



Trends in the Effectiveness of Instructional Models in Enhancing Spatial Thinking Skills in Geography Education: A Systematic Literature Review

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Article History:

Received: May 30, 2026

Revised: Jun 10, 2026

Accepted: Oct 15, 2026

Online First: Oct 28, 2026

Keywords:

Geography Education,
Problem-Based Learning,
Learning Models,
Spatial Thinking,
Systematic Literature
Review.

Kata Kunci:

Berpikir Spasial,
Model Pembelajaran,
Pendidikan Geografi,
Problem-Based Learning,
Systematic Literature Review.

How to cite:

Syafira, R. O., Hadi, B. S., & Astutik, S. (2026). Trends in the Effectiveness of Instructional Models in Enhancing Spatial Thinking Skills in Geography Education: A Systematic Literature Review. *Edunesia : Jurnal Ilmiah Pendidikan*, 7(3), 2133-2152.

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Abstract: This study synthesized evidence on instructional models for students' spatial thinking in geography education and mapped publication patterns from 2021 to 2026. Following PRISMA 2020, a Systematic Literature Review included 15 empirical studies retrieved from Google Scholar, Garuda, and Crossref. Data were extracted using a review matrix and synthesized qualitatively; effect sizes were calculated when possible, but no meta-analysis was conducted. All ten controlled studies reported higher spatial-thinking scores in experimental groups ($p \leq .001$); Cohen's d ranged from 0.77 to 1.85 in eight calculable studies. Five classroom action research studies reported gains across cycles. Problem-Based Learning was most frequently studied (five studies), followed by Project-Based Learning and Discovery Learning (four each). Seven studies used digital geospatial tools, but their effect sizes were not consistently larger than those in other studies. Publications peaked in 2022; no eligible 2026 study was identified. Given varied designs and measures, no model was established as superior; findings offer a cautious basis for instructional planning.

Abstrak: Penelitian ini menyintesis bukti mengenai model pembelajaran untuk mengembangkan kemampuan berpikir spasial dalam pendidikan geografi dan memetakan publikasi periode 2021–2026. SLR dilakukan mengikuti panduan PRISMA 2020 terhadap 15 studi empiris dari Google Scholar, Garuda, dan Crossref. Data diekstraksi melalui matriks telaah dan disintesis secara kualitatif; ukuran efek dihitung jika memungkinkan, tanpa meta-analisis. Kualitas metodologis dinilai menggunakan lima kriteria. Hasil dibandingkan berdasarkan model, media, indikator, serta statistik yang tersedia. Sepuluh studi dengan kelompok pembandingan melaporkan skor lebih tinggi pada kelompok eksperimen ($p \leq 0,001$); Cohen's d berkisar 0,77–1,85 pada delapan studi yang dapat dihitung. Lima penelitian tindakan kelas melaporkan peningkatan antarsiklus. PBL paling sering diteliti (lima studi), sedangkan PjBL dan Discovery Learning masing-masing empat. Tujuh studi menggunakan teknologi geospasial digital, tetapi ukuran efeknya tidak selalu lebih besar daripada studi lainnya. Publikasi memuncak pada 2022; tidak ada studi tahun 2026 yang memenuhi kriteria. Karena desain dan instrumen beragam, tidak ada model yang dapat dinyatakan paling unggul.

A. Introduction

Geography education helps students understand spatial phenomena and respond to issues such as climate change, urbanization, environmental degradation, and natural disasters. Addressing these issues requires spatial thinking, which the [National Research Council](#) (2006) defines through spatial concepts, tools of representation, and processes of reasoning. In geography learning, spatial thinking supports the analysis of location, distribution, patterns, and relationships among phenomena and has been associated with students' geography learning outcomes ([Aliman et al., 2019](#)). It is an important capability for interpreting how places and geographic processes are connected.

Geospatial technologies, including Geographic Information Systems (GIS), Google Earth, and digital maps, have expanded opportunities to develop these capabilities by enabling students to visualize spatial data and examine relationships. A quasi-experimental study found that geography lessons using geospatial technologies supported students' relational thinking more than conventional lessons, with a medium-to-large effect ([Favier & van der Schee, 2014](#)). GIS learning has also been associated with critical spatial thinking ([Kim & Bednarz, 2013](#)). Nevertheless, access to digital tools alone does not ensure meaningful learning; their value depends partly on how teachers organize tasks and connect spatial representations with geographic reasoning.

Despite this potential, spatial thinking is not always adequately developed in Indonesian classrooms. Recent research indicates that senior high school students may demonstrate low spatial-thinking performance when learning materials and classroom activities provide limited opportunities to reason spatially ([Bana et al., 2025](#)). Because spatial thinking cannot be developed through memorization alone, geography teachers need approaches that engage students in observing, comparing, interpreting, and solving spatial problems. These demands are particularly relevant in Indonesia, where geography education addresses land-use change, disaster risk, urbanization, and environmental sustainability.

Student-centered learning models, including Problem-Based Learning (PBL), Project-Based Learning (PjBL), Discovery Learning, Inquiry Learning, and Contextual Teaching and Learning (CTL) are often used to support active engagement with geographic problems. PBL begins with a real-world problem; PjBL guides students toward producing a project or spatial representation; Discovery and Inquiry Learning emphasize identifying patterns and developing explanations; and CTL connects concepts with students' surroundings. These approaches reflect constructivist assumptions that learners develop understanding through active engagement with problems and evidence. However, the effectiveness of minimally guided instruction remains debated, particularly for novice learners ([Kirschner et al., 2006](#)), making it important to examine each model in relation to implementation and measured outcomes.

In Indonesia, studies of instructional models and spatial thinking have generally examined individual approaches in separate classroom settings. [Dewi et al](#) (2021) investigated PBL supported by geospatial information, [Putra et al](#) (2021) examined blended

PjBL with a STEM approach, [Zakiy et al \(2022\)](#) studied Discovery Learning, and [Kusuma et al \(2024\)](#) examined Discovery Learning with Google Earth. These studies used different samples, instruments, designs, and comparison conditions. Consequently, their findings are scattered across publications and cannot be compared reliably by looking only at reported improvements or statistical significance.

Recent reviews have begun to consolidate this evidence. [Lase et al \(2026\)](#), for example, reviewed 12 articles on spatial thinking and sustainability awareness published during 2016–2026 and identified PBL and PjBL as frequently reported models. An important question remains: does a model's frequency in the literature correspond to stronger evidence of its effects? Addressing this question requires examining each study's design, sample, instrument, comparison group, and statistical results. It is also necessary to understand how learning models are combined with geospatial technologies, which spatial-thinking indicators are measured, and how publications are distributed over time. Without such a synthesis, readers may mistake research popularity for comparative effectiveness.

The present review addresses these gaps by synthesizing empirical studies of instructional models and spatial thinking in geography education published within the 2021–2026 search period. It distinguishes model frequency from reported outcomes by extracting samples, educational levels, research designs, instruments, and statistical results, and calculating effect sizes when the available statistics permit. It also brings learning models, geospatial technologies, and spatial-thinking indicators together in a synthesis matrix and maps the distribution of studies by publication year. Rather than only counting models mentioned in prior research, this approach examines what each study reports and the limitations affecting interpretation. The review follows PRISMA 2020 guidance ([Page et al., 2021](#)). Because the included studies differ in design, instruments, and outcome reporting, findings are synthesized qualitatively rather than pooled through meta-analysis.

Accordingly, this review examines which instructional models are most frequently studied to improve students' spatial thinking in geography education, what the studies report about their effects in light of their designs and statistical results, how digital geospatial technologies are integrated with these models and which indicators are measured, and how the studies and models are distributed across publication years from 2021 to 2026. By addressing these questions together, the review aims to provide a transparent account of the available evidence and an evidence-informed reference for geography teachers and researchers. Its contribution is not to declare a universally superior model, but to clarify patterns, outcomes, and limitations reported in the current empirical literature.

B. Method

This Systematic Literature Review (SLR) synthesized empirical evidence on instructional models for developing spatial thinking in geography education, following PRISMA 2020 guidance for identification, screening, eligibility, and inclusion ([Page et al., 2021](#)).

Searches of Google Scholar, Garuda, and Crossref were conducted on 20 February 2026 using (“spatial thinking” OR “spatial thinking ability” OR “berpikir spasial”) AND (“geography learning model” OR “Problem Based Learning” OR “Project Based Learning” OR “Inquiry Learning” OR “Discovery Learning”). The Indonesian term “berpikir spasial” (“spatial thinking”) was included to retrieve Indonesian-language studies. Eligible publications (2021–2026) were in Indonesian or English and concerned geography or social studies education. Each article was the unit of analysis.

Studies qualified if they examined a geography instructional model through experimental, quasi-experimental, or classroom action research; measured spatial thinking primarily using tests or observation; and provided accessible Indonesian/English full texts. Sources included journal articles, conference proceedings, and empirical theses or dissertations with full texts and research designs. Exclusions were non-empirical studies, studies without spatial-thinking measures, media-only studies without an instructional model, non-geography studies, duplicates, and inaccessible full texts. Screening yielded 15 empirical studies.

An extraction matrix captured authors/year, sample, educational level, design, instructional model, technology/media, spatial-thinking indicators, instruments, statistical analyses, and quantitative findings (Tables 1 and 3). Cohen’s *d* was calculated from reported *t* values or group means and variances where possible, assuming equal group sizes when unreported. Findings were synthesized narratively by instructional model, technology, indicator category, and publication year. Because designs, instruments, and reporting varied, effect sizes were not pooled and no meta-analysis was conducted.

Quality was assessed against five criteria: relevance to spatial thinking in geography education, objective clarity, design/analysis appropriateness, consistency of results and discussion, and contribution to geography education. Each criterion was scored 0 (not met), 1 (partly met), or 2 (fully met; maximum 10). Studies scoring at least 5 were retained: 9–10 indicated high, 7–8 moderate, and 5–6 low quality. The first author assessed quality, and the second checked scores. Disagreements were resolved through discussion and consensus; no inter-rater reliability coefficient was calculated. Results are reported in Table 6.

This review used published studies and other secondary data without direct involvement of human participants. Therefore, ethical clearance was not required. All sources were appropriately cited, and the extracted data were recorded without deliberate alteration. The overall study selection process, from initial identification to the inclusion of the 15 eligible studies, is summarized in Figure 1.

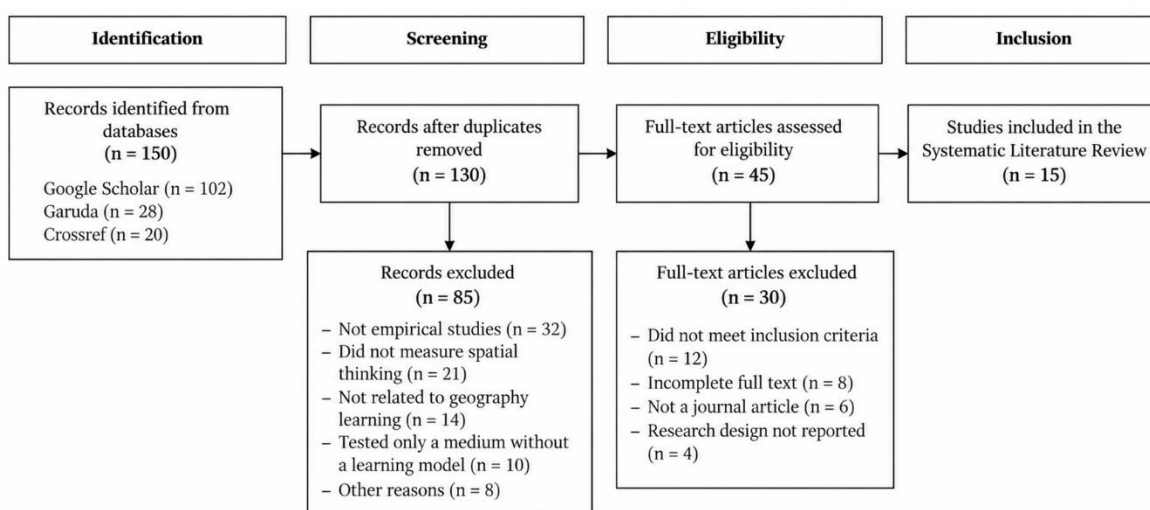


Figure 1. PRISMA 2020 Flow Diagram of the Literature Selection Process

The search identified 150 records (Figure 1). After 20 duplicates were removed, 130 records were screened by title and abstract, and 85 were excluded because they did not meet the inclusion criteria. Of the 45 full-text articles assessed, 30 were excluded: one tested a medium without a learning model (Khoirunnisa et al., 2025), one was a development study whose outcome was 4C skills in university students (Listiqowati et al., 2025), and 28 did not meet the other inclusion criteria. No article was excluded at the quality appraisal stage. Fifteen studies were included.

C. Result

This section answers the four research questions in order. Table 1 presents the 15 included studies and the main finding reported by each; Table 3 adds the sample, design, instrument, and statistical result, and Table 6 reports the quality appraisal. Table 1 summarizes the learning model, media or technology, spatial thinking indicators, and main finding of each study, as reported by the primary authors.

Table 1. Characteristics and Synthesis Matrix of the Reviewed Articles

No	Author & Year	Learning Model	Media/ Technology	Spatial Thinking Indicators Improved	Main Results/ Research Findings
1	Dewi et al (2021)	Problem-Based Learning (PBL)	Geospatial information (maps)	Gersmehl-based components (8 essay items)	PBL class gained more than the control class (gain 13.8 vs 6.1; $t = 6.553$, $p < 0.001$).
2	Putra et al (2021)	Project-Based Learning (PjBL; blended, STEM)	Google Classroom, Google Meet, WebGIS	Concepts of space, tools of representation, reasoning	Experimental class scored higher at posttest (85.8 vs 73.1; $t = 7.844$, $p < 0.001$).

No	Author & Year	Learning Model	Media/ Technology	Spatial Thinking Indicators Improved	Main Results/ Research Findings
			population data		
3	Nurcahyo & Winanti (2021)	PBL with inductive approach	No geospatial tool reported	Spatial thinking components (STAT)	Normalized gain 52% vs 37% for the control class ($p = 0.000$).
4	Rahayu et al (2022)	PjBL	Google Classroom; mind-map project	Eight AAG components	Observed mean rose from 55.6 to 78.8 across two cycles; classical mastery 67% to 100%.
5	Zakiy et al (2022)	<i>Discovery Learning</i>	Online worksheets; no geospatial tool	Not itemized	Experimental class scored higher than the lecture class ($t = 3.776$, $p < 0.001$).
6	Medani et al (2022)	Guided Discovery Learning	Google My Maps	Region, spatial association, map use, causality, invention	Experimental posttest higher than control (76.23 vs 67.72; Sig. = 0.00).
7	Anggreni & Sumarmi (2022)	Guided Inquiry based on geoliteracy (GIGL)	Maps, soil images and samples	Eight Gersmehl indicators	Higher gain than the control class (57.94 vs 33.96; $t = 4.138$, $p < 0.001$).
8	Astawa (2022)	<i>Contextual Teaching and Learning (CTL; demonstration method, contextual approach)</i>	Pictures and moving images	Concepts of space, tools of representation, reasoning	Spatial thinking score rose from 20.26 to 36.56 over two cycles; classical mastery 86.96%.
9	Mike & Nofrion (2023)	PBL	Learning video as problem stimulus	Six Huynh-Sharpe indicators (total score)	PBL class scored higher (abstract: mean 37 vs 31; $t = 3.964$, $p < 0.001$).
10	Buana & Putra (2023)	PBL with self-efficacy approach	WebGIS InaRISK	Concepts of space, tools of representation, cognitive process	Mean rose from 45.39 to 75.24 over two cycles; largest gains in representation tools and output.
11	Virgiawan et al (2023)	Discovery Learning	Thematic maps; Google Earth maps	Location, pattern, analogy, association, connectivity	Mean rose from 52.33 to 72.83; pattern +118.78%, location +42.56%.
12	Kusuma et al (2024)	Discovery Learning	Google Earth	Concepts of space, tools of	Posttest 73.94 vs 64.25 against a PjBL class (Mann-

No	Author & Year	Learning Model	Media/ Technology	Spatial Thinking Indicators Improved	Main Results/ Research Findings
				representation, reasoning	Whitney, $p < 0.001$).
13	Elisa (2024)	PjBL	Google Earth	Six Huynh-Sharpe indicators	Experimental class scored higher ($t = 3.791$, $p < 0.001$); analysis most mastered (30%), scale least (5%).
14	Purba et al (2025)	PjBL	Microsoft Excel 3D Maps	Concepts of space, tools of representation, reasoning	High category rose from 0% to 91.18%; all 34 students reached the mastery score in cycle II.
15	Bana et al (2025)	PBL	Geospatial information media	Not itemized	Reported posttest 71.57 vs 42.26 (control declined); statistics internally inconsistent (low quality).

Note. Model labels follow the original authors. Putra et al (2021), Nurcahyo & Winanti (2021), Buana & Putra (2023), and Astawa (2022) combined a main model with a blended, inductive, self-efficacy, or contextual approach, and were classified by the main model. Guided inquiry with geoliteracy (Anggreni & Sumarmi, 2022) was classified as Inquiry Learning and guided discovery (Medani et al., 2022) as Discovery Learning.

The frequency distribution of instructional models across the selected articles was analyzed to identify which approaches were most commonly investigated in geography education and spatial thinking development. The distribution of learning models identified in the 15 selected articles is presented in Table 2.

Table 2. Frequency Distribution of Learning Models in Selected Articles

No	Learning Models	Number of Articles	Percentage (%)
1	Problem-Based Learning (PBL)	5	33.33%
2	Project-Based Learning (PjBL)	4	26.67%
3	Discovery Learning	4	26.67%
4	Inquiry Learning	1	6.67%
5	Contextual Teaching and Learning (CTL)	1	6.67%
Total		15	100%

PBL was studied in five articles (33.33%), PjBL and Discovery Learning in four each (26.67%), and Inquiry Learning and CTL in one each (6.67%). These percentages describe how often each model was studied. They do not show which model is more effective, because the studies differ in design, instrument, and outcome measures.

Effectiveness Reported by the Studies

Given the heterogeneity in research designs, measurement instruments, and statistical reporting, instructional effectiveness was synthesized narratively based on individual study findings (Table 3). Of the 15 studies, ten employed comparison-class designs, all reporting significantly higher spatial thinking outcomes in experimental classes ($p \leq .001$). Cohen's d was calculated for eight studies, ranging from 0.77 to 1.85. Specifically, effect sizes were 1.75 for Dewi et al (2021), 1.85 for Putra et al (2021), 0.97 for Zakiy et al (2022), 0.77 for Medani et al (2022), 1.06 for Anggreni & Sumarmi (2022), 0.98 for Mike & Nofrion (2023), 1.66 for Kusuma et al (2024), and 0.99 for Elisa (2024). Effect sizes were unavailable for Nurcahyo & Winanti (2021) and Bana et al (2025) because of missing statistics and inconsistent reporting, respectively. The remaining five studies used classroom action research, reporting improvements across intervention cycles without comparison classes or inferential tests. Mean scores increased from 52.33 to 72.83 in Virgiawan et al (2023) and from 45.39 to 75.24 in Buana & Putra (2023). Although effect sizes varied across instructional models, methodological heterogeneity precludes definitive effectiveness rankings. Table 3 summarizes study-level significance, available effect sizes, and reported changes in spatial thinking outcomes.

Table 3. Data Extraction of the Reviewed Studies

No	Study	Level and sample	Design	Instrument	Statistical analysis and reported result
1	Dewi et al (2021)	Grade X IIS, SMAN Bandarkedungmulyo, Jombang; 56 students, inferred from df = 54	Quasi-experimental design with a pretest and posttest control group; comparison group received conventional instruction	Eight-item essay test based on Gersmehl indicators	Independent-samples t-test: $t = 6.553$, $df = 54$, $p < .001$. Mean difference = 6.821. The reported gain was 13.8 in the experimental group and 6.1 in the comparison group. Cohen's d approximately 1.75.
2	Putra et al (2021)	Grade XI IPS, SMA Negeri 1 Kepanjen; 36 students in the experimental group and 35 or 36 in the comparison group. The text and tables report different sample sizes.	Quasi-experimental design with a pretest and posttest control group; comparison group received conventional instruction	Spatial thinking and geographic skills tests; expert validated, with reported reliability above .6	Independent-samples t-test: $t = 7.844$, $df = 70$, $p < .001$. Mean difference = 12.667. Posttest means were 85.8 in the experimental group and 73.1 in the comparison group. Cohen's d approximately 1.85.

No	Study	Level and sample	Design	Instrument	Statistical analysis and reported result
3	Nurcahyo & Winanti (2021)	Grade XI IPS, SMA Negeri 2 Ponorogo; 33 students in each group	Quasi-experimental design with a pretest and posttest control group; comparison group received video-based and lecture instruction	Spatial Thinking Ability Test (STAT), multiple-choice format; validity and reliability were assessed	Independent-samples t-test: reported $p = .000$. Normalized gain was 52% in the experimental group and 37% in the comparison group. Pretest means were 55 and 60, respectively, while posttest means were 79 and 75. The t statistic and Cohen's d were not reported.
4	Rahayu et al (2022)	Grade X MIPA 3, SMA Laboratorium UM, Malang; 33 students	Classroom action research conducted over two cycles	Observation sheet covering eight AAG components, project assessment, and pre-cycle test	Descriptive analysis showed that the observed mean increased from 55.6 to 66.6 in Cycle I and from 75.9 to 78.8 in Cycle II. The project score increased from 73 to 85, while classical mastery increased from 67% to 100%.
5	Zakiy et al (2022)	Grades XII IPS 1 and XII IPS 2, MAN 1 Trenggalek; 30 students in each group	Quasi-experimental posttest-only control group design; comparison group received lecture-based instruction	Five essay items; expert validation and a trial were conducted	Independent-samples t-test: $t = 3.776$, $df = 58$, $p < .001$. Mean difference = 4.067. The reported class means were 83.5 in the experimental group and 67.5 in the comparison group. Cohen's d approximately 0.97.
6	Medani et al (2022)	Grade XI IPS A and XI IPS B, SMA Negeri 1 Singosari; 34 and 36 students, respectively	Quasi-experimental posttest-only control group design; random lottery was used. The comparison group received generative learning	Essay test; Pearson validity testing and Cronbach's alpha reliability coefficient of .733	Independent-samples t-test: reported significance = .00. Posttest means were 76.23 in the experimental group and 67.72 in the comparison group. Cohen's d approximately 0.77.
7	Anggreni & Sumarmi (2022)	Grade X IPS 2 and X IPS 3, SMA Negeri 1 Pracimantoro; 61 students	Quasi-experimental nonequivalent control group design; comparison group received conventional instruction	Essay test based on Gersmehl indicators; content validity, reliability, item difficulty, and discrimination were assessed	Independent-samples t-test: $t = 4.138$, $df = 59$, $p < .001$. Posttest means were 80.16 in the experimental group and 67.33 in the comparison group. Gains were 57.94 and 33.96, respectively. Cohen's d approximately 1.06.

No	Study	Level and sample	Design	Instrument	Statistical analysis and reported result
8	Astawa (2022)	Grade X IPS 1, SMA Laboratorium Undiksha, Singaraja; 23 students	Classroom action research conducted over two cycles	Questionnaire, observation, and test	Descriptive analysis showed that spatial thinking scores increased from 20.26 to 29.30 and then to 36.56. Learning outcomes increased from 67.30 to 75.87. Classical mastery reached 86.96%, representing 20 of the 23 students.
9	Mike & Nofrion (2023)	Grade X, class X.E, SMAN 15 Padang; 33 students in each group	Quasi-experimental design with a pretest and posttest control group. The methods section states a posttest-only design; the comparison group received conventional instruction.	Essay test; validity and reliability were assessed	Independent-samples t-test: $t = 3.964$, $df = 64$, $p < .001$. Mean difference = 5.667, with a 95% confidence interval from 2.811 to 8.522. The abstract reports means of 37 in the experimental group and 31 in the comparison group. Cohen's d approximately 0.98.
10	Buana & Putra (2023)	Grade XI IPS 2, MA Al-Maarif Singosari; 38 students	Classroom action research based on the Kemmis and Taggart model, conducted over two cycles	Five essay items based on the indicators of Jo and Bednarz	Descriptive analysis showed that scores increased from 45.39 to 62.87 and then to 75.24. The reported increases were 17.47 points between the initial assessment and Cycle I and 12.37 points between Cycles I and II. In Cycle II, 29 students achieved the mastery threshold of 73.
11	Virgiawan et al (2023)	Grade X-4, SMA Negeri 13 Surabaya; 30 students	Classroom action research conducted over two cycles, with one meeting per cycle	Observation sheet based on the PPL 2 PPG (pre-service teacher field practice) rubric, project assessment, and documentation	Descriptive analysis showed that the mean score increased from 52.33 to 72.83. The proportion of students in the good category increased from 0% to 80%. The reported increase for the pattern indicator was 118.78%, while that for the location indicator was 42.56%.

No	Study	Level and sample	Design	Instrument	Statistical analysis and reported result
12	Kusuma et al (2024)	Grade XI IPS 1 and XI IPS 2, SMA Negeri 1 Gambiran; 32 students in each group	Quasi-experimental design with a pretest and posttest control group; the comparison group also received Project-Based Learning	Five essay items; Pearson validity testing and Cronbach's alpha reliability assessment	Mann-Whitney test: $U = 124.000$, $Z = -5.238$, $p < .001$. Posttest means were 73.94 in the experimental group and 64.25 in the comparison group. The reported effect size was r approximately 0.65, with Cohen's d approximately 1.66.
13	Elisa (2024)	Grade XI IPS 1 and XI IPS 2, MA Al Hidayah Wajak; 30 students in the experimental group and 29 in the comparison group	Quasi-experimental design with a pretest and posttest control group; comparison group received lecture-based instruction	Twenty-five objective items; validity, reliability, item difficulty, and discrimination were assessed	Independent-samples t-test: $t = 3.791$, $df = 57$, $p < .001$. Cohen's d approximately 0.99. Reported indicator mastery was 30% for analysis and 5% for scale.
14	Purba et al (2025)	Grade X, class X-6, SMA Negeri 1 Gondanglegi; 34 students	Classroom action research conducted over two cycles	Spatial thinking test administered before and after the intervention, together with an observation sheet	Descriptive analysis showed that the proportion of students in the high category increased from 0% to 8.82% and then to 91.18%. The number of students meeting or exceeding the mastery threshold of 75 increased from 16 to 29 and finally to all 34 students.
15	Bana et al (2025)	Grade X, classes X1 and X2, SMA Negeri 1 Amarasi Barat; 26 students in each group, although the text also reports a total of 54 students	Described as classroom action research but analyzed as an experimental and comparison group study; the comparison group received Discovery Learning	Test and questionnaire	The reported t-test significance was .000. Posttest means were 71.57 and 42.26, while the comparison group's score reportedly declined from 57.65. Normalized gain was reported as 0.76 and 76.65. Regression significance was .062. No effect size was calculated because the reported statistics were internally inconsistent.

Note. Cohen's d was calculated by the review authors from the reported t value and group sizes (equal group sizes assumed when not reported), or from reported means and variances ([Medani et al., 2022](#); [Kusuma et al., 2024](#)). Class and school labels follow the original reports: IPS/IIS = social sciences track; MIPA = mathematics and natural sciences track; SMA/SMAN = senior high school; MA/MAN = Islamic senior high school.

Integration of Digital Geospatial Technology

Seven of the 15 studies incorporated digital geospatial tools: WebGIS (Putra et al., 2021; Buana & Putra, 2023), Google My Maps (Medani et al., 2022), Google Earth (Virgiawan et al., 2023; Kusuma et al., 2024; Elisa, 2024), and Microsoft Excel 3D Maps (Purba et al., 2025). Three studies used maps or geospatial information without specifying a digital tool (Dewi et al., 2021; Anggreni & Sumarmi, 2022; Bana et al., 2025). The remaining five employed non-geospatial media: Google Classroom (Rahayu et al., 2022), a learning video (Mike & Nofrion, 2023), pictures and moving images (Astawa, 2022), online worksheets (Zakiy et al., 2022), or no reported medium (Nurcahyo & Winanti, 2021). Table 4 classifies studies by instructional model, technology, indicator coverage, and reported findings.

Table 4. Synthesis of Learning Model, Technology, Spatial Thinking Indicators, and Reported Results

Learning Model (N)	Studies	Technology / Media	Indicator Coverage	Design and Reported Result
Problem-Based Learning (PBL), 5 studies	Dewi et al (2021); Nurcahyo & Winanti (2021); Mike & Nofrion (2023); Buana & Putra (2023); Bana et al (2025).	Geospatial information and maps; no geospatial tool reported; learning video; WebGIS InaRISK; geospatial information media.	Dewi et al. reported concepts of space and processes of reasoning. Nurcahyo and Winanti, Mike and Nofrion, and Buana and Putra covered concepts of space, tools of representation, and processes of reasoning. Bana et al. did not itemize the indicators.	Four controlled studies and one classroom action research study. Calculable Cohen's d values ranged from 0.98 to 1.75 in two studies. Nurcahyo and Winanti reported normalized gains of 52% in the experimental group and 37% in the comparison group. Buana and Putra reported scores increasing from 45.39 to 75.24 across the reported assessment points.
Project-Based Learning (PjBL), 4 studies	Putra et al (2021); Rahayu et al (2022); Elisa (2024); Purba et al (2025).	WebGIS with Google Classroom and Google Meet; Google Classroom; Google Earth; Microsoft Excel 3D Maps.	Putra et al., Elisa, and Purba et al. covered concepts of space, tools of representation, and processes of reasoning. Rahayu et al. covered concepts of space and processes of reasoning.	Two controlled studies and two classroom action research studies. Calculable Cohen's d values ranged from 0.99 to 1.85. Rahayu et al. reported observed means increasing from 55.6 to 78.8 across the two cycles. In Purba et al., all 34 students met or exceeded the mastery threshold by Cycle II.

Learning Model (N)	Studies	Technology / Media	Indicator Coverage	Design and Reported Result
Discovery Learning, 4 studies	Zakiy et al (2022) ; Medani et al (2022) ; Virgiawan et al (2023) ; Kusuma et al (2024) .	Online worksheets; Google My Maps; thematic maps and Google Earth; Google Earth.	Zakiy et al. did not itemize the indicators. Medani et al. and Kusuma et al. covered concepts of space, tools of representation, and processes of reasoning. Virgiawan et al. covered concepts of space and processes of reasoning.	Three controlled studies and one classroom action research study. Calculable Cohen's d values ranged from 0.77 to 1.66. Virgiawan et al. reported mean scores increasing from 52.33 to 72.83.
Inquiry Learning, 1 study	Anggreni & Sumarmi (2022) .	Maps, soil images, and soil samples.	Concepts of space and processes of reasoning, mapped by the review authors from eight Gersmehl-based indicators.	One controlled study. Cohen's d was approximately 1.06, and positive gains were reported for the individual indicators.
Contextual Teaching and Learning (CTL), 1 study	Astawa (2022) .	Pictures and moving images.	Concepts of space, tools of representation, and processes of reasoning.	One classroom action research study. The spatial thinking score increased from 20.26 to 36.56 across the reported intervention cycles.

Note. C = concepts of space, R = tools of representation, P = processes of reasoning ([National Research Council, 2006](#)). The Gersmehl-based components were mapped to C and P by the review authors.

Indicators were mapped onto the [National Research Council's \(2006\)](#) three-component framework. Nine studies assessed all three components ([Putra et al., 2021](#); [Nurchayho & Winanti, 2021](#); [Medani et al., 2022](#); [Astawa, 2022](#); [Mike & Nofrion, 2023](#); [Buana & Putra, 2023](#); [Kusuma et al., 2024](#); [Elisa, 2024](#); [Purba et al., 2025](#)). Four used Gersmehl-based indicators of spatial concepts and reasoning ([Dewi et al., 2021](#); [Rahayu et al., 2022](#); [Anggreni & Sumarmi, 2022](#); [Virgiawan et al., 2023](#)), while two did not specify indicators ([Zakiy et al., 2022](#); [Bana et al., 2025](#)). [Putra et al. \(2021\)](#) reported higher experimental-class scores for spatial concepts (87 compared with 73, $p < .001$), representation (83 compared with 72, $p = .028$), and reasoning (83 compared with 72, $p = .008$). [Buana & Putra \(2023\)](#) found gains in representation tools and output, but not complex spatial concepts. [Virgiawan et al \(2023\)](#) reported gains of 118.78% in pattern and 42.56% in location; [Elisa \(2024\)](#) identified analysis as strongest (30%) and scale as weakest (5%). Effect sizes overlapped between digital geospatial studies (0.77–1.85) and other studies (0.97–1.75). Because models and technologies were evaluated jointly, their individual effects cannot be isolated.

Publication Trends, 2021–2026

Table 5 shows the number of studies per year and model. Three studies were published in 2021, five in 2022, three in 2023, and two each in 2024 and 2025; no study from

2026 met the eligibility criteria. Eleven of the 15 studies appeared in 2021–2023. PBL appears in 2021, 2023, and 2025; PjBL in 2021, 2022, 2024, and 2025; Discovery Learning in 2022–2024; and Inquiry Learning and CTL only in 2022. With 15 studies, these counts are descriptive and do not support claims of growth or decline.

Table 5. Number of Reviewed Articles per Year and Learning Model

Year	PBL	PjBL	Discovery	Inquiry	CTL	Total
2021	2	1	0	0	0	3
2022	0	1	2	1	1	5
2023	2	0	1	0	0	3
2024	0	1	1	0	0	2
2025	1	1	0	0	0	2
2026	0	0	0	0	0	0
Total	5	4	4	1	1	15

Methodological Quality

Table 6 presents the appraisal of the 15 included studies. Seven scored 9 of 10 (high), seven scored 8 (moderate), and one scored 5 (low); none fell below the cut-off, so no article was removed at this stage. The low score belongs to [Bana et al \(2025\)](#), whose design and statistics are internally inconsistent (for example, the study is described as classroom action research but analyzed as an experimental–control comparison, N-gain is reported as both 0.76 and 76.65, and a regression result of Sig. = 0.062 contradicts the stated conclusion). It was retained under the 50% cut-off and its findings are interpreted with caution; removing it does not change any conclusion of this review. The most common weaknesses among the other studies were unreported instrument validity and inconsistencies between abstract, method, and tables.

Table 6. Quality Appraisal of the Included Studies

Study	C1	C2	C3	C4	C5	Total	Grade	Main concern
Dewi et al (2021)	2	2	1	2	2	9	High	Instrument validity and group sizes not reported
Putra et al (2021)	2	2	2	1	2	9	High	Control n stated as 35 in text, 36 in tables
Nurcahyo & Winanti (2021)	2	2	2	1	2	9	High	t value not reported; pretest means differ
Rahayu et al (2022)	2	2	1	1	2	8	Moderate	No comparison class; mislabeled tables; no instrument validation
Zakiy et al (2022)	2	2	1	1	2	8	Moderate	Sampling stated as random and non-random; mean difference conflicts with class means
Medani et al (2022)	2	2	2	1	2	9	High	Posttest only; t value and df not reported
Anggreni & Sumarmi (2022)	2	2	2	1	2	9	High	Hypothesis decision stated inversely; group sizes not given

Study	C1	C2	C3	C4	C5	Total	Grade	Main concern
Astawa (2022)	2	2	1	1	2	8	Moderate	Score scale unclear; no instrument validity reported
Mike & Nofrion (2023)	2	2	1	1	2	8	Moderate	Design differs between abstract and method; class labels swapped in Table 4
Buana & Putra (2023)	2	2	1	1	2	8	Moderate	No inferential test but results called significant; mastery counts exceed class size
Virgiawan et al (2023)	2	2	1	1	2	8	Moderate	One meeting per cycle; observation rubric not validated
Kusuma et al (2024)	2	2	2	1	2	9	High	Abstract states posttest-only and t-test; pretest-posttest and Mann-Whitney were used
Elisa (2024)	2	2	2	1	2	9	High	Posttest means not reported; conclusion states Sig. 0.000 > 0.05
Purba et al (2025)	2	2	1	1	2	8	Moderate	Class (X-5/X-6) and dates differ between abstract and text
Bana et al (2025)	2	2	0	0	1	5	Low	Design and statistics internally inconsistent

Note. C1 = relevance; C2 = clarity of objectives; C3 = appropriateness of method (design, instrument validity, analysis); C4 = clarity and internal consistency of results and discussion; C5 = contribution to geography learning. Each criterion scored 0–2; cut-off 5 of 10; grades: 9–10 high, 7–8 moderate, 5–6 low.

D. Discussion

The reviewed studies most frequently examined Problem-Based Learning (PBL), followed by Project-Based Learning (PjBL) and Discovery Learning (Table 2). However, research frequency does not establish comparative effectiveness. All ten controlled studies reported outcomes favoring the experimental condition, although eight used conventional, lecture-based, or video-based comparison instruction, while [Kusuma et al \(2024\)](#) compared Discovery Learning with PjBL and [Bana et al \(2025\)](#) compared PBL with Discovery Learning. The latter study also reported internally inconsistent statistics, limiting interpretation.

PBL may support spatial thinking by engaging students in authentic geographic problems requiring spatial concepts, representations, and reasoning ([National Research Council, 2006](#)). Examples include analyzing agricultural land conversion ([Dewi et al., 2021](#)) and disaster distribution using WebGIS InaRISK ([Buana & Putra, 2023](#)). Positive outcomes were reported both when geospatial tools were used and when no specific tool was documented ([Mike & Nofrion, 2023](#); [Nurcahyo & Winanti, 2021](#)). In PjBL, students created population-projection maps, land-use mind maps, disaster-risk projects, and three-dimensional poverty-distribution maps ([Putra et al., 2021](#); [Rahayu et al., 2022](#); [Elisa, 2024](#); [Purba et al., 2025](#)), potentially strengthening spatial representation. Discovery Learning and inquiry-based approaches also showed positive outcomes ([Zakiy et al., 2022](#); [Medani et al., 2022](#); [Anggreni & Sumarmi, 2022](#); [Virgiawan et al., 2023](#); [Kusuma et al., 2024](#)). However, the single CTL study lacked a comparison group, preventing conclusions about its relative effectiveness ([Astawa, 2022](#)).

Seven studies employed digital geospatial tools, including WebGIS, Google My Maps, Google Earth, and Excel 3D Maps. These tools may facilitate multiscale visualization and spatial-layer comparison, supporting representation and analysis. This interpretation aligns with [Favier & van der Schee \(2014\)](#), who reported benefits of geospatial technologies for relational thinking, and [Kim & Bednarz \(2013\)](#), who associated GIS learning with critical spatial thinking. [Khoirunnisa et al \(2025\)](#) similarly reported higher posttest scores using Google Earth than lecture-based instruction, although no specific learning model was tested. Nevertheless, effect sizes ranged from 0.77 to 1.85 in studies using digital geospatial tools and from 0.97 to 1.75 in other studies. Thus, the additional contribution of technology cannot be isolated because instructional models, media, and research designs varied. Weak performance on scale indicators in [Elisa \(2024\)](#) and [Khoirunnisa et al \(2025\)](#) also suggests that digital mapping alone may not develop scale reasoning.

Consistent with the [National Research Council's \(2006\)](#) framework, the reviewed studies addressed concepts of space and reasoning processes in 13 studies each, while nine addressed representation tools; two did not specify indicators. Reported gains in pattern recognition ([Virgiawan et al., 2023](#)) and representation-related outcomes ([Buana & Putra, 2023](#)) suggest that problem- and product-oriented tasks may encourage reasoning beyond place-name memorization. These interpretations remain provisional because five studies used classroom action research without comparison groups. The findings broadly agree with [Lase et al \(2026\)](#), who identified PBL, PjBL, and geospatial technologies as prominent approaches. However, differences in designs, instruments, comparison conditions, and reporting including inconsistencies in [Zakiy et al \(2022\)](#) limit direct comparisons. Furthermore, [Kirschner et al \(2006\)](#) cautioned that minimally guided discovery, problem-based, and inquiry-based approaches may disadvantage novice learners, highlighting teacher guidance as a variable requiring further investigation.

Overall, PBL was the most frequently studied model, while all ten controlled studies and five action research studies reported positive outcomes. Digital tools were not consistently associated with larger effect sizes, and publications peaked in 2022. Accordingly, the evidence supports the potential of student-centered, context-rich instruction but does not establish the superiority of any model.

E. Implication

The findings suggest that geography teachers should integrate student-centered learning models, particularly PBL and PjBL, with geospatial tools to develop students' spatial thinking skills. Schools may support this integration through teacher training and accessible digital resources. However, because the reviewed studies vary in design and quality, further comparative research is needed before recommending one model as superior.

F. Limitations and Suggestions for Further Research

This review is limited by the small number of included studies, variation in research designs, instruments, and statistical reporting, and the predominance of studies conducted in individual schools. Five studies used classroom action research without comparison groups, while inconsistencies in some primary reports further restricted direct comparisons. Therefore, the findings do not establish the superiority of any instructional model or the independent contribution of geospatial technology.

Future research should employ more rigorous comparative or experimental designs, validated spatial thinking instruments, and transparent statistical reporting. Studies should also compare the same instructional model with and without geospatial technology and extend investigations across primary, secondary, and higher education levels to strengthen the generalizability of the evidence.

G. Conclusion

This review provides an evidence-informed foundation for understanding instructional approaches to spatial thinking in geography education. Its contribution lies in connecting pedagogical design, geospatial resources, and spatial thinking assessment while highlighting the need for more rigorous and transparent research. These insights can guide future efforts to strengthen the quality and relevance of geography learning.

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