Journal of Curriculum and Teaching; Vol. 15, No. 4; 2026
ISSN 1927-2677 E-ISSN 1927-2685
Published by Sciedu Press

The Effectiveness of a Visual Representation Strategy in Developing Geographical Thinking Skills among Tenth-Grade Students

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Received: June 8, 2026 Accepted: September 29, 2026 Online Published: November 2, 2026

doi:10.5430/jct.v15n4p258 URL: https://doi.org/10.5430/jct.v15n4p258

Abstract

This study aimed to examine the effectiveness of a visual representation strategy in developing geographical thinking skills among tenth-grade female students in Jordan. A quasi-experimental design was employed with 40 female students at Mughayir Al-Sarhan Coeducational Secondary School during the second semester of the 2025–2026 academic year. Two intact classes were randomly selected from four available classes. According to a predetermined assignment procedure, the first selected class was designated as the experimental group (n = 20), taught using the visual representation strategy, while the second was designated as the control group (n = 20), which received conventional instruction based primarily on teacher explanation, questioning, and classroom discussion. A geographical thinking test was developed to measure three domains: acquiring geographical information, collecting and organizing geographical information, and analyzing geographical information. The instrument demonstrated appropriate validity and reliability. The findings revealed statistically significant differences in favor of the experimental group in the overall geographical thinking test and its three domains. The study concluded that visual representation strategies can enhance students' geographical thinking skills. Accordingly, it recommends integrating visual representation activities into geography curricula and providing professional development for teachers. Given the small sample and single-school setting, the findings should be interpreted with caution.

Keywords: visual representation strategy, geography education, geographical thinking skills, teaching methods

1. Introduction

Education extends beyond knowledge transmission to developing students' thinking skills and their ability to apply knowledge in meaningful contexts. Rapid knowledge expansion and technological advancement have increased the need for instructional strategies that promote active learning and knowledge application. This need is particularly relevant to geography education, where students are expected to acquire, interpret, and analyze geographical information and recognize relationships among geographical phenomena. Al-Asadi and Al-Masoudi (2015) indicated that effective instructional strategies develop learners' cognitive skills, including observation, interpretation, and analysis, while facilitating the organization and presentation of geographical information.

Geography relies on various tools to collect, organize, represent, and interpret geographical information. Maps, graphs, and diagrams provide visual representations that facilitate understanding of geographical phenomena (Al-Jawhari, 1997). Aerial photographs and satellite imagery further support the identification and analysis of geographical features, monitoring changes over time, and obtaining accurate information (Daoud, 2013). Given the visual and spatial nature of geography, these representations help students observe phenomena, recognize relationships, and interpret spatial patterns.

The educational value of visual representations depends on their systematic integration into instruction. Ammar and Al-Qabbani (2011) emphasized that visual representation can organize knowledge and connect concepts rather than serve merely as an illustrative aid. This perspective aligns with Dual Coding Theory, which proposes that learning is

enhanced when information is processed through interconnected verbal and nonverbal systems (Clark & Paivio, 1991). Accordingly, combining verbal explanations with visual representations may enhance information processing and retention, particularly in geography, where maps, images, graphs, and diagrams are central to representing geographical phenomena.

Technological developments have expanded opportunities for visual learning in geography through interactive maps, animations, three-dimensional models, and other digital resources that support students' exploration and analysis. Such resources have been associated with engagement, critical thinking, and spatial analysis (Panjaitan et al., 2023). However, their availability alone does not ensure the development of geographical thinking skills; their effectiveness depends on systematic integration into instruction and alignment with learning outcomes.

From a sociocultural perspective, visual representations can function as mediational tools that support knowledge construction through social interaction. Vygotsky's sociocultural theory emphasizes the role of cultural tools in connecting learners' prior experiences with abstract concepts and constructing meaning through interaction with teachers and peers (Vygotsky, 1978, as cited in Yoon et al., 2021). Similarly, Al-Khafaji (2021) highlighted how images, symbols, shapes, and diagrams can organize information and reveal relationships among concepts. Building on these perspectives, the present study developed a structured visual representation strategy that integrates visual materials into activities for acquiring, organizing, analyzing, and interpreting geographical information.

Geographical thinking is an essential component of geography education and involves analyzing geographical information and examining relationships among people, places, and the environment. The National Geography Standards, developed by the National Council for Geographic Education (NCGE), emphasize skills such as asking geographical questions, collecting and organizing geographical information, and analyzing and interpreting information using appropriate geographical tools and technologies, including GIS (Heffron, 2012).

Visual representations can support these processes by enabling students to compare, classify, and interpret geographical information and solve geographical problems (Hilander, 2023). These skills also involve recognizing relationships and interpreting geographical phenomena (Al-Qursh & Abdulrahman, 2010).

Previous studies have demonstrated the value of visual representations in geography learning and in developing geographical and learning-related skills. However, many have focused on specific types of visual representations, such as electronic maps (El-Hosary, 2016), illustrative images (Trahorsch & Bláha, 2020), comics (Reumont & Budke, 2021), and mind maps (Huang et al., 2024).

Although these studies provide evidence of the value of particular visual representations, limited attention has been given to integrating multiple types of visual representations within a structured instructional strategy and examining its effectiveness in developing specific geographical thinking skills. The present study addresses this gap by developing and employing a structured visual representation strategy that integrates multiple representations according to the geographical content and intended learning objectives.

Building on this gap, the present study developed and examined a structured visual representation strategy integrating multiple geographical representations to develop students' geographical thinking skills. The study examined its effectiveness among tenth-grade female students in Jordan using a quasi-experimental pretest–posttest design. The experimental group received instruction through the strategy, while the control group received conventional instruction. Post-test scores were analyzed while controlling for pre-test scores. The null hypothesis stated that no statistically significant differences at $\alpha = .05$ would exist between the groups in Geographical Thinking Test scores attributable to the teaching method.

2. Methodology

The study employed a quasi-experimental pretest–posttest design with two intact tenth-grade classes to examine the effectiveness of a visual representation strategy in developing geographical thinking skills among female students. Four tenth-grade classes were available at the selected school, from which two intact classes were randomly selected by drawing lots. According to a predetermined assignment procedure, the first selected class was designated as the experimental group, whereas the second selected class was designated as the control group. Individual students were not randomly assigned to the groups. Both groups completed the Geographical Thinking Test before and after the intervention. The design was represented as follows:

Experimental Group: O_1 X O_2

Control Group: O_1 — O_2

where O_1 denotes the pretest, X denotes instruction using the visual representation strategy, and O_2 denotes the posttest.

The participants were 40 tenth-grade female students from two intact classes at Mughayir Al-Sarhan Coeducational Secondary School, Directorate of Education of the Northwestern Badia, Jordan, during the second semester of the 2025–2026 academic year. Each group consisted of 20 students. The study was conducted in a computer laboratory equipped with computers, a projector, and Internet access, which were used to present the lessons through PowerPoint presentations and to display images, tables, videos, and other visual representations. Official approval to conduct the study was obtained from the Ministry of Education through Yarmouk University, and parental consent was obtained before the students' participation.

The Geographical Thinking Test consisted of 30 multiple-choice items equally distributed across three geographical thinking skills: acquiring geographical information, collecting and organizing geographical information, and analyzing geographical information, with 10 items assigned to each skill. Each correct response received one point, whereas an incorrect or unanswered response received zero points, yielding a total score ranging from 0 to 30 and a maximum of 10 points for each skill. The pretest scores for the total test and the three skills were used as covariates in the statistical analyses.

The Geographical Thinking Test was developed based on the relevant literature and previous studies and was reviewed by expert reviewers of the instrument. The test was refined in light of their feedback and recommendations before its final administration. To examine item validity, the test was administered to a pilot sample of 20 female students from the study population who were excluded from the main sample. Pearson correlation coefficients were calculated between each item and its corresponding skill and between each item and the total test score. The results are presented in Table 1.

Table 1. Item–Skill and Item–Total Correlation Coefficients for the Geographical Thinking Test

Skill	Item No.	Item–Skill Correlation	Item–Total Correlation
Acquiring geographical information	4	.64	.43
	20	.55	.36
	23	.67	.44
	24	.60	.40
	25	.62	.41
	26	.66	.43
	27	.57	.38
	28	.61	.40
	29	.67	.44
	30	.57	.39
Collecting and organizing geographical information	1	.68	.44
	2	.52	.37
	3	.63	.45
	7	.60	.41
	11	.58	.36
	13	.59	.39
	15	.56	.37
	19	.60	.40
	21	.63	.42
	22	.57	.38

Table 1. Item–Skill and Item–Total Correlation Coefficients for the Geographical Thinking Test (continued)

Skill	Item No.	Item–Skill Correlation	Item–Total Correlation
Analyzing geographical information	5	.61	.41
	6	.58	.39
	8	.62	.41
	9	.55	.38
	10	.70	.46
	12	.61	.40
	14	.66	.42
	16	.60	.39
	17	.64	.42
	18	.55	.37

Note. Pearson's correlation coefficient was used to calculate item–skill and item–total correlations.

As shown in Table 1, all item–skill and item–total correlation coefficients exceeded the reference criterion of .20 adopted in this study based on Oudah (2010). Accordingly, no items were deleted, and the final version of the test comprised 30 items. Test reliability was assessed using Cronbach's alpha and test–retest reliability over a two-week interval using the same pilot sample. The results are presented in Table 2.

Table 2. Reliability Coefficients of the Geographical Thinking Test

Skill	Internal Consistency	Test–Retest Reliability	Number of Items
Acquiring geographical information	.82	.85	10
Collecting and organizing geographical information	.84	.86	10
Analyzing geographical information	.80	.83	10
Total test	.87	.87	30

Note. Internal consistency was assessed using Cronbach's alpha.

The results in Table 2 show that the Cronbach's alpha coefficients were .82, .84, and .80 for acquiring geographical information, collecting and organizing geographical information, and analyzing geographical information, respectively, and .87 for the total test. The corresponding test–retest reliability coefficients were .85, .86, and .83, respectively, and .87 for the total test. Item difficulty and discrimination indices were also calculated to evaluate the test items. The results are presented in Table 3.

The item difficulty indices ranged from .35 to .74, whereas the discrimination indices ranged from .28 to .64. All items were retained in the final version of the test.

The instructional intervention was based on the Environmental Issues unit in the Grade 10 Geography textbook. The unit included three lessons: Climate Change: Its Causes, Effects, and Ways to Address It; Environmental Impact Assessment; and Technological Development and Its Impact on the Environment. Relevant literature and previous studies were reviewed in developing the instructional strategy, and the Geographical Thinking Test was refined based on the feedback and recommendations of the instrument reviewers.

Both groups studied the same instructional content for the same number of sessions and the same total instructional time. Two introductory sessions were conducted to familiarize students with the study procedures and were not included in the intervention period. The intervention lasted three weeks and consisted of six 45-minute sessions, with two sessions conducted per week.

The experimental group was taught by the researcher using a structured visual representation strategy. The strategy integrated multiple forms of geographical visual representations, including images, graphs, tables, maps, aerial and satellite imagery, and models, selected according to the content and intended learning outcomes. The strategy was implemented through five main steps. First, the content and learning outcomes were identified and the appropriate visual representations were selected. Second, the selected representations were presented to introduce the content,

engage students, and activate their prior knowledge. Third, students were guided to acquire, collect, and organize geographical information using the presented representations. Fourth, students were guided to analyze and interpret the information and identify relationships through questions and classroom discussion. Fifth, students' learning was evaluated through activities requiring them to apply the targeted geographical thinking skills using visual representations.

Table 3. Difficulty and Discrimination Indices of the Geographical Thinking Test

Item No.	Difficulty Index	Discrimination Index	Item No.	Difficulty Index	Discrimination Index
1	.58	.42	16	.54	.62
2	.63	.36	17	.48	.46
3	.61	.42	18	.48	.44
4	.54	.48	19	.58	.36
5	.49	.42	20	.65	.46
6	.50	.46	21	.58	.41
7	.58	.38	22	.56	.52
8	.42	.32	23	.62	.64
9	.48	.36	24	.64	.58
10	.51	.42	25	.69	.49
11	.35	.28	26	.72	.45
12	.50	.55	27	.62	.49
13	.52	.46	28	.74	.52
14	.56	.52	29	.72	.55
15	.64	.48	30	.74	.57

The control group received conventional instruction delivered by the school teacher, based primarily on teacher explanation, questioning, and classroom discussion. Students listened to explanations, responded to questions, and participated in classroom discussions, without the systematic integration of diverse visual representations to support the acquisition, collection and organization, and analysis of geographical information. The experimental group was taught by the researcher, whereas the control group was taught by the school teacher; the two teachers had comparable teaching experience.

Before the intervention, the Geographical Thinking Test was administered to both groups as a pretest. Following completion of the intervention, the same test was administered as a posttest to assess students' geographical thinking skills. The pretest results were examined to determine whether the two groups were comparable before the intervention. The results are presented in Table 4.

Table 4. Independent-Samples *t*-Test Results for Pretest Comparability between the Study Groups

Dependent Variable	Group	Mean	Std. Deviation	t	df	Sig.
Acquiring geographical information	Experimental	3.50	1.05	0.52	38	.606
	Control	3.35	0.75			
Collecting and organizing geographical information	Experimental	3.65	0.88	1.12	38	.272
	Control	3.95	0.83			
Analyzing geographical information	Experimental	3.60	0.94	0.87	38	.390
	Control	3.35	0.88			
Geographical Thinking Test (total)	Experimental	10.75	1.52	0.20	38	.845
	Control	10.65	1.69			

Note. t = independent-samples t test; df = degrees of freedom.

As shown in Table 4, there were no statistically significant differences between the experimental and control groups in the pretest scores for acquiring geographical information, collecting and organizing geographical information, analyzing geographical information, or the total Geographical Thinking Test score ($p > .05$), indicating comparable pretest performance between the two groups.

The data were analyzed using SPSS. Means and standard deviations were calculated for the study variables. An independent-samples t test was used to examine pretest comparability between the two groups. Analysis of covariance (ANCOVA) was conducted to examine differences in the total posttest score while controlling for the corresponding pretest score. Multivariate analysis of covariance (MANCOVA) was used to examine differences across the three geographical thinking skills simultaneously while controlling for their corresponding pretest scores, followed by univariate analyses to examine the effects on each skill. Box's M test was used to examine the homogeneity of the covariance matrices for the multivariate analysis. Statistical significance was evaluated at $\alpha = .05$, and partial eta squared (ηp^2) was reported as an effect-size measure.

3. Results

This section presents the results of the statistical analyses conducted to address the research question and examine differences between the experimental and control groups. Descriptive and inferential statistics were used to analyze the data, with relevant pretest scores included as covariates where appropriate.

3.1 Results Related to the Research Question

The research question was:

"Are there statistically significant differences at $\alpha = .05$ between the mean scores of the experimental and control groups on the Geographical Thinking Test attributable to the teaching method (visual representation strategy versus conventional instruction)?"

To address the research question, means and standard deviations were calculated for the experimental and control groups' pre-test and post-test scores on the Geographical Thinking Test and its three subskills. Adjusted post-test means and standard errors were also calculated using the covariance analyses. The results are presented in Table 5.

Table 5. Means, Standard Deviations, Adjusted Means, and Standard Errors for the Geographical Thinking Test and Subskills

Group	Skill	Pretest M	Pretest SD	Posttest M	Posttest SD	Adjusted M	SE
Experimental	Acquiring geographical information	3.50	1.05	8.95	0.83	8.97	0.22
	Collecting and organizing geographical information	3.65	0.88	8.70	0.98	8.67	0.26
	Analyzing geographical information	3.60	0.94	9.05	0.76	9.03	0.21
	Total test	10.75	1.52	26.70	1.75	26.68	0.41
Control	Acquiring geographical information	3.35	0.75	7.25	1.33	7.23	0.22
	Collecting and organizing geographical information	3.95	0.83	7.00	1.30	7.03	0.26
	Analyzing geographical information	3.35	0.88	7.20	1.11	7.22	0.21
	Total test	10.65	1.69	21.45	2.19	21.47	0.41

Note. M = mean; SD = standard deviation; SE = standard error. The maximum possible score on the Geographical Thinking Test was 30.

As shown in Table 5, both groups had higher posttest than pretest mean scores. For the total Geographical Thinking Test, the experimental group's mean increased from 10.75 to 26.70, compared with an increase from 10.65 to 21.45 for the control group. The adjusted posttest means were 26.68 and 21.47 for the experimental and control groups, respectively.

Similar patterns were observed across the three geographical thinking skills. The experimental group had adjusted posttest means of 8.97, 8.67, and 9.03 for acquiring, collecting and organizing, and analyzing geographical information,

respectively. The corresponding means for the control group were 7.23, 7.03, and 7.22, respectively.

Because descriptive differences do not establish statistical significance, ANCOVA was conducted to determine whether the difference between the groups in total posttest scores remained significant after controlling for pretest scores. The results are presented in Table 6.

Table 6. ANCOVA Results for the Total Geographical Thinking Test

Source of Variance	Sum of Squares	df	Mean Square	F	Sig.	Eta Squared
Pretest (Covariate)	23.098	1	23.098	6.780	.013	.155
Teaching Method	270.284	1	270.284	79.336	<.001	.682
Error	126.052	37	3.407	—	—	—
Total	424.775	39	—	—	—	—

Note. Eta squared (η^2) represents the effect size.

As shown in Table 6, after controlling for pretest scores, a statistically significant difference was found between the experimental and control groups in total Geographical Thinking Test scores, $F(1, 37) = 79.336$, $p < .001$, $\eta^2 = .682$. The adjusted posttest mean was higher for the experimental group ($M = 26.68$) than for the control group ($M = 21.47$), with the teaching method accounting for 68.2% of the variance in adjusted posttest scores.

3.2 Results for the Geographical Thinking Skills

Table 7. MANCOVA Results for the Geographical Thinking Skills

Source	Skill	Hotelling's Trace	Sum of Squares	df	Mean Square	F	p	Partial ηp^2
Pretest (Covariate)	Acquiring geographical information	—	11.518	1	11.518	11.983	.001	.255
	Collecting and organizing geographical information	—	.289	1	.289	.222	.640	.006
	Analyzing geographical information	—	2.742	1	2.742	3.121	.086	.082
Teaching Method	Overall multivariate effect	2.049	—	3, 33	—	22.542	<.001	.672
Teaching Method	Acquiring geographical information	—	28.627	1	28.627	29.782	<.001	.460
	Collecting and organizing geographical information	—	25.136	1	25.136	19.324	<.001	.356
	Analyzing geographical information	—	30.818	1	30.818	35.072	<.001	.501
Error	Acquiring geographical information	—	33.642	35	.961	—	—	—
	Collecting and organizing geographical information	—	45.527	35	1.301	—	—	—
	Analyzing geographical information	—	30.754	35	.879	—	—	—
Corrected Total	Acquiring geographical information	—	75.600	39	—	—	—	—
	Collecting and organizing geographical information	—	79.100	39	—	—	—	—
	Analyzing geographical information	—	68.375	39	—	—	—	—

Note. Hotelling's Trace = 2.049, $F(3, 33) = 22.542$, $p < .001$, and partial $\eta p^2 = .672$ for the overall multivariate effect of teaching method. Partial ηp^2 represents partial eta squared.

A multivariate analysis of covariance (MANCOVA) was conducted to examine differences between the experimental and control groups across the three geographical thinking skills simultaneously, controlling for the corresponding pretest scores. Follow-up univariate analyses were conducted for each skill. The results are presented in Table 7.

Overall, the analyses showed significant differences between the experimental and control groups in the total Geographical Thinking Test score and all three geographical thinking skills after controlling for pretest performance. Effect sizes were also reported to indicate the magnitude of these differences.

4. Discussion

The findings showed statistically significant differences between the experimental and control groups in the overall Geographical Thinking Test score and in each of its three skills, with higher adjusted posttest means for the experimental group after controlling for pretest scores. The teaching method showed a substantial partial eta squared effect for the total test ($\eta p^2 = .682$), while the partial eta squared values for the three geographical thinking skills ranged from .356 to .501. These findings indicate that students in the experimental group demonstrated higher adjusted posttest performance than those in the control group.

These findings may be related to the systematic integration of visual representations into activities designed to develop students' abilities to acquire, collect and organize, analyze, and interpret geographical information. The strategy incorporated maps, images, graphs, tables, aerial and satellite imagery, and models alongside teacher explanations, questioning, discussion, and analytical tasks. This structured approach may have provided students with repeated opportunities to identify relevant geographical information, organize relationships among geographical elements, and examine geographical patterns. The sequence of activities may also help explain why statistically significant differences were observed across all three geographical thinking skills rather than in only one dimension.

The findings can be interpreted in light of Dual Coding Theory, which proposes that learning may be supported when information is represented through complementary verbal and nonverbal systems (Clark & Paivio, 1991). In the present study, visual representations were combined with teacher explanations and classroom discussion, potentially providing students with complementary ways to process and organize geographical information. The findings may also be understood from a sociocultural perspective, in which representational tools serve as mediational resources that can support learning through interaction, guidance, and shared activity (Vygotsky, 1978, as cited in Yoon et al., 2021). From this perspective, the potential value of visual representations lies not only in their presence but also in how they are incorporated into guided learning activities.

The findings are broadly consistent with previous research highlighting the instructional value of visual materials and geographical representations in geography education (Janko et al., 2018; El-Hosary, 2016; Trahorsch & Bláha, 2020; Reumont & Budke, 2021; Huang et al., 2024; Bendl et al., 2025). For example, Huang et al. (2024) reported that geographic subject mind maps supported students' geographical synthetic thinking, while Janko et al. (2018) emphasized the instructional importance of visual materials in geography education. Other studies have examined visual and illustrative materials, electronic maps, and comics in geographical learning. Although these studies differ in the types of representations, learning outcomes, and instructional contexts investigated, they provide a relevant background for considering the role of visual resources in geography education. The present study adds to this body of research by examining a structured strategy that integrates multiple forms of visual representation to target several geographical thinking skills.

Nevertheless, the findings should not be interpreted as evidence that visual representations are uniformly effective across all geographical learning contexts. Their potential effectiveness may depend on how they are designed and used, the nature and complexity of the geographical content, the level of teacher guidance, and students' prior knowledge and ability to interpret visual information. Accordingly, the results provide evidence within the specific instructional context examined in this study, but they do not establish that comparable effects would necessarily occur across different grade levels, schools, or geographical topics.

The magnitude of the observed effects also warrants cautious interpretation. The study involved 40 students from two intact classes at a single school, and students were not randomly assigned individually to the experimental and control groups. Although the groups were comparable at pretest and baseline scores were statistically controlled, unmeasured differences between the classes cannot be completely ruled out. Furthermore, the intervention lasted only three weeks, and no delayed posttest was conducted. It therefore remains uncertain whether the observed differences would persist over time. The relatively large partial eta squared values should consequently be interpreted within the specific design and setting of the present study rather than as evidence of a universally large effect.

Overall, the findings suggest that systematically integrating visual representations with guided geographical thinking activities may support students' performance in acquiring, collecting and organizing, and analyzing geographical information. Further research involving larger and more diverse samples, multiple schools, longer interventions, and delayed assessments is needed to examine the consistency, durability, and broader applicability of these findings.

5. Conclusion

The study provides evidence that a structured visual representation strategy was associated with higher adjusted posttest performance in the total Geographical Thinking Test and in acquiring, collecting and organizing, and analyzing geographical information among the participating tenth-grade students. The findings support the systematic integration of visual representations into geography instruction, particularly when linked to specific learning outcomes and supported by guided questioning and analytical activities. Accordingly, geography teachers may benefit from training in the effective use of visual representations, and geography textbooks and classroom environments may be enhanced with diverse visual and digital resources. Future research should examine the strategy with larger and more diverse samples, across multiple schools and longer intervention periods, and should consider delayed posttests and additional learning outcomes using qualitative or mixed-methods approaches.

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Author Statements

Acknowledgments

Not applicable.

Author Contributions

Not applicable.

Consent for Publication

All authors have read and approved the published version of the manuscript.

Funding

This research received no external funding.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Informed Consent

Informed consent was obtained from all participants.

Ethics Approval

Approval was obtained from the Ministry of Education / Yarmouk University; parental consent was obtained.

Data Availability Statement

All data generated or analyzed during this study are included in this published article.

Use of Artificial Intelligence

The authors declare that no generative artificial intelligence (AI) tools were used in the conception, design, analysis, interpretation, or writing of this manuscript.

Supplementary Materials

No supplementary materials are available.

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