Insight into Modern Education
ISSN: 3057-0050 (Online), Vol 2 No 2 (May-August, 2024)

Research Paper

Geographic Process-Based Learning Management: A Mixed-Methods Research and Development Study in Northeast Thailand's Secondary Schools[1]

Siriyawan Rookeb [1]*

[1]Chaiyaphum Pariyattidhamma School (General Education), Thailand
*Corresponding author ✉: Toonsiriyawan@gmail.com

Abstract:

Background: Traditional geography education in northeast Thailand faces significant challenges including limited student engagement, inadequate spatial thinking development, and poor academic outcomes. Geographic process-based learning represents an innovative pedagogical approach that integrates constructivist learning principles with hands-on spatial analysis to enhance educational effectiveness.

Purpose: This study investigates the development and implementation of geographic process-based learning management on academic achievement, spatial thinking skills, and student satisfaction among junior high school students across four provinces in northeast Thailand.

Methods: A mixed-methods research and development (R&D) approach was employed using sequential explanatory design. The quantitative phase utilized a quasi-experimental pretest-posttest control group design with 384 participants (calculated using Taro Yamane formula at 95% confidence level, 5% margin of error from population N=2,847) from 48 schools across Chaiyaphum, Nakhon Ratchasima, Ubon Ratchathani, and Khon Kaen provinces. The qualitative phase involved 42 purposively selected participants for semi-structured interviews. Data collection instruments included validated geographic knowledge tests ($\alpha=0.89$), spatial thinking assessments ($\alpha=0.91$), and satisfaction questionnaires ($\alpha=0.94$).

Results: Geographic process-based learning significantly improved academic achievement (experimental: M=82.45, SD=7.23; control: M=68.17, SD=8.91; $t(382)=16.78$, $p<0.001$, Cohen's d=1.72) and spatial thinking skills (experimental: M=79.38, SD=6.45; control: M=65.92, SD=7.82; $t(382)=18.24$, $p<0.001$, Cohen's d=1.87). Student satisfaction was high (M=4.38, SD=0.67 on 5-point scale). ANCOVA controlling for pretest scores confirmed intervention effectiveness ($F(1,381)=287.45$, $p<0.001$, partial $\eta^2=0.43$). Qualitative findings revealed themes of enhanced engagement, improved spatial reasoning, and positive learning experiences.

[1]**Article info**: Received: 14 August 2022; Revised: 26 August 2023; Accepted: 26 April 2024

Insight into Modern Education
ISSN: 3057-0050 (Online), Vol 2 No 2 (May-August, 2024)

Conclusions: Geographic process-based learning management demonstrates significant effectiveness in improving geography education outcomes in northeast Thailand's secondary schools. The approach successfully addresses traditional pedagogical limitations while promoting 21st-century spatial thinking competencies. Findings provide evidence-based recommendations for curriculum developers and educational policymakers in Southeast Asian contexts.

Keywords: geographic processes; constructivist learning; spatial thinking; secondary education; northeast Thailand; mixed-methods research

1. INTRODUCTION

Geographic education in the 21st century faces unprecedented challenges related to developing students' spatial thinking capabilities, environmental awareness, and global citizenship competencies (Brooks et al., 2024; Solem et al., 2023). In Southeast Asian contexts, particularly Thailand, traditional geography instruction continues to emphasize rote memorization and passive knowledge transmission, limiting students' ability to develop critical spatial reasoning skills essential for understanding complex global challenges (Kakkeaw, 2024; Orsuwan et al., 2023).

Northeast Thailand, comprising the Isan region, presents unique educational challenges characterized by socioeconomic disparities, limited educational resources, and cultural diversity (Bhutwanakul et al., 2023). The region encompasses 20 provinces with predominantly rural populations dependent on agriculture, where educational institutions often lack technological infrastructure and qualified geography teachers (Chaowarakul et al., 2021). Recent studies indicate that secondary school students in northeast Thailand demonstrate significantly lower geography achievement compared to national averages, with particular deficits in spatial thinking and environmental reasoning capabilities (Pimdee et al., 2017).

The COVID-19 pandemic has further exacerbated educational inequalities in the region, disrupting traditional instructional practices and highlighting the urgent need for innovative pedagogical approaches that can adapt to diverse learning environments (Thongdee & Prasertsin, 2024). Educational recovery efforts emphasize the importance of developing active learning strategies that promote student engagement, critical thinking, and practical application of geographic knowledge (Pongtorn, 2021).

Geographic process-based learning emerges as a promising pedagogical framework that addresses these challenges by integrating constructivist learning principles with hands-on spatial analysis activities (Silviarza & Handoyo, 2021). This approach emphasizes active knowledge construction through collaborative investigation of real-world geographic phenomena, promoting deeper understanding of spatial relationships and environmental processes (Kim & Lee, 2021). Research demonstrates that geographic process-based learning significantly enhances spatial thinking development, academic achievement, and student motivation across diverse educational contexts (Schlemper et al., 2023).

Insight into Modern Education
ISSN: 3057-0050 (Online), Vol 2 No 2 (May-August, 2024)

Constructivist learning theory, as articulated by Piaget (1972) and Vygotsky (1978), provides the theoretical foundation for geographic process-based learning by emphasizing active knowledge construction through social interaction and experiential learning (Chand, 2023). In geographic education contexts, constructivism promotes student-centered inquiry that connects abstract concepts to meaningful real-world applications, fostering deeper conceptual understanding and transfer of learning (Roberts, 2023).

Recent meta-analytical evidence demonstrates the effectiveness of constructivist approaches in enhancing student learning outcomes across educational levels and subject areas (Li et al., 2023). However, limited research has examined the implementation of geographic process-based learning in Southeast Asian educational contexts, particularly in resource-constrained environments typical of rural Thailand (Belayb & Seifuc, 2024).

This study addresses critical research gaps by investigating the development and implementation of geographic process-based learning management in northeast Thailand's secondary schools. The research employs a comprehensive mixed-methods approach to examine the impact of this intervention on academic achievement, spatial thinking skills, and student satisfaction while providing insights into implementation challenges and opportunities.

The significance of this research extends beyond immediate educational outcomes to contribute broader understanding of effective geography education practices in developing country contexts. Findings inform curriculum development, teacher preparation, and educational policy decisions while advancing theoretical knowledge of constructivist learning applications in geographic education (Nyamekye et al., 2023).

2. LITERATURE REVIEW

2.1 Constructivist Learning Theory in Geographic Education

Constructivist learning theory provides essential theoretical foundations for understanding how students develop geographic knowledge and spatial thinking capabilities (Triantafyllou, 2022). The theory emphasizes that learners actively construct understanding through interaction with their environment, prior knowledge activation, and social collaboration rather than passive information reception (Semerci & Batdi, 2022).

Jean Piaget's cognitive constructivism highlights the importance of mental schema development through accommodation and assimilation processes (Chand, 2023). In geographic education contexts, students construct spatial understanding by integrating new geographic experiences with existing cognitive frameworks, gradually developing more sophisticated spatial reasoning capabilities. Lev Vygotsky's social constructivism emphasizes the role of social interaction and cultural mediation in learning processes, suggesting that collaborative geographic investigations enhance conceptual development through peer dialogue and shared problem-solving (Roberts, 2023).

Contemporary research demonstrates that constructivist geography instruction significantly improves student learning outcomes compared to traditional transmission-based

Insight into Modern Education
ISSN: 3057-0050 (Online), Vol 2 No 2 (May-August, 2024)

approaches (Belayb & Seifuc, 2024). Meta-analytical evidence indicates that constructivist interventions produce large effect sizes (d=0.89) for academic achievement and moderate to large effects (d=0.67) for critical thinking development (Ayaz & Sekerci, 2015).

However, implementation challenges persist in many educational contexts, particularly related to teacher preparation, resource availability, and institutional support for innovative pedagogical practices (Moskal et al., 2016). Research in African contexts reveals that teachers often lack confidence and skills necessary for effective constructivist instruction, highlighting the need for comprehensive professional development programs (Melesse & Jirata, 2016).

2.2 Geographic Process-based Learning Approaches

Geographic process-based learning represents a specialized application of constructivist principles that emphasizes hands-on investigation of spatial phenomena and environmental processes (Lee & Kim, 2021). This approach integrates multiple geographic methodologies including spatial analysis, field investigation, geographic information systems (GIS), and collaborative inquiry to promote comprehensive spatial thinking development (Kim & Lee, 2021).

Research demonstrates that geographic process-based learning significantly enhances spatial visualization, map reading, and geographic reasoning capabilities (Favier & van der Schee, 2014). Students engaged in process-based instruction show improved performance on spatial thinking assessments, with effect sizes ranging from moderate (d=0.52) to large (d=1.23) depending on implementation duration and intensity (Schlemper et al., 2023).

Technology integration plays an increasingly important role in contemporary geographic process-based learning implementations (Lee & Kim, 2021). Web-based mapping platforms, mobile applications, and GIS software provide students with powerful tools for spatial data analysis and visualization, enhancing engagement and learning outcomes. However, research also indicates that low-technology approaches using physical maps and spatial manipulatives can be equally effective in promoting spatial thinking development, particularly in resource-constrained environments (Fargher, 2018).

Recent studies emphasize the importance of connecting geographic process-based learning to local environmental and social contexts to enhance relevance and student motivation (Kim & Lee, 2021). Community-based investigations that address real-world problems demonstrate particular effectiveness in promoting both academic achievement and civic engagement among secondary school students.

2.3 Spatial Thinking Development in Secondary Education

Spatial thinking encompasses the ability to visualize, interpret, and reason about spatial information, representing a fundamental component of geographic literacy and 21st-century competencies (National Research Council, 2006). Research demonstrates that spatial thinking skills transfer across academic disciplines and contribute to success in science, technology, engineering, and mathematics (STEM) fields (Uttal et al., 2013).

Secondary education represents a critical period for spatial thinking development, as students transition from concrete operational to formal operational thinking capabilities (Lee

Insight into Modern Education
ISSN: 3057-0050 (Online), Vol 2 No 2 (May-August, 2024)

& Bednarz, 2012). Systematic spatial thinking instruction during this developmental period can produce lasting improvements in spatial abilities with transfer effects persisting into adulthood (Newcombe & Shipley, 2015).

Geographic education provides natural contexts for spatial thinking development through map reading, scale relationships, coordinate systems, and spatial pattern analysis activities (Bednarz et al., 2013). Research indicates that students exposed to systematic spatial thinking instruction in geography demonstrate significant improvements across multiple spatial ability measures, including mental rotation, spatial visualization, and perspective-taking tasks (Jo & Bednarz, 2009).

However, many geography curricula fail to systematically address spatial thinking development, instead focusing on factual knowledge acquisition and memorization (Lee & Bednarz, 2012). International comparative studies reveal significant variations in spatial thinking performance among students from different countries, suggesting that educational approaches strongly influence spatial ability development (Uttal et al., 2013).

2.4 Geography Education in Southeast Asian Contexts

Southeast Asian geography education faces unique challenges related to rapid urbanization, environmental degradation, and cultural diversity (Tan et al., 2021). Traditional instructional approaches emphasize teacher-centered delivery and examination preparation, limiting opportunities for active learning and critical thinking development (Liu et al., 2023).

Thailand's geography curriculum emphasizes both physical and human geography concepts but has historically relied on textbook-based instruction with limited hands-on activities (Pongtorn, 2021). Recent curriculum reforms promote competency-based learning outcomes and 21st-century skill development, creating opportunities for innovative pedagogical approaches including constructivist and inquiry-based instruction (Chaowarakul et al., 2021).

Research in Thai educational contexts demonstrates that active learning approaches significantly improve student engagement and academic achievement compared to traditional methods (Pimdee et al., 2017). However, implementation challenges persist related to teacher preparation, resource limitations, and institutional resistance to pedagogical innovation (Thongdee & Prasertsin, 2024).

International collaboration and knowledge exchange programs have supported geography education development in several Southeast Asian countries (Pongsin et al., 2023). Singapore and Malaysia have successfully implemented technology-enhanced geography curricula with demonstrated improvements in student spatial thinking and environmental awareness (Lee & Tan, 2022).

2.5 Educational Equity in Northeast Thailand

Northeast Thailand (Isan region) encompasses 20 provinces with predominantly rural populations characterized by lower socioeconomic status and limited educational opportunities compared to urban areas (Bhutwanakul et al., 2023). Educational disparities

Insight into Modern Education
ISSN: 3057-0050 (Online), Vol 2 No 2 (May-August, 2024)

persist across multiple indicators including teacher qualifications, technological resources, and student achievement outcomes (Kakkeaw, 2024).

The COVID-19 pandemic has exacerbated existing educational inequalities in the region, with rural students experiencing greater learning losses due to limited access to technology and online learning resources (Orsuwan et al., 2023). Recovery efforts emphasize the importance of developing innovative pedagogical approaches that can succeed in resource-constrained environments while promoting educational equity and inclusion.

Temple schools (Phrapariyattidhamma) represent a unique component of Thailand's educational system, serving predominantly underprivileged students while combining religious and secular education (Tantinimit, 2018). These institutions face particular challenges related to funding, teacher recruitment, and curriculum integration but also offer opportunities for community-based learning and cultural preservation.

Research demonstrates that innovative pedagogical approaches, when properly implemented and supported, can significantly reduce achievement gaps and improve educational outcomes for disadvantaged students (Wongchaiya et al., 2021). However, successful implementation requires comprehensive support including teacher professional development, material resources, and ongoing technical assistance.

3. RESEARCH QUESTIONS

This study addresses the following research questions:

RQ1: How does geographic process-based learning management affect academic achievement in geography among secondary school students in northeast Thailand?

RQ2: To what extent does geographic process-based learning management impact spatial thinking skills development among participating students?

RQ3: What are the levels of student satisfaction with geographic process-based learning management implementation?

RQ4: What are the relationships between academic achievement, spatial thinking skills, and student satisfaction in geographic process-based learning contexts?

RQ5: What are the implementation challenges and opportunities for geographic process-based learning management in northeast Thailand's educational contexts?

4. OBJECTIVES

The objectives of this study are:

4.1 To develop and validate geographic process-based learning management materials and implementation protocols for northeast Thailand's secondary schools.

4.2 To evaluate the effectiveness of geographic process-based learning management on academic achievement in geography among participating students.

4.3 To assess the impact of geographic process-based learning management on spatial thinking skills development.

Insight into Modern Education
ISSN: 3057-0050 (Online), Vol 2 No 2 (May-August, 2024)

4.4 To measure student satisfaction levels with geographic process-based learning management implementation and identify contributing factors.

4.5 To analyze relationships between academic achievement, spatial thinking skills, and student satisfaction outcomes.

4.6 To investigate implementation challenges and opportunities for geographic process-based learning management in northeast Thailand's educational contexts.

4.7 To provide evidence-based recommendations for curriculum developers, educators, and policymakers regarding effective geography education practices.

5. METHODOLOGY

5.1 Research Design

This study employed a mixed-methods research and development (R&D) approach using sequential explanatory design (Creswell & Creswell, 2018). The R&D methodology was selected to systematically develop, implement, and evaluate geographic process-based learning management while accommodating the practical constraints of educational settings (Borg & Gall, 2007).

The research proceeded through three phases: (1) development phase involving material creation and validation, (2) quantitative phase using quasi-experimental design to assess intervention effectiveness, and (3) qualitative phase employing interviews to explore implementation experiences and outcomes.

5.2 Population and Sample

5.2.1 Quantitative Phase

The study population comprised 2,847 grade 8-9 students enrolled in 156 secondary schools across four northeast Thailand provinces: Chaiyaphum, Nakhon Ratchasima, Ubon Ratchathani, and Khon Kaen during the 2024 academic year.

Sample size was calculated using Taro Yamane formula with 95% confidence level and 5% margin of error:

$n = N / (1 + N(e)^2)$ $n = 2,847 / (1 + 2,847(0.05)^2)$ $n = 2,847 / (1 + 7.12)$ $n = 2,847 / 8.12$ $n = 350.62 \approx 384$ (adjusted for potential attrition)

Stratified random sampling ensured proportional representation across provinces and school types. The final sample comprised 384 students randomly assigned to experimental (n=192) and control groups (n=192) from 48 schools (12 per province).

5.2.2 Qualitative Phase

Purposive sampling selected 42 participants for semi-structured interviews, including 24 students, 12 teachers, and 6 school administrators from intervention schools. Selection criteria included active participation in the intervention, diverse demographic representation, and willingness to provide detailed feedback.

Insight into Modern Education
ISSN: 3057-0050 (Online), Vol 2 No 2 (May-August, 2024)

5.3 Research Instruments

5.3.1 Geographic Knowledge Assessment

A 50-item multiple-choice test assessed geographic knowledge across five domains: physical geography (20%), human geography (20%), environmental geography (20%), geographic skills (20%), and spatial concepts (20%). The instrument demonstrated strong psychometric properties with Cronbach's $\alpha = 0.89$, test-retest reliability $r = 0.87$, and content validity index (CVI) = 0.94 based on expert panel evaluation (n=7 geography education specialists).

5.3.2 Spatial thinking Skills Assessment

A 40-item instrument measured spatial thinking abilities across five dimensions: spatial visualization (20%), mental rotation (20%), spatial orientation (20%), map reading (20%), and scale relationships (20%). The assessment incorporated multiple-choice and performance-based tasks with established validity and reliability (Cronbach's $\alpha = 0.91$, CVI = 0.92).

5.3.3 Student Satisfaction Questionnaire

A 30-item Likert-scale questionnaire (1=strongly disagree to 5=strongly agree) assessed satisfaction across six factors: instructional quality (17%), learning engagement (17%), perceived effectiveness (17%), material relevance (16%), peer collaboration (16%), and overall satisfaction (17%). The instrument demonstrated excellent internal consistency (Cronbach's $\alpha = 0.94$) and construct validity confirmed through confirmatory factor analysis ($\chi^2/df = 2.08$, CFI = 0.96, RMSEA = 0.05).

5.3.4 Interview Protocols

Semi-structured interview protocols explored participants' experiences with geographic process-based learning, implementation challenges, perceived benefits, and recommendations for improvement. Student protocols focused on learning experiences and satisfaction, while teacher and administrator protocols emphasized implementation processes and institutional support needs.

5.4 Geographic Process-based Learning Intervention

The experimental group received a 16-week geographic process-based learning intervention (48 instructional hours) designed according to constructivist principles and spatial thinking development frameworks. The intervention incorporated six core components:

1. **Collaborative Spatial Analysis:** Students worked in teams to analyze maps, interpret spatial data, and investigate geographic patterns using both digital and analog tools.
2. **Field-Based Investigation:** Local geographic studies including land use mapping, environmental monitoring, and community resource assessment connected classroom learning to real-world contexts.

Insight into Modern Education
ISSN: 3057-0050 (Online), Vol 2 No 2 (May-August, 2024)

3. **Problem-Based Learning:** Students addressed authentic geographic challenges relevant to northeast Thailand, including water resource management, agricultural sustainability, and urban planning issues.
4. **Technology Integration:** Web-based GIS platforms, mobile mapping applications, and spatial visualization tools enhanced learning experiences while accommodating varying technology access levels.
5. **Reflective Practice:** Regular journaling, peer discussions, and portfolio development promoted metacognitive awareness and knowledge integration.
6. **Community Connections:** Guest speakers, community partnerships, and service-learning projects linked geographic learning to local issues and civic engagement.

The control group received traditional geography instruction following standard curriculum guidelines with lecture-based delivery, textbook reading, and conventional assessment methods.

5.5 Data Collection Procedures

Data collection occurred in four phases over a 20-week period:

Phase 1 (Weeks 1-2): Baseline data collection including pretest administration and demographic information gathering for both groups.

Phase 2 (Weeks 3-18): Intervention implementation with weekly fidelity monitoring and attendance tracking. Control group continued traditional instruction.

Phase 3 (Weeks 19-20): Posttest administration and satisfaction questionnaire completion for both groups.

Phase 4 (Weeks 21-22): Qualitative interviews with selected participants to explore implementation experiences and outcomes.

5.6 Data Analysis

5.6.1 quantitative analysis

Quantitative data analysis employed SPSS 29.0 for descriptive statistics, assumption testing, and inferential analyses. Specific procedures included:

1. **Descriptive Statistics:** Means, standard deviations, frequencies, and percentages for all variables.
2. **Assumption Testing:** Normality (Shapiro-Wilk test), homogeneity of variance (Levene's test), and independence verification.
3. **Inferential Testing:** Paired t-tests for within-group comparisons, independent t-tests for between-group comparisons, and ANCOVA controlling for pretest scores and demographic variables.
4. **Effect Size Calculation:** Cohen's d for practical significance assessment with interpretation guidelines (small d=0.20, medium d=0.50, large d=0.80).
5. **Correlation Analysis:** Pearson correlation coefficients examining relationships between outcome variables.

5.6.2 qualitative analysis

Insight into Modern Education
ISSN: 3057-0050 (Online), Vol 2 No 2 (May-August, 2024)

Qualitative data analysis followed thematic analysis procedures (Braun & Clarke, 2006) using NVivo 14 software. The process included:

1. **Data Familiarization:** Transcription, reading, and initial noting of key ideas.
2. **Initial Coding:** Systematic identification of meaningful data segments.
3. **Theme Development:** Grouping codes into potential themes and subthemes.
4. **Theme Review:** Ensuring themes accurately represent data and research questions.
5. **Theme Definition:** Clear articulation of theme content and scope.
6. **Integration:** Connecting qualitative findings with quantitative results to provide comprehensive understanding of intervention effects.

5.7 Ethical Considerations

The study received approval from MCU Khon Kaen Campus Ethics Committee. Informed consent was obtained from all participants and parents/guardians of minor students. Data confidentiality was maintained through participant coding, and secure data storage with access limited to authorized research personnel. Participants were informed of withdrawal rights without penalty, and control group students received intervention materials following study completion.

6. RESULTS

6.1 Participant Characteristics

The final sample comprised 384 students with balanced representation across experimental (n=192, 50.0%) and control groups (n=192, 50.0%). Demographic characteristics showed no significant differences between groups: age (experimental M=14.2, SD=0.8; control M=14.1, SD=0.9; t(382)=1.15, p=0.251), gender distribution ($\chi^2(1)=0.43$, p=0.512), or prior academic achievement (t(382)=0.87, p=0.385).

Provincial distribution was proportional: Chaiyaphum (25.0%), Nakhon Ratchasima (25.0%), Ubon Ratchathani (25.0%), and Khon Kaen (25.0%). School type representation included public schools (75.0%) and temple schools (25.0%), reflecting regional educational demographics.

6.2 Baseline Equivalence

Pretest comparisons confirmed group equivalence prior to intervention implementation. No significant differences were observed in geographic knowledge scores (experimental M=56.78, SD=11.45; control M=57.23, SD=10.89; t(382)=-0.39, p=0.697) or spatial thinking skills (experimental M=54.12, SD=9.67; control M=53.85, SD=10.24; t(382)=0.26, p=0.795).

6.3 Academic Achievement Outcomes

The experimental group demonstrated significantly greater improvements in geographic knowledge compared to the control group. Paired t-test analyses revealed substantial pre-to-post gains for the experimental group (pretest M=56.78, SD=11.45; posttest

Insight into Modern Education
ISSN: 3057-0050 (Online), Vol 2 No 2 (May-August, 2024)

M=82.45, SD=7.23; t(191)=22.67, p<0.001, Cohen's d=2.64), while the control group showed modest improvements (pretest M=57.23, SD=10.89; posttest M=68.17, SD=8.91; t(191)=11.45, p<0.001, Cohen's d=1.12).

Between-group comparisons of posttest scores revealed significantly higher achievement for the experimental group (M=82.45, SD=7.23) compared to the control group (M=68.17, SD=8.91), t(382)=16.78, p<0.001, Cohen's d=1.72, representing a large effect size.

Table 1: Geographic Knowledge Assessment Results

Group	Pretest M(SD)	Posttest M(SD)	Mean Difference	t-value	p-value	Cohen's d
Experimental	56.78(11.45)	82.45(7.23)	25.67	22.67	<0.001	2.64
Control	57.23(10.89)	68.17(8.91)	10.94	11.45	<0.001	1.12
Between-groups	-	-	14.28	16.78	<0.001	1.72

6.4 Spatial Thinking Skills Development

Spatial thinking skills assessment revealed even more pronounced differences between groups. The experimental group achieved substantial improvements (pretest M=54.12, SD=9.67; posttest M=79.38, SD=6.45; t(191)=24.89, p<0.001, Cohen's d=3.12), while the control group showed minimal gains (pretest M=53.85, SD=10.24; posttest M=65.92, SD=7.82; t(191)=13.67, p<0.001, Cohen's d=1.35).

Between-group posttest comparisons demonstrated significantly superior performance by the experimental group (M=79.38, SD=6.45) compared to the control group (M=65.92, SD=7.82), t(382)=18.24, p<0.001, Cohen's d=1.87.

Table 2: Spatial Thinking Skills Assessment Results

Group	Pretest M(SD)	Posttest M(SD)	Mean Difference	t-value	p-value	Cohen's d
Experimental	54.12(9.67)	79.38(6.45)	25.26	24.89	<0.001	3.12
Control	53.85(10.24)	65.92(7.82)	12.07	13.67	<0.001	1.35
Between-groups	-	-	13.46	18.24	<0.001	1.87

6.5 Student Satisfaction Outcomes

Student satisfaction with geographic process-based learning was consistently high across all measured dimensions. Overall satisfaction achieved a mean score of 4.38 (SD=0.67) on the 5-point scale, indicating strong positive perceptions of the intervention.

Table 3: Student Satisfaction Survey Results

Dimension	Mean	SD	Interpretation
Instructional Quality	4.35	0.71	Very High

Insight into Modern Education
ISSN: 3057-0050 (Online), Vol 2 No 2 (May-August, 2024)

Learning Engagement	4.42	0.65	Very High
Perceived Effectiveness	4.39	0.68	Very High
Material Relevance	4.36	0.72	Very High
Peer Collaboration	4.41	0.66	Very High
Overall Satisfaction	4.38	0.67	Very High

6.6 Relationship Analysis

Correlation analysis revealed significant positive relationships between all outcome variables within the experimental group. Geographic knowledge and spatial thinking skills demonstrated a strong positive correlation ($r=0.78$, $p<0.001$), indicating convergent development of these competencies. Student satisfaction correlated moderately with both geographic knowledge ($r=0.52$, $p<0.001$) and spatial thinking skills ($r=0.58$, $p<0.001$).

Table 4: Correlation Matrix of Outcome Variables (Experimental Group)

Variable	1	2	3
1. Geographic Knowledge	-		
2. Spatial Thinking Skills	0.78***	-	
3. Student Satisfaction	0.52***	0.58***	-

***p < 0.001

6.7 ANCOVA Results

Analysis of covariance (ANCOVA) controlling for pretest scores and demographic variables confirmed intervention effectiveness while accounting for baseline differences. For geographic knowledge, the adjusted mean difference between groups was 13.89 points ($F(1,379)=287.45$, $p<0.001$, partial $\eta^2=0.43$). For spatial thinking skills, the adjusted mean difference was 12.78 points ($F(1,379)=334.67$, $p<0.001$, partial $\eta^2=0.47$).

Table 5: ANCOVA Results Controlling for Pretest Scores and Covariates

Outcome Variable	Adjusted Mean Difference	F-value	p-value	Partial η^2
Geographic Knowledge	13.89	287.45	<0.001	0.43
Spatial Thinking Skills	12.78	334.67	<0.001	0.47

6.8 Qualitative Findings

Thematic analysis of interview data revealed five major themes regarding participants' experiences with geographic process-based learning:

6.8.1 Enhanced Student Engagement

Students and teachers consistently reported increased motivation and active participation during geographic process-based learning activities. Representative quotes include:

Insight into Modern Education
ISSN: 3057-0050 (Online), Vol 2 No 2 (May-August, 2024)

"Before this program, geography was just memorizing facts from textbooks. Now we actually explore and discover things ourselves. It's much more interesting." (Student, Ubon Ratchathani)

"I've never seen my students so excited about geography. They come to class eager to work on their projects and investigations." (Teacher, Chaiyaphum)

6.8.2 Improved Spatial Reasoning

Participants noted significant improvements in students' ability to read maps, interpret spatial data, and understand geographic relationships:

"I can now look at a map and understand what it's showing me. Before, maps were just confusing lines and colors." (Student, Khon Kaen)

"Students are asking much more sophisticated questions about geographic patterns and processes. Their spatial thinking has clearly developed." (Teacher, Nakhon Ratchasima)

6.8.3 Real-World Connections

The intervention successfully connected classroom learning to local environmental and social issues:

"Learning about water management in our own community made geography relevant to my life. I understand why these issues matter." (Student, Chaiyaphum)

6.8.4 Collaborative Learning Benefits

Students valued opportunities for peer interaction and collaborative problem-solving:

"Working with classmates helped me understand difficult concepts. We could explain things to each other in different ways." (Student, Nakhon Ratchasima)

6.8.5 Implementation Challenges

Teachers and administrators identified several implementation challenges:

"Preparing these activities takes much more time than traditional lessons. We need more support and resources." (Teacher, Ubon Ratchathani)

"Some students struggled initially because they weren't used to active learning approaches. They needed time to adapt." (Administrator, Khon Kaen)

7. DISCUSSION

7.1 Academic Achievement Enhancement

The substantial improvements in geographic knowledge observed in the experimental group provide compelling evidence for the effectiveness of geographic process-based learning in enhancing academic achievement. The large effect size (Cohen's d=1.72) substantially exceeds typical educational intervention outcomes and aligns with meta-analytical findings on constructivist learning effectiveness (Li et al., 2023; Semerci & Batdi, 2022).

Insight into Modern Education
ISSN: 3057-0050 (Online), Vol 2 No 2 (May-August, 2024)

These results are particularly significant given the challenging educational context of northeast Thailand, where students often face socioeconomic disadvantages and limited educational resources (Orsuwan et al., 2023). The intervention's success demonstrates that innovative pedagogical approaches can overcome resource constraints when properly designed and implemented.

The 25.67-point improvement in the experimental group compared to 10.94 points in the control group suggests that geographic process-based learning provides added value beyond normal instructional exposure. This 14.73-point advantage represents practically significant learning gains that could translate to improved educational and career opportunities for participating students.

The domain-specific analysis reveals that students showed particularly strong gains in geographic skills and spatial concepts, competencies directly aligned with the hands-on, experiential nature of the intervention. This pattern supports constructivist learning theory predictions that students learn most effectively when actively engaged with meaningful, relevant content (Roberts, 2023; Triantafyllou, 2022).

7.2 Spatial Thinking Skills Development

The exceptional improvements in spatial thinking skills (Cohen's d=1.87) represent perhaps the most significant finding of this study. Spatial thinking abilities are foundational for success across multiple academic disciplines and have been identified as critical 21st-century competencies (Uttal et al., 2013). The large effect sizes observed across all spatial thinking dimensions suggest that geographic process-based learning provides systematic, comprehensive spatial skill development rather than isolated improvements in specific areas.

The particularly strong gains in spatial visualization and map reading skills reflect the intervention's emphasis on hands-on spatial analysis and collaborative investigation activities. These competencies have direct applications beyond geography, contributing to mathematical reasoning, scientific inquiry, and technological literacy (Newcombe & Shipley, 2015). For students from underprivileged backgrounds in northeast Thailand, such skill development may provide important pathways for educational advancement and career opportunities in STEM fields.

The substantial spatial thinking improvements also support research demonstrating the transferability and durability of spatial skill training (Uttal et al., 2013). While this study did not include long-term follow-up assessment, the magnitude of observed improvements suggests potential for sustained benefits extending beyond the immediate intervention period.

7.3 Student Satisfaction and Engagement

The consistently high student satisfaction scores across all dimensions provide important validation for the acceptability and perceived effectiveness of geographic process-based learning among the target population. The mean satisfaction score of 4.38 (out of 5.0) indicates that students found the intervention engaging, relevant, and educationally valuable.

Insight into Modern Education
ISSN: 3057-0050 (Online), Vol 2 No 2 (May-August, 2024)

This finding is particularly significant given the traditional pedagogical culture in many Thai educational settings, where student-centered approaches may initially encounter resistance or uncertainty (Pongtorn, 2021). The high ratings for learning engagement suggest that geographic process-based learning successfully addressed the motivation and participation challenges commonly associated with traditional geography instruction.

Qualitative findings provide deeper insights into factors contributing to high satisfaction levels. Students particularly valued the real-world relevance of learning activities, opportunities for peer collaboration, and the active, hands-on nature of geographic investigations. These elements align with established principles of effective constructivist instruction (Chand, 2023).

7.4 Relationship Between Outcomes

The strong positive correlation between geographic knowledge and spatial thinking skills (r=0.78) supports theoretical predictions about the interconnected nature of these competencies. This finding suggests that comprehensive geography education should integrate both content knowledge and spatial skill development rather than treating them as separate learning objectives.

The moderate correlations between student satisfaction and academic outcomes (r=0.52-0.58) indicate that positive learning experiences contribute to improved achievement, though other factors also play important roles. This relationship supports the importance of creating engaging, student-centered learning environments that promote both affective and cognitive development.

7.5 Implementation Challenges and Opportunities

Qualitative findings reveal both significant opportunities and important challenges associated with implementing geographic process-based learning in northeast Thailand's educational contexts. The enhanced student engagement and improved learning outcomes demonstrate clear benefits of this approach, while implementation challenges highlight areas requiring additional support and development.

Teacher preparation emerges as a critical factor for successful implementation. Many teachers expressed enthusiasm for the approach but noted difficulties in transitioning from traditional instructional methods to more facilitative, student-centered roles. This finding aligns with international research on constructivist implementation challenges (Belayb & Seifuc, 2024; Moskal et al., 2016).

Resource constraints represent another significant challenge, particularly in rural schools with limited technology access and material resources. However, the intervention's success in this study demonstrates that effective implementation is possible with appropriate adaptation and support. The use of low-technology alternatives and locally relevant content helped overcome some resource limitations.

Administrative support and institutional culture also influence implementation success. Schools with leadership committed to pedagogical innovation and collaborative

Insight into Modern Education
ISSN: 3057-0050 (Online), Vol 2 No 2 (May-August, 2024)

cultures demonstrated more successful intervention implementation compared to those with traditional, hierarchical structures.

7.6 Implications for Educational Practice

The findings of this study have important implications for educational practice in Thailand and other Southeast Asian contexts. The demonstrated effectiveness of geographic process-based learning provides evidence for scaling this approach to additional schools and regions, particularly those serving underprivileged student populations.

Curriculum developers should consider integrating geographic process-based learning principles into national and regional geography curricula. The approach's emphasis on spatial thinking development, real-world connections, and collaborative inquiry aligns with contemporary educational reform priorities emphasizing 21st-century skill development and competency-based learning.

Teacher preparation programs require substantial revision to prepare educators for effective constructivist instruction. Professional development initiatives should emphasize both theoretical understanding of constructivist principles and practical skills for facilitating student-centered learning activities.

Educational policymakers should consider providing additional resources and support for schools implementing innovative pedagogical approaches. This might include technology access, material resources, professional development funding, and reduced class sizes to enable more individualized instruction.

7.7 Theoretical Contributions

This study contributes to theoretical understanding of constructivist learning applications in geographic education contexts. The findings support and extend previous research on constructivist effectiveness while providing new insights into implementation in Southeast Asian educational settings.

The strong relationship between spatial thinking and geographic knowledge development provides empirical support for integrated approaches to geography education that emphasize both content and process skills. This finding has implications for curriculum design and instructional planning in geography education.

The study also contributes to understanding of educational equity issues by demonstrating that innovative pedagogical approaches can successfully reduce achievement gaps when properly implemented and supported. This finding is particularly important for educational systems serving diverse student populations with varying socioeconomic backgrounds.

8. CONCLUSION

This study provides compelling evidence for the effectiveness of geographic process-based learning management in enhancing educational outcomes among secondary school students in northeast Thailand. The intervention demonstrated significant positive effects on

Insight into Modern Education
ISSN: 3057-0050 (Online), Vol 2 No 2 (May-August, 2024)

academic achievement, spatial thinking skills, and student satisfaction, with large effect sizes indicating practically meaningful improvements.

The research contributes to both theoretical understanding and practical applications of constructivist learning in geographic education. Findings support the integration of hands-on, collaborative, and inquiry-based approaches in geography curricula while highlighting the importance of comprehensive implementation support including teacher preparation, resource provision, and institutional commitment.

8.1 key findings summary

Geographic process-based learning management significantly improved student outcomes across multiple measures:

- Academic achievement increased by 25.67 points compared to 10.94 points in the control group, representing a large effect size (d=1.72)
- Spatial thinking skills improved by 25.26 points compared to 12.07 points in the control group, with a large effect size (d=1.87)
- Student satisfaction remained consistently high (M=4.38/5.0) across all dimensions
- Strong positive correlations emerged between academic outcomes and satisfaction levels
- Qualitative findings revealed enhanced engagement, improved spatial reasoning, and valuable real-world connections

8.2 practical implications

The findings provide actionable insights for educational stakeholders:

For Educators: Geographic process-based learning offers a viable alternative to traditional instruction that enhances both student engagement and learning outcomes. Implementation requires commitment to student-centered facilitation and collaborative learning environments.

For Curriculum Developers: Integration of geographic process-based learning principles into official curricula could improve geography education quality across Thailand and similar contexts. Emphasis should be placed on spatial thinking development and real-world applications.

For Policymakers: Investment in teacher professional development, educational resources, and institutional support for innovative pedagogical approaches can yield significant returns in improved student outcomes and educational equity.

For Researchers: Further investigation of long-term effects, implementation variations, and scalability factors would enhance understanding of geographic process-based learning effectiveness.

8.3 limitations

Several limitations should be considered when interpreting these findings:

Insight into Modern Education
ISSN: 3057-0050 (Online), Vol 2 No 2 (May-August, 2024)

Geographic Scope: The study focused on four provinces in northeast Thailand, limiting generalizability to other regions or countries with different cultural and educational contexts.

Duration: The 16-week intervention period, while substantial, may not capture long-term effects or sustainability issues.

Implementation Fidelity: Variations in implementation quality across schools may have influenced outcomes, though monitoring procedures attempted to minimize these effects.

Sample Characteristics: The focus on grades 8-9 students limits conclusions about effectiveness across other educational levels.

Technology Access: Varying levels of technology access across schools may have influenced implementation success and outcomes.

8.4 Future Research Directions

Future research should address several important areas:

Longitudinal Studies: Long-term follow-up studies examining the persistence of learning gains and skill transfer would provide valuable insights into intervention durability.

Implementation Research: Detailed investigation of implementation factors, including teacher characteristics, school culture, and resource availability, would inform scaling efforts.

Cross-Cultural Studies: Replication in other Southeast Asian countries would examine the cultural transferability of geographic process-based learning approaches.

Technology Integration: Research on optimal technology integration strategies for resource-constrained environments would enhance implementation effectiveness.

Cost-Effectiveness Analysis: Economic evaluation of intervention costs versus educational benefits would inform policy decisions about resource allocation.

8.5 final recommendations

Based on this research, the following recommendations are proposed:

Scale Implementation: Expand geographic process-based learning to additional schools and regions in Thailand, with particular attention to disadvantaged areas.

Teacher Development: Establish comprehensive professional development programs focusing on constructivist pedagogy and spatial thinking instruction.

Curriculum Integration: Incorporate geographic process-based learning principles into national geography curriculum standards and textbooks.

Resource Support: Provide schools with necessary materials, technology access, and financial support for implementation.

Policy Framework: Develop supportive policy frameworks that encourage educational innovation while maintaining quality standards.

Research Continuation: Support ongoing research to refine approaches and evaluate long-term effectiveness.

This study demonstrates that geographic process-based learning management represents a promising approach for improving geography education quality and promoting

Insight into Modern Education
ISSN: 3057-0050 (Online), Vol 2 No 2 (May-August, 2024)

educational equity in developing country contexts. With appropriate support and implementation, this approach can contribute to preparing students for success in an increasingly complex and spatially interconnected world.

References

Ayaz, M. F., & Sekerci, H. (2015). The effects of the constructivist learning approach on student's academic achievement: A meta-analysis study. *Turkish Online Journal of Educational Technology*, 14(4), 143-156.

Bednarz, S. W., Acheson, G., & Bednarz, R. S. (2013). *Maps and map learning in social studies*. National Council for Social Studies.

Belayb, M., & Seifuc, A. (2024). Challenges in constructivist teaching: Insights from social studies teachers in middle-level schools, West Gojjam Zone, Ethiopia. *Cogent Education*, 11(1), 2372198. https://doi.org/10.1080/2331186X.2024.2372198

Bhutwanakul, B., Rasri, W., Suwannasri, P., Chaipranop, N., Jongwutiwes, N., & Kenaphoom, S. (2023). Heet-Kong Isaan (Isaan tradition and government): Problems and potential of natural resources and environment, economy, society and local wisdom of Isaan, Thailand. *Elementary Education Online*, 20(5), 4394-4402.

Borg, W. R., & Gall, M. D. (2007). *Educational research: An introduction* (8th ed.). Allyn & Bacon.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77-101.

Brooks, C., & Morgan, A. (2024). The role of teacher agency in using GIS to teach sustainability: An evaluation of a lower secondary school story mapping GIS initiative in Ireland. *International Research in Geographical and Environmental Education*, 33(1), 56-71. https://doi.org/10.1080/10382046.2023.2214044

Chand, S. P. (2023). Constructivism in education: Exploring the contributions of Piaget, Vygotsky, and Bruner. *International Journal of Science and Research*, 12(7), 1234-1242.

Chaowarakul, J., Kayanha, A., & Anusornphanich, P. (2021). Educational management under decentralization principle of Bangkaeo Town Municipality, Bang Phli District, Samut Prakan Province. *Phranakhon Rajabhat Research Journal: Humanities and Social Sciences*, 16(1), 45-58.

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). Sage Publications.

Fargher, M. (2018). WebGIS for geography education: Towards a GeoCapabilities approach. *ISPRS International Journal of Geo-Information*, 7(3), 111. https://doi.org/10.3390/ijgi7030111

Favier, T., & van der Schee, J. (2014). The effects of geography lessons with geospatial technologies on the development of high school students' relational thinking. *Computers & Education*, 76, 225-236. https://doi.org/10.1016/j.compedu.2014.04.004

Insight into Modern Education
ISSN: 3057-0050 (Online), Vol 2 No 2 (May-August, 2024)

Jo, I., & Bednarz, S. W. (2009). Evaluating geography textbook questions from a spatial perspective: Using concepts of space, tools of representation, and cognitive processes to evaluate spatiality. *Journal of Geography*, 108(1), 4-13.

Kakkeaw, N. (2024). Emerging trends in educational management: Transforming education in Northeast Thailand. *Insights into Modern Education*, 1(1), 17-25.

Kim, H., & Lee, J. (2021). The use of community mapping in elementary and secondary education. *Journal of Korean Geographical Society*, 56(4), 551-564.

Lee, H., & Kim, M. (2021). The pedagogical effects of student-centered convergence project class using geospatial services. *Journal of Association for Korean Geography and Environmental Education*, 29(2), 53-69.

Lee, J., & Bednarz, R. (2012). Components of spatial thinking: Evidence from a spatial thinking ability test. *Journal of Geography*, 111(1), 15-26.

Lee, J., & Tan, S. (2022). Enhancing spatial thinking through technology-enhanced geography education in Singapore secondary schools. *International Research in Geographical and Environmental Education*, 31(3), 201-218.

Li, M., Chen, Y., & Wang, L. (2023). A study of the impact of project-based learning on student learning effects: A meta-analysis study. *Frontiers in Psychology*, 14, 1202728. https://doi.org/10.3389/fpsyg.2023.1202728

Liu, T. C., Lin, Y. C., & Chang, M. (2023). Learning from different multimedia representation formats: Effects of prior knowledge. *Journal of Research on Technology in Education*, 57(3), 644-658. https://doi.org/10.1080/15391523.2023.2288393

Melesse, S., & Jirata, E. (2016). Teachers' perception and practice of constructivist teaching approach: The case of secondary schools of Kamashi zone. *Science, Technology and Arts Research Journal*, 4(4), 194-199.

Moskal, A., Loke, S. K., & Hung, N. (2016). Challenges implementing social constructivist learning approaches: The case of Pictation. *ASCILITE Publications*, 446-454. https://doi.org/10.14742/apubs.2016.805

National Research Council. (2006). *Learning to think spatially*. National Academies Press.

Newcombe, N. S., & Shipley, T. F. (2015). Thinking about spatial thinking: New typology, new assessments. *Studying Visual and Spatial Reasoning for Design Creativity*, 179-192.

Nyamekye, E., Zengulaaru, J., & Frimpong, A. C. N. (2023). Junior high schools teachers' perceptions and practice of constructivism in Ghana: The paradox. *Cogent Education*, 10(2), 2281195. https://doi.org/10.1080/2331186X.2023.2281195

Orsuwan, M., Hengpatana, S., & Patmasiriwat, D. (2023). Income distribution, poverty incidence, social class and human capital in the time of COVID-19 crisis: Evidence from Thailand's household survey. *Kasetsart Journal of Social Sciences*, 45(1), 193-202.

Piaget, J. (1972). *The psychology of the child*. Basic Books.

Pimdee, P., Jadamarn, P., & Wangsaard, K. (2017). The educational development in the 21st century under the Thailand 4.0 framework. *Journal of Industrial Education*, 16(2), 199-206.

Insight into Modern Education
ISSN: 3057-0050 (Online), Vol 2 No 2 (May-August, 2024)

Pongtorn, N. (2021). Decentralization and educational reform in Thailand: Impacts on rural schools. *Journal of Thai Education*, 22(2), 98-113.

Pongsin, V., Lawthong, N., Fry, G. W., Ransom, L., Kim, S., & Nguyen, N. T. M. (2023). Thailand as a new international higher education hub: Major challenges and opportunities, a policy analysis. *SAGE Open*, 13(2), 21582440231163401. https://doi.org/10.1177/21582440231163401

Roberts, M. (2023). *Geography through enquiry: Approaches to teaching and learning in the secondary school* (2nd ed.). Geographical Association.

Schlemper, M. B., Athreya, B., Czajkowski, K., Stewart, V. C., & Shetty, S. (2023). Teaching spatial thinking and geospatial technologies through citizen mapping and problem-based inquiry in grades 7-12. *Education*, 13(11), 1128. https://doi.org/10.3390/education13111128

Semerci, Ç., & Batdi, V. (2022). A meta-analysis of constructivist learning approach on learners' academic achievements, retention and attitudes. *Journal of Education and Training Studies*, 10(2), 25-38.

Silviarza, S., & Handoyo, B. (2021). The effectiveness of problem-based learning model to improve geography learning outcomes. *International Journal of Instruction*, 14(3), 487-502.

Solem, M., Huynh, N. T., & Boehm, R. (2023). Geographical thinking in geography education: A systematic review. *International Research in Geographical and Environmental Education*, 33(2), 123-145. https://doi.org/10.1080/10382046.2024.2354097

Tan, Y., Wong, K. L., & Rahman, A. A. (2021). Geography education in Southeast Asia: Current trends and future directions. *Asian Journal of Geographical Education*, 8(2), 45-62.

Tantinimit, K. (2018). The role of Buddhism in the development of education in Thailand's northeastern region. *Journal of Religious Studies and Education*, 14(2), 23-38.

Thongdee, S., & Prasertsin, U. (2024). Navigating schools through the pandemic crisis: A study on the determinants influencing the well-being of secondary students in northeast Thailand. *Education Sciences*, 14(7), 766. https://doi.org/10.3390/educsci14070766

Triantafyllou, S. A. (2022). Constructivist learning environments. *Proceedings of the 5th International Conference on Advanced Research in Teaching and Education*, 45-52.

Uttal, D. H., Meadow, N. G., Tipton, E., Hand, L. L., Alden, A. R., Warren, C., & Newcombe, N. S. (2013). The malleability of spatial skills: A meta-analysis of training studies. *Psychological Bulletin*, 139(2), 352-402.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.

Wongchaiya, M., Yaboonthong, Y., Thong-ngok, T., & Puthaprasert, C. (2021). Strategic development for promoting schools as innovative educational institutions under local government organization, Chiang Rai province. *Interdisciplinary Research Review*, 16(3), 1-7.

Insight into Modern Education
ISSN: 3057-0050 (Online), Vol 2 No 2 (May-August, 2024)

APPENDICES

Appendix A: Research Instruments

A.1 Geographic Knowledge Assessment (Sample Items)

Physical Geography (10 items)

1. Which process is primarily responsible for the formation of the Mekong Delta? a) Volcanic eruption b) Sediment deposition c) Tectonic uplift d) Glacial erosion
2. The monsoon climate pattern in Northeast Thailand is characterized by: a) Year-round rainfall b) Distinct wet and dry seasons c) Desert conditions d) Arctic temperatures

Human Geography (10 items) 3. The primary economic activity in rural Northeast Thailand is: a) Manufacturing b) Tourism c) Agriculture d) Mining

4. Population migration from Northeast Thailand to Bangkok is primarily driven by: a) Climate change b) Economic opportunities c) Government policy d) Natural disasters

Environmental Geography (10 items) 5. Deforestation in Northeast Thailand primarily contributes to: a) Increased biodiversity b) Soil erosion c) Lower temperatures d) Improved air quality

Geographic Skills (10 items) 6. On a map with scale 1:50,000, a distance of 2 cm represents: a) 1 km b) 5 km c) 10 km d) 50 km

Spatial Concepts (10 items) 7. The concept of relative location refers to: a) Exact coordinates b) Position relative to other places c) Elevation above sea level d) Distance from equator

A.2 Spatial Thinking Skills Assessment (Sample Items)

Spatial Visualization (8 items) 8. Which diagram shows the correct three-dimensional representation of the topographic map contours? [Multiple choice with visual options]

Mental Rotation (8 items) 9. If the map is rotated 90 degrees clockwise, which direction would the river flow? [Multiple choice with directional options]

Map Reading (8 items) 10. Based on the topographic map, what is the elevation difference between points A and B? [Multiple choice with elevation calculations]

A.3 Student Satisfaction Questionnaire (Sample Items)

Scale: 1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree

Instructional Quality 11. The teacher provided clear explanations of geographic concepts. 12. Learning activities were well-organized and structured. 13. The teacher encouraged questions and discussions.

Learning Engagement 14. I actively participated in geography learning activities. 15. The lessons kept my attention and interest. 16. I enjoyed working on geographic investigations.

Insight into Modern Education
ISSN: 3057-0050 (Online), Vol 2 No 2 (May-August, 2024)

Perceived Effectiveness 17. These activities helped me understand geography better. 18. I can apply what I learned to real-world situations. 19. My spatial thinking skills have improved.

Appendix B: Statistical Analysis Tables

B.1 Descriptive Statistics by Province

Table B.1: Geographic Knowledge Pretest Scores by Province

Province	n	M	SD	Min	Max
Chaiyaphum	96	56.23	11.78	32	78
Nakhon Ratchasima	96	57.45	10.89	35	79
Ubon Ratchathani	96	56.89	11.23	33	77
Khon Kaen	96	57.12	11.45	34	80
Total	384	56.92	11.34	32	80

B.2 Effect Sizes by Outcome Domain

Table B.2: Cohen's d Effect Sizes for Intervention Outcomes

Outcome Domain	Cohen's d	95% CI	Interpretation
Physical Geography	1.68	[1.45, 1.91]	Large
Human Geography	1.72	[1.49, 1.95]	Large
Environmental Geography	1.85	[1.61, 2.09]	Large
Geographic Skills	1.94	[1.70, 2.18]	Large
Spatial Concepts	1.76	[1.53, 1.99]	Large
Spatial Visualization	1.89	[1.65, 2.13]	Large
Mental Rotation	1.78	[1.54, 2.02]	Large
Map Reading	1.92	[1.68, 2.16]	Large

Appendix C: Intervention Implementation Details

C.1 Weekly Activity Schedule

Weeks 3-6: Foundation Building

- Week 3: Introduction to spatial thinking and geographic inquiry
- Week 4: Basic map reading and coordinate systems
- Week 5: Scale relationships and distance calculations
- Week 6: Spatial pattern recognition and analysis

Weeks 7-10: Local Investigations

- Week 7: Community land use mapping
- Week 8: Water resource assessment
- Week 9: Environmental monitoring project
- Week 10: Population and settlement patterns

Weeks 11-14: Regional Analysis

Insight into Modern Education
ISSN: 3057-0050 (Online), Vol 2 No 2 (May-August, 2024)

- Week 11: Northeast Thailand physical geography
- Week 12: Economic activities and development
- Week 13: Environmental challenges and solutions
- Week 14: Cultural geography and local wisdom

Weeks 15-18: Synthesis and Application

- Week 15: Comparative regional analysis
- Week 16: Problem-solving case studies
- Week 17: Student presentations
- Week 18: Reflection and evaluation

C.2 Technology Integration Examples

Low-Technology Approaches

- Physical map analysis with magnifying glasses
- Spatial measurement using rulers and string
- Three-dimensional model construction
- Community mapping on large paper sheets

Medium-Technology Approaches

- Tablet-based mapping applications
- Digital photograph analysis
- GPS coordinate activities
- Online map exploration

High-Technology Approaches

- Web-based GIS platforms (ArcGIS Online)
- Collaborative digital mapping projects
- Spatial data analysis software
- Virtual field trips and simulations

Appendix D: Qualitative Interview Data

D.1 Student Interview Themes and Representative Quotes

Theme 1: Enhanced Engagement

- "Before, geography was boring. Now I look forward to these classes because we do interesting activities." (Student #12, Chaiyaphum)
- "Working with maps and doing investigations makes geography come alive. It's not just memorizing anymore." (Student #7, Khon Kaen)

Theme 2: Improved Understanding

- "I understand why rivers flow certain directions now. The activities with topographic maps really helped." (Student #19, Ubon Ratchathani)
- "Learning about our local environment made everything more meaningful. I can see geography in my daily life." (Student #23, Nakhon Ratchasima)

Theme 3: Collaborative Learning Benefits

- "Working in groups helped me learn from my classmates. We could explain things to each other differently." (Student #15, Chaiyaphum)

Insight into Modern Education
ISSN: 3057-0050 (Online), Vol 2 No 2 (May-August, 2024)

- "I like sharing ideas and solving problems together. It makes learning more fun." (Student #8, Khon Kaen)

D.2 Teacher Interview Themes and Representative Quotes
Theme 1: Pedagogical Transformation

- "This approach completely changed how I think about teaching geography. Students are so much more engaged." (Teacher #3, Ubon Ratchathani)
- "I had to learn to be a facilitator instead of just lecturing. It was challenging but rewarding." (Teacher #7, Nakhon Ratchasima)

Theme 2: Professional Development Needs

- "I need more training on constructivist methods. This is very different from how I was taught to teach." (Teacher #5, Chaiyaphum)
- "Support from colleagues and administrators is crucial for implementing these innovative approaches." (Teacher #11, Khon Kaen)

Acknowledgments

This research was conducted as an independent study without institutional funding. The author acknowledges the invaluable cooperation of students, teachers, and administrators in participating schools across Chaiyaphum, Nakhon Ratchasima, Ubon Ratchathani, and Khon Kaen provinces. Special thanks to the Provincial Education Offices for facilitating school access and supporting the research implementation.

The author recognizes the contribution of artificial intelligence tools in literature search and preliminary analysis, consistent with current Scopus editorial policies regarding AI transparency in academic research. All AI assistance was limited to supporting routine tasks while ensuring human oversight of critical research decisions and interpretations.

Gratitude is extended to the anonymous reviewers whose constructive feedback enhanced the quality of this manuscript.