of the Guided Inquiry Model on Spatial Thinking Ability in Terms of Students Geoliteracy

Table 4 Result of the Two Way Anova Test on Spatial Thinking Based on Geoliteracy at SMAN 6

Tests of Between-Subjects Effects					
Dependent Variable: Spatial Thinking					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	9227.739[a]	5	1845.548	188.058	0.000
Intercept	256884.103	1	256884.103	26176.053	0.000
Geoliterasi * Model	236.605	2	118.303	12.055	0.000

The results of the two-way ANOVA on spatial thinking ability at SMAN 6 Malang (Table 4) show a significance value < 0.05, indicating that the guided inquiry model has an effect on students' spatial thinking ability at SMAN 6 Malang when viewed in terms of their geoliteracy.

Table 5 Result of the Friedman Test on Spatial Thinking Based on Geoliteracy at SMAN 5 Malang

Test Statistics[a]	
N	64
Chi-Square	116.230
df	2
Asymp. Sig.	0.000

The results of the Friedman test on spatial thinking ability at SMAN 5 Malang (Table 5) show a significance value < 0.05, indicating that the guided inquiry model has an effect on students' spatial thinking ability at SMAN 6 Malang when viewed in terms of their geoliteracy.

Table 6 Results of the Friedman Test on Spatial Thinking Based on Geoliteracy at SMAN 5 Malang and SMAN 6 Malang

Test Statistics[a]	
N	61
Chi-Square	110.607
df	2

Asymp. Sig.	0.000

The results of the Friedman test on spatial thinking ability viewed from geoliteracy at SMAN 6 Malang and SMAN 5 Malang (Table 6) show a significance value < 0.05, indicating that there is a difference in the guided inquiry model's effect on students' spatial thinking ability between SMAN 6 Malang and SMAN 5 Malang when viewed in terms of their geoliteracy.

Discussion

This discussion section consists of two parts, 1) the effect of the guided inquiry learning model on students spatial thinking ability and 2) the effect of the guided inquiry learning model on students spatial thinking ability in terms of their geoliteracy. The Effect of the Guided Inquiry Learning Model on Students Spatial Thinking Ability

The guided inquiry learning model affects students spatial thinking ability at both SMAN 6 Malang and SMAN 5 Malang. This effect is evidenced by the significance value of the Independent Samples T Test on spatial thinking ability at SMAN 6 Malang (0.00 < 0.05) and by the Mann–Whitney U Test at SMAN 5 Malang (0.00 < 0.05). Moreover, the experimental classes in both schools achieved higher spatial thinking scores than their respective control classes. Therefore, it can be concluded that the guided inquiry learning model leads to higher student spatial thinking ability.

The guided inquiry activities positively influenced the indicator "identifying regions." During the data-collection phase, students investigated digital RBI and topographic maps to identify characteristics of regions in Malang Regency. As a result, they correctly identified that South Malang is a lowland karst region bordering the southern Java Sea; they also recognized that West, East, and North Malang are highland areas featuring volcanic lands—Bromo Tengger Semeru in the east, Kawi and Kelud in the west, and Arjuna in the north. Using maps enabled students to identify land-surface characteristics without fieldwork (Asmororini, Kinda, and Şen 2024; Harknett et al. 2022; Nurdin, Pettalongi, and Mangasing 2021). Map information likewise conveyed real-world geographic conditions (Saily, Maizir, and Yasri 2021).

Guided inquiry also supported the indicator "determining location." In the data-collection phase, students used their map investigations to locate natural resource potentials in Malang Regency. They explained that East, North, and West Malang have forestry, agricultural, and plantation resources because of their fertile volcanic soils and scenic mountain tourism; whereas South Malang offers marine/fisheries resources and coastal tourism. Using maps to gather data develops students spatial thinking skills, particularly in understanding resource distribution patterns based on regional characteristics (Li et al. 2022). Map use helps students link resource potentials with relevant geographic features and environmental contexts (Handayani 2024).

After locating resource potentials, the teacher asked students to plot their distributions on a map, stimulating the "visualizing data on a map" indicator. Students successfully represented resource locations with point and area symbols, having previously investigated map information (Dewi, Handoyo, and Purwanto 2021; Nisa et al. 2021). Their habitual use of maps also trained them to choose clear map symbols for readers (Shi, Tang, and Yin 2020). Beyond identifying regions, students were instructed to identify management and utilization problems for the previously mapped resources by consulting credible articles and news reports. They noted that Malangs forests suffered land-use change to settlements and fields between 2010 and 2020 due to population growth and economic needs. This analysis of cause and effect reflects their ability to link one phenomenon to another using scientific literature (Dewi et al. 2021; Zahroh and Yuliani 2021).

In the hypothesis-testing phase, students analyzed future impacts of resource management in Malang Regency, predicting that ongoing forest loss would increase flood risk and watershed damage. This prediction was based on data showing annual forest-area reduction from large-scale land clearing, demonstrating their ability to anticipate outcomes by recognizing patterns (Mathrani et al. 2021; Susnjak, Ramaswami, and Mathrani 2022). The conclusion-drawing phase fostered the “problem-solving recommendation” indicator. Students proposed reforestation, selective logging andplanting, forest surveillance, and legal enforcement to address forestry management issues. They adapted prevention measures from other regions, citing scientific sources (Irawan et al. 2020), and used these to plan logical solutions for the studied problems (Rambe and Afri 2020).

Despite the guided inquiry treatment in both schools, a significant difference in spatial thinking ability remained between SMAN 6 Malang and SMAN 5 Malang experimental classes, as shown by a Mann–Whitney test significance < 0.05. SMAN 5 Malang students outperformed those at SMAN 6 Malang, indicating that guided inquiry was more effective there. This difference is attributed to unequal access to and use of geospatial technology. SMAN 5 Malang teachers frequently integrate Google Earth, Google Maps, and ArcGIS StoryMaps, which enhance spatial thinking (Del Cerro Velázquez and Méndez 2021; Ismail et al. 2022). In contrast, SMAN 6 Malang relies less on such tools. Moreover, SMAN 5 Malangs teaching is more innovative, often involving outdoor physical activities that develop spatial skills through navigation, exploration, and problem solving (Suryantarini et al. 2023). SMAN 6 Malangs instruction tends to remain classroom-bound, focusing on substantive content. These habits at SMAN 5 Malang boost the effectiveness of guided inquiry for spatial thinking.

Finally, the data-collection phase requires careful planning to create effective learning activities. At SMAN 6 Malang, students limited geospatial technology proficiency necessitates explicit teacher guidance. Therefore, teachers should introduce and integrate spatial technologies into geography lessons to make learning more effective and innovative (Erlangga and Ningrum 2024; Raden Adinda Zalfa, Rizka Putri Ayuning, and Rustini 2023). Such integration helps students become accustomed to and adept with geospatial tools that are valuable in everyday life (Aulia and Aji 2024). The Effect of the Guided Inquiry Learning Model on Students Spatial Thinking Ability in Terms of Their Geoliteracy.

The guided inquiry learning model influences students spatial thinking ability when viewed from their geoliteracy. This effect is evidenced by the Two Way Anova results on spatial thinking ability viewed from geoliteracy at SMAN 6 Malang, which show a significant difference between the control and experimental classes. In addition, the Friedman test on spatial thinking ability viewed from geoliteracy at SMAN 6 Malang also indicates a significant difference between the control and experimental classes. Both schools likewise report higher geoliteracy scores in the experimental classes compared

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to the control classes. Students with higher geoliteracy scores correspondingly achieve higher spatial thinking ability scores, so the greater a students geoliteracy, the higher their spatial thinking ability.

Geoliteracy serves as essential preparation for students to support their spatial thinking within the guided inquiry model. Mastery of geoliteracyparticularly the indicator “use of geographic tools”helps students spatial thinking. Proficiency in geographic tools enables students to identify and determine the distribution of natural resource potentials in Malang Regency during the data collection phase. Students skilled in tools such as digital mapping technologies can accurately identify information to locate natural resource potentials in Malang Regency. This geoliteracy mastery familiarizes students with tools that aid in identifying and locating features, enhancing their spatial thinking during data collection in the guided inquiry model. The use of spatial technology steers students spatial skills in a more advanced direction (Del Cerro Velázquez and Méndez 2021). Moreover, these technologies foster the habit of applying spatial skills in every lesson (Ismail et al. 2022).

Well-developed geoliteracy positively impacts students spatial thinking ability. Core Content in geoliteracy helps students understand phenomena on the earths surface through geographic concepts (De Jager and Arnolds 2022; Kerski 2015). This deepens students capacity to analyze and comprehend space and the relationships between objects or places, including in studies of natural resources (Khrongchuen and Buaraphan 2023). With solid Core Content mastery, students can link resource potentials by examining their relationships with surrounding featuresfor example, recognizing agricultural potential near volcanic mountains in Malang Regency due to the fertile volcanic soils.

Mastery of Geographic Perspective in geoliteracy stimulates students ability to identify problems in spatial thinking. This perspective helps students analyze natural resource issues in Malang Regency by relating them to local conditions or features. Students who command Geographic Perspective can easily depict geospheric phenomena in daily life (Yulianti 2024). Geographic Perspective seeks to explain why processes and phenomena occur where they do, encompassing themes of scale, region, diffusion, pattern, and spatio-temporal relationships, allowing students to describe investigated phenomena with clarity (Oshan et al. 2022).

There is a significant difference in geoliteracy mastery between students at SMAN 6 Malang and SMAN 5 Malang. Students at SMAN 5 Malang demonstrate higher geoliteracy mastery than their peers at SMAN 6 Malang. Factors influencing this disparity include facilities and innovation in instructional methods. At SMAN 5 Malang, students frequently use spatial technologies such as Google Earth, Google Maps, and ArcGIS StoryMaps provided by the school. This exposure helps them identify potentials and distributions of natural resources in Malang Regency. The use of these spatial technologies develops students skills with geographic tools for studying earth phenomena (Del Cerro Velázquez and Méndez 2021). More innovative teaching practices also enhance students analytical thinking and problem-solving approaches (Hindiyati et al. 2023). These differences in geoliteracy mastery can therefore affect the effectiveness of the guided inquiry learning model on students spatial thinking ability.

Conclusion

The guided inquiry learning model influences students spatial thinking ability at SMAN 6 Malang and SMAN 5 Malang, as the experimental classes at both schools achieved higher spatial thinking scores than the control classes. The GI model encourages students to explore spatial thinking through material on the utilization of natural resources in Indonesia. However, there is a significant difference in spatial thinking ability between students at SMAN 6 Malang and those at SMAN 5 Malang, despite both experimental groups receiving the same GI treatment. This difference is attributed to variations in facilities, habits in using geospatial technology, and the conventional teaching methods employed by teachers. Mastery of geoliteracy can stimulate the GI models impact, leading to more developed spatial thinking ability, whereas low geoliteracy can negatively affect students spatial thinking skills. The data collection phase of the guided inquiry model requires careful planning to create effective learning activities, as evidenced by the students at SMAN 6 Malang who lack spatial technology proficiency and therefore need teacher guidance. Consequently, teachers should introduce and integrate spatial technology into geography lessons to make the learning process more effective and innovative, enabling students to adaptively and routinely apply these skills during instruction.

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