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Improving Spatial Thinking Skills Through Problem-Based Hybrid Learning in Social Science Education for Islamic Students

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ABSTRACT

Social science educators in training need strong spatial thinking skills to master geographical concepts, yet evidence shows that undergraduates in Social Science Education often have suboptimal abilities. This study examines the impact of the Problem-Based Hybrid Learning (PBHL) model on spatial reasoning skills of future social science educators. Using a quasi-experimental design, the research compared control and experimental groups through pretest and posttest evaluations. Participants were Physical Geography students at the Social Sciences Education Department, Universitas Islam Negeri Maulana Malik Ibrahim Malang, Indonesia, focusing on Environment and Its Conservation during the 2020/2021 academic year. Purposive sampling selected the experimental class (29 students in class D) receiving PBHL and the control class (29 students in class B) taught with conventional methods. Spatial thinking skills were measured with essay tests of ten items covering comprehension, representation, analysis, spatial interaction, and application. Data were tested for normality and homogeneity, followed by an independent samples t-test. Results showed that PBHL significantly improved students' spatial thinking skills ($p = 0.003 < \alpha = 0.05$). The experimental group achieved a higher average N-Gain (17.95) than the control group (12.62), with the greatest improvement in representation. The findings indicate that analysis and evaluation stages in PBHL are essential for success. Hybrid platforms provide opportunities for reflection, problem-solving, and information exchange. Future research should expand by testing more variables, replicating the model in other institutions, refining learning tools, enhancing lecturers' roles as facilitators, and documenting student activities in PBHL implementation.

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1. Introduction

Social science educators in training must develop strong spatial thinking skills to effectively understand and teach geographical concepts, yet research has revealed gaps in these abilities among Social Science Education undergraduates. Ji et al. (2025) and Xu et al. (2025) reported that more than 60% of students demonstrated only basic spatial reasoning and many failed to accurately interpret spatial patterns or maps in applied tasks. Previous interventions, such as conventional lectures and limited digital mapping exercises, have shown a minimal impact on improving these competencies, leaving future educators underprepared to foster spatial literacy in their classrooms (Duarte et al., 2022; Hickman, 2023; Lee, 2023). Addressing these persistent gaps requires innovative approaches that integrate problem-based and hybrid learning strategies to strengthen spatial reasoning more effectively (Aliman, Ulfi, et al., 2019; Yurt & Tünkler, 2016).

Effective geography education should foster spatial reasoning abilities, enabling students to comprehend geospheric phenomena and their interconnected relationships for proper geographical study (Bednarz et al., 2022). Through spatial thinking skills, students can analyze and relate spatial information (Aliman, 2016; Lamb & Vodicka, 2021) solve problems, and respond to the challenges of the 21st century (Aliman et al., 2018). For instance, learners can assess optimal placements for public infrastructure and urban development plans, evaluate the consequences and advantages of altering land usage, forecast demographic patterns and their environmental interactions, and examine how geographical positioning influences human lifestyle (Aliman, Budijanto, et al., 2019; Amin et al., 2020; Susetyo et al., 2017).

Current evidence indicates suboptimal spatial reasoning abilities among Social Science Education undergraduates. This conclusion stems from preliminary observational data at UIN Maulana Malik Ibrahim Malang, where students' spatial thinking levels were assessed using empirical statistical classification. The results of categorizing data on spatial thinking skills were found to be included in the high category as much as 19.80%, medium 61.39%, and low 18.81%. These findings align with prior research identifying underdeveloped spatial reasoning abilities among university students (Fleming & Mitchell, 2017) including secondary education students (Asiyah et al., 2020; Istifarida et al., 2017; Nofirman, 2018; Oktavianto & Handoyo, 2017) and elementary school students (Maharani & Maryani, 2016; Muraida & Sundari, 2017). This pattern likely arises from (1) limited exposure to spatially demanding tasks in social science curricula, which tend to prioritize verbal or theoretical content, and (2) inadequate instructional emphasis on spatial skill development, such as visualization, mapping, or model-based reasoning, despite their critical role in fostering higher-order cognitive abilities (Müller et al., 2025).

These circumstances position spatial thinking development as a fundamental objective of geography pedagogy for social studies majors. Such cognitive skills equip students with advanced analytical abilities and heightened sensitivity to their spatial environment (Susetyo et al., 2017). If students as social studies teacher candidates misunderstand spatial concepts, this will be fatal for their future understanding of geography. There will be repeated mistakes in understanding geography from the elementary to university level.

The PBHL model offers a viable solution for addressing the challenges of cultivating spatial reasoning abilities. The PBHL model represents an innovative adaptation of PBL, employing a blended delivery approach that combines traditional classroom instruction with digital learning components such as a Learning Management System (LMS) or other web-based learning platforms that support learning. This approach is designed to mitigate the limitations observed in traditional face-to-face PBL implementations, which focus on group discussions facilitated by teachers, using limited learning resources, such as books or modules, and synchronous interactions in the classroom with a fixed schedule that requires physical attendance (Foo et al., 2021; Leavy et al., 2022). Sugiharto et al. (2019) affirmed that hybrid learning (HL) effectively compensates for the shortcomings of conventional (in-person) learning methods (Sugiharto et al., 2019). Key challenges in traditional PBL implementation include students' limited adaptability to collaborative problem-solving approaches, primarily due to a lack of experience with group-based learning methodologies (Brata & Mahatmaharti, 2020; Guido, 2016), thus, they must adjust their learning approach when engaging with PBL (Dubec, 2017; Hidayati et al., 2021); and 2) students experience difficulties during final exams (Lillo, 2023). The conventional PBL approach tends to focus students excessively on problem-solving procedures, potentially compromising their content mastery (Guido, 2016), while teachers or lecturers believe that preparing PBL questions is not easy (Brata & Mahatmaharti, 2020); 3) Existing research (Dubec, 2017) indicates that PBL demands significant temporal investment, particularly for preparatory activities, field-based inquiries, and collaborative discourse sessions, including student presentations (Fatani, 2015; Harizah et al., 2022); and (4) Implementing PBL presents significant planning difficulties for instructors at various educational levels (Dubec, 2017).

As an educational advancement, PBHL merges constructivist pedagogical frameworks with information and communication technologies, aligned with the principles of blended learning (Halverson et al., 2023; Tzuriel, 2021). The approach was purposefully developed to meet contemporary educational needs, specifically to prepare social studies teacher candidates (inherently digital natives) with essential modern competencies (David, 2022). Grounded in experiential learning theory (Kolb, 2015), PBHL facilitates authentic problem solving while integrating digital tools, thereby fostering the 4Cs of 21st century skills such as creativity, communication, collaboration, and critical analysis (Redhana, 2019). This model also resonates with technological pedagogical content knowledge, ensuring that educators effectively leverage technology to enhance geographical and social science learning (Luo & Zou, 2024).

The PBHL model was implemented based on the hypothesis that it effectively enhances spatial reasoning ability. This premise is further supported by the constructivist foundation of the PBHL model, which adapts PBL's approach to having students construct knowledge by solving real-world problems (Debbané et al., 2023; Orozco & Yangco, 2016). It is emphasized that students are able to think analytically, formulate problems, and work together to solve problems (Chaeruman, 2018). Thus, this model highlights the dynamic interplay between environmental stimuli and student responses (Moust et al., 2019). The learning environment presents authentic challenges and scaffold support, prompting learners to engage in investigative inquiry and analytical problem-solving. This interactive process demands advanced critical reasoning to foster spatial cognitive development (Manek et al., 2019; Susetyo et al., 2017).

Numerous studies have explored the integration of PBL with blended and hybrid learning approaches. The research conducted by Aeni et al. (2017) provided empirical evidence that problem-based blended learning significantly improves students' academic achievement (Aeni et al., 2017). These findings align with the Dewi study, which established that integrating PBL with blended learning enhances comprehensive learning outcomes across cognitive, affective, and psychomotor domains (Pratimi, 2024). Building on these findings, Alfi et al. study reveals a significant correlation between problem-based geography instruction that incorporates blended learning and the development of students' critical thinking abilities (Alfi et al., 2016). The hybrid problem-based learning (H-PBL) approach effectively fosters multiple scientific competencies while creating a more engaging, stimulating, and enjoyable learning experience (Montafej et al., 2022). Blended learning and PBL applications using websites are appropriate for teaching tutorials in student classes (Lestaringsih, 2017). Salari et al. conduct) comparison of pure PBL (PPBL) with hybrid PBL (HPBL), showing that the HPBL strategy is more effective than the PPBL strategy in learning (Salari et al., 2018). The results of these previous studies reinforce the empirical evidence regarding the superiority of the PBHL model in its effect on learning.

The current literature lacks specific investigations into how PBL-hybrid learning combinations affect spatial cognition development in social studies teacher candidates. This study addresses this gap by offering novel contributions through its focus on the contextual characteristics of geographic materials and the enhanced PBHL framework featuring an added actualization component.

Building upon this theoretical framework, this study hypothesizes that implementing PBHL in geography education for social studies teacher candidates enhances critical thinking abilities. The hybrid problem-based approach, integrating both face-to-face and online modalities, is proposed to optimize learning effectiveness using web learning. This study specifically investigated how the PBHL model influences the cultivation of spatial thinking abilities in geographic pedagogy for preservice social studies teachers.

2. Method

2.1. Research design

This study employed a quasi-experimental methodology utilizing a pretest-posttest control group design to assess the effects of the intervention (Table 1).

Table 1. Pretest-posttest control group design

Group	Pretest	Treatment	Posttest
Experiment	O_1	X	O_2
Control	O_3	-	O_4

Source: Sugiyono (2016)

Description:

O1	:	Baseline spatial reasoning evaluation conducted prior to PBHL implementation
O2	:	Spatial reasoning assessment administered following PBHL implementation
X	:	Experimental condition featuring the PBHL pedagogical approach
O3	:	Baseline assessment conducted in the comparison group preceding traditional learning
O4	:	Final spatial reasoning measurement collected from control condition participants
-	:	The control condition received traditional fully online instruction, consisting of standard lectures and digital discussions.

The PBHL model integrates three learning modalities: face-to-face PBL sessions, online PBL components, and field-based environmental investigation. This tripartite approach enabled students to identify ecological issues, develop solutions, and implement practical environmental conservation actions. The PBHL model integrates three learning modalities: face-to-face PBL sessions, online PBL components, and field-based environmental investigations across five structured meetings (50 minutes each). The traditional model is also the same with a duration of five meetings, and each meeting has a duration of 50 minutes.

The PBHL instructional framework adapts Amin et al. 'sresearch-based syntax to guide this multidimensional learning process (Table 2) (Amin et al., 2022). The control group received traditional online discussion-based instruction. Pretests established baseline spatial thinking abilities for both groups, while posttests measured the intervention effects. Gain scores (posttest-pretest differences) were computed and analyzed to compare the efficacy of PBHL and conventional models.

Table 2. PBHL model syntax

Stage	Activity	Description
Problem orientation	The intervention initiates with didactic orientation to spatially-relevant problem scenarios in students' immediate surroundings.	Face to face & field
Problem-solving planning	Participants collaboratively categorize and analyze problem components through structured group work. Subsequently, they engage in systematic problem comprehension and develop solution frameworks through planned investigative processes.	Online
Observation and investigation	Learners conduct systematic observations and investigative procedures to address identified problems. They utilize researcher-provided worksheets containing problem-solving tasks, accompanied by documentary photographs of relevant activities, which are distributed by instructional staff.	Online & field
Preparation and presentation of results	Participants synthesize their investigative findings into comprehensive problem-solving reports, subsequently presenting and articulating their results through structured classroom presentations to demonstrate knowledge integration.	Online
Analysis and Evaluation	Students carry out an analysis of the process of solving problems and determine the solutions to problems that will be used.	Online
Actualization	Students take action in the field to actualize the solution to the problem that has been chosen.	Online & field

Source: Amin et al. (2022)

2.2. Partisipants

The study population comprised undergraduate students enrolled in the Physical Geography course (Environmental Studies module) within the Social Sciences Education Department at Universitas Islam Negeri Maulana Malik Ibrahim Malang, Indonesia, during the second semester of the 2020/2021 academic year. Using purposive sampling criteria, participants were selected based on cognitive homogeneity, as operationalized through midterm examination (UTS) performance metrics from the same academic period.

The experimental group (Class D, n=29) received PBHL, while the control group (Class B, n=29) received standard fully online instruction consisting of lectures and discussions. Group allocation was based on the midterm examination results.

2.3. Instrument and data collection

The study employed a item constructed response test to evaluate students' spatial thinking abilities. An essay-based assessment was developed using Huynh's framework of spatial thinking skill indicators, specifically measuring (1) comprehensive, (2) representation, (3) analysis, (4) spatial interaction, and (5) application (Huynh, 2010). The spatial cognition assessment tool was subjected to comprehensive validity verification prior to implementation. The validation process utilized Pearson's r correlation analysis, with the correlation coefficient computed according to a conventional parametric formula (Walker, 2017).

$$r = \frac{n\sum xy - \sum x \sum y}{\sqrt{[n(\sum x^2) - (\sum x)^2]\,[n(\sum y^2) - (\sum y)^2]}}$$

where r is the correlation coefficient, n is the total number of respondents, ∑xy is the number of times the variable x and variable y are equal, ∑x is the summation of individual item scores, ∑y is the total of all assessment scores, ∑x2 is the sum of squared x-values, and ∑y2 is the sum of squared y-values.

The instrument's validity was established through a statistical comparison of the computed correlation coefficient (r-count) against the critical threshold value (r_table) at an $\alpha = 5\%$ significance level. If rcount is greater than rtable, the instrument is considered valid; otherwise, it is deemed invalid (Sugiyono, 2016). Empirical validation involving 35 student participants established the instrument's validity for measuring spatial thinking skills, with the complete statistical results presented in Table 3.

Table 3. The results of the validity test of the spatial thinking skill instrument

Item	r count	r Table	Description
1	0.434	0.430**	Valid
2	0.922	0.430**	Valid
3	0.750	0.430**	Valid

Item	r count	r Table	Description
4	0.408	0.334*	Valid
5	0.472	0.430**	Valid
6	0.732	0.430**	Valid
7	0.520	0.430**	Valid
8	0.432	0.430**	Valid
9	0.717	0.430**	Valid
10	0.426	0.334*	Valid

*Significance of 0,05, ** Significance of 0,01

Source: Analysis Results

In addition, the instrument was tested for reliability using Cronbach's alpha. The use of Cronbach's alpha is based on the suitability of the method for instruments with more than one correct answer (Vaske et al., 2017), for example, instruments in the form of essays or questionnaires (Yusup, 2018). Cronbach's alpha was calculated using the following formula:

$$r_i = \frac{k}{k-1}\left\{1 - \frac{\sum s_i^2}{s_t^2}\right\}$$

where k is the number of items, $\sum s_i^2$ is the total variance score for each item, and s_t^2 is the total variance.

The reliability of the instrument was categorized into five levels ranging from very high to very low, with corresponding reliability coefficients of 0.80–1.00 for very high reliability, 0.60–0.79 for high reliability, 0.40–0.59 for moderate reliability, 0.20–0.39 for low reliability, and 0.00–0.19 for very low reliability (Arikunto, 2019). The study established a minimum reliability threshold of $\alpha > 0.60$ for instrument acceptance. The psychometric evaluation of the spatial thinking skills assessment, conducted with a sample of 35 participants, demonstrated satisfactory internal consistency. Table 4 presents the complete reliability statistics.

Table 4. The results of the reliability test of the spatial thinking skill instrument

Cronbach's Alpha	N of Items
0,780	10

Source: Analysis Results

2.4. Data analysis

Normality (Kolmogorov-Smirnov test), homogeneity, and independent t-test analyses were conducted on all spatial thinking measures (Gio & Irawan, 2016). Normality was confirmed when the p-value (≥ 0.05) exceeded an alpha level of 5% (Purnomo, 2016). Variance homogeneity was evaluated using Levene's test of equality (Abdillah et al., 2025). A p-value above the 0.05 significance level indicated acceptable variance homogeneity (Purnomo, 2016). The efficacy of the PBHL intervention in enhancing spatial cognition was evaluated through between-group comparisons using an independent sample t-test (Gio & Irawan, 2016). Statistical significance was determined by evaluating whether t-test p-values reached the predetermined α level of 0.05, with $p \geq \alpha$ resulting in null hypothesis (Ho) retention and alternative hypothesis (Ha) rejection (Sugiyono, 2016).

The hypothesis in this study can be seen as follows.

Ho: Implementation of the PBHL model produces no statistically significant change in spatial reasoning. abilities among social studies education candidates.

Ha: significant difference exists in spatial thinking skills following PBHL intervention compared to baseline measures.

All statistical analyses in this investigation were performed using IBM SPSS Statistics 23.0 for Windows to ensure computational efficiency and analytical precision. A significance level of 5 % %was used for all analyses.

3. Results and discussion

Students' spatial thinking abilities were quantitatively represented using pretest and posttest performance data. Descriptive statistics, including the mean values, score ranges, and variability measures, are summarized in Table 5.

Table 5. Spatial thinking skill data

Group		N	Average (Mean)	Minimum	Maximum	Standard Deviation
Experiment	Pretest	29	66.40	46.00	82.00	9.85
	Posttest	29	84.35	67.00	100.00	6.66
	Gain	29	17.95	5.00	34.00	7.37
Control	Pretest	29	64.19	40.00	75.00	8.67
	Posttest	29	76.81	63.00	90.00	7.27
	Gain	29	12.62	5.00	23.00	4.75

Source: Analysis Results

As presented in Table 5, the experimental class demonstrated superior performance to the control group in both assessments, with mean pretest scores of 66.40 versus 64.19 and posttest averages of 84.35 compared with 76.81, respectively. Furthermore, the average value of the increase (gain) for the experimental class was 17.95, which was higher than that for the control class (12.62). The conclusion based on these data is that 1) spatial thinking skills in both class groups have increased, and 2) the increased spatial thinking skill in the experimental class is greater than that in the control class, with a difference of 5.33. The percentages per indicator are shown in Figure 1.

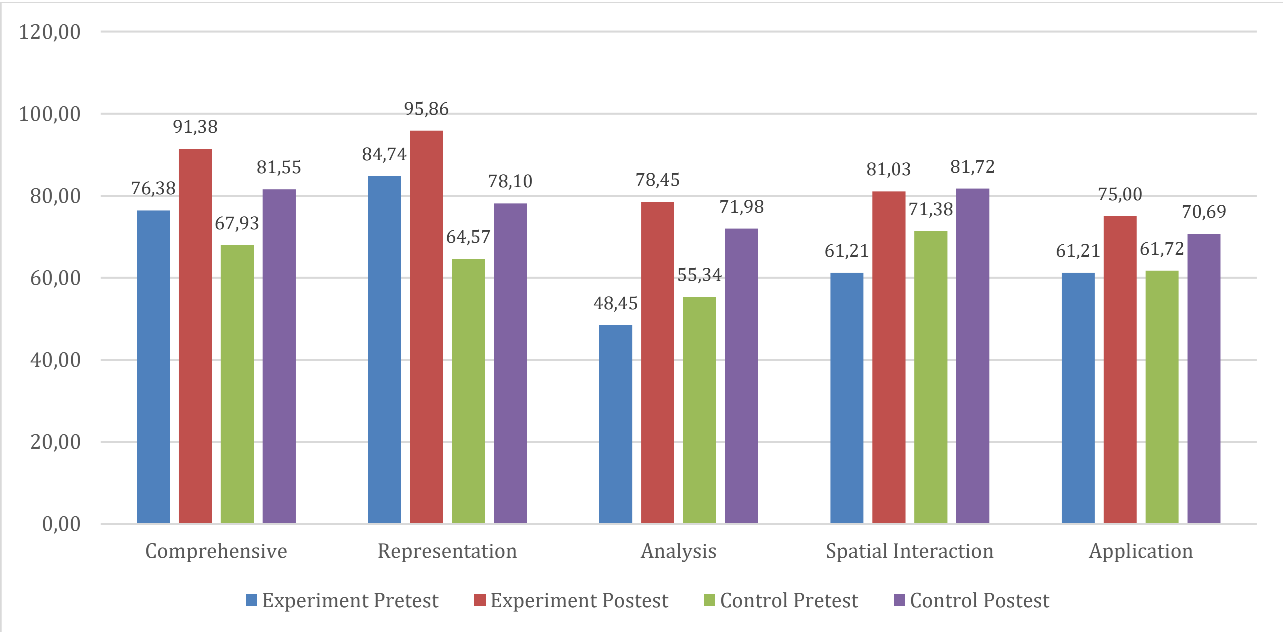

Figure 1. Percentage of Data Description by Indicator
Source: Analyzed Result

Based on Figure 1, the Representation indicator consistently ranked the highest in both the pretest and posttest in both groups. In the experimental class, the average value of this indicator reached 84.74 in the pretest and increased to 95.86 in the posttest, making it the indicator with the highest absolute score among all the aspects measured. Similarly, in the control class, although the value was lower, the Representation indicator remained superior, with an average of 64.57 on the pretest and 78.10 on the posttest.

The high value of the representation indicator in the PBHL model can be explained by the unique characteristics of this learning model, which naturally develop students' representation skills. PBHL integrates a problem-based approach with hybrid learning, creating conditions in which students must continuously express their ideas and solutions through various forms of representation (Awuja et al., 2025; Wagino et al., 2024). In the process of solving authentic problems, students are automatically encouraged to transform their understanding into visual forms, such as diagrams, graphs, or models, as well as verbal representations through oral and written explanations.

Based on Setiani et al. (2025) and Mulenga and Shilongo (2025), the flexibility of the hybrid system further reinforces this aspect, as learners have access to digital tools that facilitate the creation of multimedia representations, as well as the opportunity to discuss and revise their representations based on feedback. The collaborative environment in PBHL also plays an important role in learning from the representations created by peers, thereby enriching their repertoire of ways to present information (Kučera & Haffner, 2025). In addition, the iterative nature of problem-based learning forces learners to continuously refine and sharpen their representations as their understanding of the problem deepens.

This study employed experimental data analysis to evaluate the impact of the PBHL model on spatial reasoning development. All datasets underwent mandatory preliminary verification, including normality distribution and variance homogeneity testing, before primary comparative analyses between the intervention and control conditions were conducted.

The spatial thinking skill data underwent normality testing before conducting the hypothesis tests; the outcomes are displayed in Table 6.

Table 6. Results of the data normality test for spatial thinking skills

Group	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistics	df	Sig.	Statistics	df	Sig.
Experiment	0.094	29	0.200	0.975	29	0.708
Control	0.116	29	0.200	0.965	29	0.440

Source: Analysis Results

Normality tests confirmed that the data from both the experimental and control groups followed a normal distribution, as all p-values were above the significance level of 0.05. For the experimental group, the Kolmogorov-Smirnov test yielded a p-value of 0.200, and the Shapiro-Wilk test showed a p-value of 0.708, while the control group produced p-values of 0.200 and 0.440 for the respective tests. These results indicate that the spatial thinking skills data met the normality assumption required for further parametric statistical analyses.

Then, the homogeneity of variance in spatial thinking skill data was assessed using Levene's test, and the results are presented in Table 7.

Table 7. Results of the homogeneity test of spatial thinking skill data

Levene Statistic	df1	df2	Sig.
4.545	1	56	0.037

Source: Analysis Results

Levene's test results ($p = 0.037$) indicated that the two groups did not have equal variances in spatial thinking performance.

An independent samples t-test (assuming unequal variances) was performed to compare spatial thinking skills between groups, as the data met normality assumptions but showed unequal variances. Detailed statistical outcomes are provided in Table 8.

Table 8. Independent sample t-test results (equal variances not assumed)

		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 skill	Equal variances not assumed	3.097	46.953	.003	5.00000	1.61442	1.75213	8.24787

Source: Analysis Results

Analysis using the independent samples t-test with unequal variance assumption yielded a significant result ($p = 0.003$), prompting the rejection of Ho and acceptance of Ha. This finding confirms the substantial positive impact of the PBHL model on the development of spatial thinking skills.

The findings demonstrate that the PBHL instructional model significantly enhances spatial thinking abilities of social studies preservice teachers. These results align with those of prior research by Susetyo et al. (2017), who investigated the impact of Outdoor Adventure Education-based Problem-Based Learning on geographic spatial intelligence. The results of the study show that outdoor-based PBL has an effect on spatial thinking intelligence. Spatial intelligence is also related to geography and environmental ethics. Therefore, it is necessary to develop more comprehensive environmental geography and ethics skills for learning. The difference with this study is that the research conducted by Susetyo et al. (2017) was only carried out face-to-face outside the classroom (outdoors) without online learning.

Charcharos et al. (2016) conducted an experimental study to determine the relationship between spatial thinking and problem-solving (Charcharos et al., 2016). The research was conducted on young subjects (13-19 years) and young adults (20-25 years). The results show that spatial thinking has a significant effect on problem-solving. This further explains that it is very important to equip students with skills that help them overcome complex problems. Establishing a relationship between spatial thinking and problem solving leads to the possibility that spatial thinking is useful for promoting an advanced understanding of everyday problems. In addition, it provides a foundation for improving skills, spatial thinking, and problem-solving. This study differs from Charcharos's research, which solely examined the correlation between spatial thinking skills and problem-solving abilities using multiple regression analysis without implementing any instructional model intervention (Charcharos et al., 2016).

Another research is conducted by Hsu regarding learning projects using the Green Map database in solving PBL problems (Hsu, 2024). The results recommend PBL as an alternative means of improving spatial thinking. This is based on the fact that PBL can overcome spatial literacy gaps. The research conducted by Hsu used GIS media in PBL learning (Hsu, 2024). This finding is similar to that of Istifarida et al. (2017). on developing a PBL-GIS-based e-book to improve spatial thinking skills. The incorporation of GIS technology in this research enabled students to engage in both online and traditional face-to-face learning modalities. These two studies align with PBHL model research based on PBL in improving spatial thinking skills. The difference lies in the media used for the learning.

Implementing the PBHL model in learning physical geography from environmental material and its conservation can improve students' spatial thinking skills. Students identified environmental problems. The spatial analysis of environmental issues enables students to identify root causes while enhancing their critical reasoning skills for solution development. This approach is theoretically grounded in the National Research Council's model of spatial thinking, which synthesizes spatial knowledge, visualizations, and deductive processes into a unified cognitive framework (Kolvoord, 2024). Through spatial reasoning, students systematically combine abstract concepts with visual data, engaging in analytical processing, conjecturing, generalizing, and evaluative thinking to resolve spatial challenges (Jo, 2018). Spatial understanding serves as a cognitive tool for analyzing difficulties, generating answers, and creating resolutions in daily contexts (Charcharos et al., 2016).

Spatial thinking competencies that promote spatial cognition are fundamental to geography learning, enabling students to become more perceptive of their surroundings (Hartono, 2015). Following the identification of solutions to local environmental issues, students were guided to implement practical conservation initiatives in their communities. The process of spatial analysis in finding solutions will foster the sensitivity of each student to protect the environment. Through spatial thinking skills in PBHL learning, students can solve environmental problems (J. Lee & Jo, 2022) and have better academic performance and sensitivity to the potential of the surrounding environment (Susetyo et al., 2017).

The success of the PBHL model is inseparable from that of the PBL platform. PBL is learning that can facilitate the development of students' thinking potential, particularly spatial thinking (Amin et al., 2020; Susetyo et al., 2017). PBL allows students to develop a scientific attitude by empowering their thinking (Musalamani et al., 2021). The real problems presented in learning encourage students' thinking power while developing control over their cognitive processes (Hasan & Syatriandi, 2018). Students are trained to understand clearly and definitely what problems they face and then know the extent of the knowledge capital they have obtained to solve their problems (Sugiharto, 2019).

The PBHL model's influence on spatial thinking skills was also affected by the learning stages or phases included in the model. During the investigative data collection phase, which takes place through online activities and fieldwork, students are guided to develop solutions for environmental problems (Mustajab et al., 2020; Sari et al., 2021). Students require spatial thinking skills to understand environmental problems in a space (location), which is a source of problems (Aliman, Ulfi, et al., 2019; Hadi, 2019). Through this investigation, it was found that students have contextual learning experiences in solving problems (Putra & Purwasih, 2015; Yew & Goh, 2016). Students can adapt their knowledge with practice in the field to make problem-solving easier (Cranton, 2023). The use of both online and field-based systems in this phase provided students with ample time to engage in the investigation process. In comparison, the control class demonstrated a smaller improvement in outcomes than did the experimental class. While there was some enhancement in spatial thinking skills within the control class, the increase was relatively limited. This difference is due to variations in instructional approaches, as the control class applies a conventional model that relies solely on online discussions and question-and-answer sessions. The students in the control class identified environmental problems online in several countries. Online data makes students unable to identify directly in the field (contextual), so reasoning in the problem-solving process cannot be maximized (Bustami et al., 2018).

Furthermore, the actualization phase of the PBHL model as a differentiator from other models is the strength of this model for improving spatial thinking skills. Students engage in real-world actions to address problems encountered in the field. This form of actualization is intended to bring the problem-solving process to life, allowing students to learn directly from their experiences throughout the learning activities. In the control class, students only made presentations on solving environmental problems in several countries, so they could not actualize the problem-solving process. This makes cognitive abilities only short memory, which will affect memory for limited subject matter, so the results of the spatial thinking skills of the control class were lower than those of the experimental class. According to Dale (Davis & Summers, 2015; S. J. Lee & Reeves, 2018) direct learning can increase student memory by up to 90%. Through direct learning, students experience meaningful learning (von Fircks, 2025) to help them understand and solve problems (Freyn et al., 2021; Sumarmi et al., 2020). This will encourage students' higher-order thinking to increase, which impacts their spatial thinking skills.

Based on the Geography for Life: The National Geography Standards 1994, Geography Education Standards Project, geographic spatial skills are related to the ability to explore the environment and improve spatial thinking skills (Beriguete Alcántara et al., 2024). Students recognize environmental conditions, potential human resources, potential threats, the physical potential of natural resources, vulnerability, and disaster risks (Aliman, Budijanto, et al., 2019).

Spatial thinking allows students to view space as a representation of the real world, enabling them to formulate problems, seek solutions, and analyze and assess the problem-solving process within a specific context. This real-world representation is illustrated through the use of maps, graphs, sketches, and images, which help identify, explain, and convey relevant information (Goel et al., 2023).

Spatial thinking correlates with high-level reasoning skills, such as evaluating, synthesizing, and generalizing (J. Lee & Jo, 2022), enabling students to address challenges encountered in their daily lives (Khani, 2025). Higher-order thinking skills are reinforced by curiosity, which serves as the foundation for scientific attitudes (Sugiharto, 2019). Curiosity is further fostered by the real problems in learning geography found in the environment around students. The inclusion of problems in the learning process is crucial to advancing subsequent learning and fostering the development of students' cognitive abilities. Problems have the potential to spark curiosity, stimulate inquiry, and promote deep and meaningful thinking (Hidayah et al., 2021).

The efficacy of the PBHL model in geographic education stems not only from its Problem-Based Learning foundation, but also from its strategic incorporation of digital learning within a blended instructional approach. These findings corroborate existing studies that demonstrate that web-mediated PBL environments promote extended cognitive processing and reflective practice, thereby facilitating the cultivation of advanced cognitive abilities (Kibret et al., 2021). PBL can increase student learning initiatives and improve thinking skills (Peranginangin, 2025). Likewise, Gholami et al. (2016) concluded that PBL can enhance higher-order thinking skills, which are a component of spatial thinking abilities (Gholami et al., 2016).

When lectures are held online, students communicate in writing to complete assignments that must be uploaded or through online discussion mechanisms, both synchronously and asynchronously (de Jong et al., 2018). Completing assignments and discussion online requires intelligent and effective communication. The evaluation of thinking processes will occur continuously in a communicative atmosphere when searching for information about space (location) online. Students can exchange spatial information to solve environmental problems, whereas lecturers can provide input to facilitate the problem-solving process.

Although effective in improving representation and analysis skills, the PBHL model has several weaknesses that must be considered. One of the main challenges is the varying levels of readiness among the students. Not all students are able to learn independently, especially in a hybrid environment that combines online and offline learning. Some students may struggle with time management or lack motivation when there is no direct supervision from educators (Ates & Aktamis, 2024; Mineshima-Lowe et al., 2024). Additionally, a high cognitive load may occur because PBHL requires students to simultaneously understand complex problems, seek solutions, and master digital learning technologies. This has the potential to cause mental fatigue, especially for students who are not yet accustomed to a student-centered learning approach (Fitria et al., 2024).

Another weakness is the dependence on technological infrastructure. Hybrid learning requires stable Internet access, adequate devices, and mastery of digital platforms. In areas with limited connectivity, or for students from low-income backgrounds, this can widen the learning gap (Agoestanto et al., 2024; Pimdee et al., 2024). Mursali et al. (2025) revealed that assessing learning outcomes in hybrid learning tends to be more subjective because it is project-based and discussion-driven, making it challenging for educators to conduct standardized evaluations. The final challenge is teacher preparation, as PBHL requires educators who not only master the subject matter, but are also capable of designing authentic problems, facilitating hybrid discussions, and effectively integrating technology.

4. Conclusion

T-test results confirmed PBHL's significant positive influence on spatial skills development, with the experimental group outperforming conventional online learners ($p < .05$). The higher average score in the PBHL group is attributed to the reasoning involved in solving real-world problems, students' scientific attitudes during investigations, structured learning phases, and the hybrid learning platform that allows ample time for reflection, deep thinking, and information exchange in problem solving.

Although this study has proven the effectiveness of the PBHL model, it has limitations in terms of the scope of the study, which is focused on only one Islamic university; therefore, the findings cannot necessarily be generalized to other contexts. In addition, a long implementation period risks academic fatigue among students and requires a large allocation of resources. Based on these findings, further research is recommended to test additional dependent variables (communication skills, scientific writing, and learning outcomes) and expand the study to other Islamic universities to strengthen external validity, accompanied by the development of learning tools such as student worksheets and more comprehensive measurement instruments. Institutions should facilitate the socialization of the PBHL model for lecturers, while lecturers are expected to prepare learning tools thoroughly before implementation, maintain face-to-face interaction, especially during the presentation of results, facilitate active student participation, and act as facilitators and motivators through field visits supported by documentation of student activities in the form of visual evidence as part of the learning evaluation.

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