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THE EFFECTIVENESS OF SPACIA JOURNEY TEACHING MATERIALS WITH ATTENTION TO STUDENT DIFFERENTIATION FOR IMPROVING SPATIAL CRITICAL THINKING

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ABSTRACT

Teaching materials are one of the important components in learning activities, because they function as guidelines, learning resources, and means to achieve learning objectives. However, teaching materials at SMAN 6 Surakarta are still in the form of printed teaching materials dominated by reading texts and a small part in the form of images, so they are less interesting, and students with auditory and kinesthetic learning styles will experience learning difficulties. This study aims to determine the level of effectiveness of SPACIA Journey teaching materials in improving spatial critical thinking skills. This is an experimental study with the subjects of this study consisting of 36 students of class X-E10 as the experimental class and 36 students of class X-E11 as the control class. Based on the results of the study, it can be concluded that the experimental class produced a gain index (g) of 0.75 with a high category, while the control class was 0.64 with a medium category. Both classes were quite effective, but the experimental class had a higher average N-Gain score, including the maximum N-Gain value (91.67% compared to 76.28%). These results provide implications that the implementation of SPACIA Journey is more effective in improving spatial critical thinking skills according to the diversity of students' learning needs.

Keywords: *differentiation; story maps, SPACIA Journey; spatial critical thinking*

INTRODUCTION

Education plays a crucial role in developing superior human resources capable of competing amidst the developments in science and technology in the global era. However, to realize this role, education must heed Ki Hadjar Dewantara's belief that every individual is unique. This understanding emphasizes the need for education to consider the unique potential and diverse characteristics of students, and to truly understand the nature of nature and connect it to the nature of the times in which they live.

Differentiated learning is a relevant approach because it can provide

educational services tailored to the diverse needs of students. Differentiated learning is believed to be a breath of fresh air for improving Indonesian education (Ambarita, J., & Simanullang, 2023). This is because differentiated learning is a student-centered approach that provides students with the freedom to learn according to their needs, interests, and learning profiles.

Geography is a difficult subject to understand, resulting in low interest in learning geography (Meyzilia et al., 2019). On the other hand, geography is closely related to the problems surrounding students, thus requiring contextual learning to train their spatial thinking (Anggreni & Sumarmi, 2022). Geography subjects are related to spatiality, so it is necessary to create images, maps, symbols, and graphs to simplify abstract concepts (Chandra et al., 2019). Therefore, to facilitate students in learning geography and improve spatial thinking skills, there is a need for teaching materials tailored to the needs and characteristics of students, namely differentiated teaching materials.

Many studies have been conducted on spatial thinking skills. First, a study measured the spatial thinking skills of high school students (Adzani et al., 2023). Second, a study used Google Earth to improve spatial thinking skills (Khoirunnisa et al., 2025). Subsequent research involved a differentiated learning approach to determine its effect on spatial thinking skills (Navri et al., 2023). Similar research involved a differentiated Project-Based Learning model to improve spatial thinking skills (Angga Oktavianto, 2022).

These various studies demonstrate the importance of spatial thinking, which can be enhanced through a differentiated learning approach. However, studies that integrate spatial thinking skills need to be supported by critical thinking to develop the ability to analyze, evaluate, and draw conclusions from spatial information. The integration of these two skills underpins the importance of spatial critical thinking skills for students.

The hydrosphere is one of the topics in the hydrosphere course that can be used to develop students' spatial critical thinking skills. This is because the hydrosphere is not only about water; with spatial critical thinking skills, students can understand its location, distribution, causes, impacts, and provide alternative solutions to water problems.

Currently, grade X students at SMA Negeri 6 Surakarta use printed teaching materials sourced from teachers and the library. These teaching materials are still relatively new; however, when viewed in terms of their form and related to the learning styles of Visual, Auditory, Read/Write, and Kinesthetic (VARK) students, these teaching materials cannot accommodate the needs of students with diverse characteristics. This is because the teaching materials are also dominated by text and only a small part of them are images, making them less interesting; students with Auditory and Kinesthetic learning styles will experience difficulties in learning. Thus, learning geography will remain a difficult subject for students, and moreover, students will have difficulty developing spatial critical thinking skills. Based on the initial analysis, it can be seen that the percentage of students who have not achieved the spatial critical thinking indicator is greater, namely 64.57%. To strengthen the initial analysis, interviews were conducted with teachers and class X students. The results of the interviews stated that spatial critical thinking is something new, and learning that emphasizes spatial critical thinking indicators has never been carried out. In addition, a differentiated learning approach has never been integrated into geography learning. This condition underlies the need to develop teaching materials that support the improvement of spatial critical thinking abilities and accommodate students with a differentiated learning approach.

SPACIA Journey is a story map-based teaching material developed for high school hydrosphere material. This teaching material is designed based on spatial critical thinking indicators, and its varied presentation can be used for all learning styles, including: Visual, Auditory, Read/Write, and Kinesthetic (VARK). Based on these conditions and the capabilities possessed by SPACIA Journey, the researcher is interested in conducting research to determine the effectiveness of SPACIA Journey in improving students' spatial critical thinking on high school hydrosphere material.

Several researchers have conducted research on spatial critical thinking . First, the development of Google Sites-based geography e-learning media to enhance spatial critical learning (Widyantoro et al., 2024). Second, spatial critical thinking skills through the

use of maps and remote sensing imagery (Saputro et al., 2020). Third, the application of a project-based learning model based on artificial intelligence (AI) to enhance spatial critical thinking skills (Sriyanti et al., 2026). Although these studies already exist, this study was conducted with a novelty that lies in the improvement of the SPACIA Journey teaching material based on story maps as the independent variable and spatial critical thinking skills as the dependent variable.

MATERIALS AND METHODS

This research is an experimental study that aims to assess the level of effectiveness of SPACIA Journey teaching materials in improving students' spatial critical thinking skills. A differentiated approach is used to accommodate the needs of students with diverse learning styles. This research was conducted at SMA Negeri 6 Surakarta with a research population involving students in phase E of class X. The sampling technique used was cluster sampling, which involves selecting samples based on the classes that have been formed, and the experimental class and control class were selected randomly with the consideration that the classes have relatively homogeneous characteristics. The sample used was 72 students, including 36 students of class XE-10 as the experimental class and 36 students of class XE-11 as the control class.

Data collection techniques were conducted through tests and documentation. Tests were administered twice: a pretest before learning and a posttest after learning. In the experimental class, learning was conducted using SPACIA Journey, while the control class used printed teaching materials. Documentation of student learning activities was used as supporting data throughout the study. The research instrument consisted of

The pretest and posttest were arranged based on the Revised Bloom's Taxonomy cognitive levels, including: applying (C3), analyzing (C4), and evaluating (C5), and were adjusted to the spatial critical thinking indicators (**Table 1**). The cognitive levels were used to ensure that the instrument used could measure students' thinking abilities at various levels of cognitive processes, while the spatial critical thinking indicators were used to ensure that each item could be used to measure spatial critical thinking abilities in accordance

with the research objectives. The collected data were then analyzed using N-Gain analysis to measure the effectiveness of SPACIA Journey in improving spatial critical thinking.

Data analysis was conducted to determine the effect of SPACIA Journey on students' spatial critical thinking skills. This analysis was conducted in three stages: normality testing, independent-samples t-testing, and N-Gain testing.

Table 1. Spatial Critical Thinking Ability Indicators

Cognitive Level			***Spatial Critical Thinking* Indicators**	**Question Number**	**Question Format**
C3	**C4**	**C5**			
✓			*Comprehensive*: Students are able to understand the concept of the hydrological cycle process in a broad and complete manner.	1	PG
✓			*Spatial interaction*: Students are able to understand the relationship between marine classification characteristics to determine the habitat of marine biota and marine ecosystems.	2	PG
✓			*Application*: Through map interpretation, students are able to adapt the information obtained to the appropriate use of the sea.	3	PG
	✓		*Analysis*: Students are able to conduct investigations into the morphological forms of the seabed.	4	PG
	✓		*Spatial interaction*: Students are able to understand the causes and effects of the phenomenon of changes in the color of seawater.	5	PG
	✓		*Scale*: Students are able to analyze the comparison of geospheric phenomena in the form of rivers in different areas.	6	PG
	✓		*Representation*: Through satellite photos, students are able to analyze and determine groundwater potential.	7	PG
	✓		*Comprehensive*: Students are able to summarize the information obtained to choose the right institution providing and using hydrological data.	8	PG
	✓		*Analysis*: Students are able to conduct investigations to analyze efforts that are appropriate to river problems.	9	PG
		✓	*Application*: Students are able to observe maps that can provide support for gaining an understanding of the distribution of marine biota.	10	PG
		✓	*Spatial interaction*: Students are able to understand the relationships and causes and effects related to swamps and lakes.	11	Essay
	✓		*Analysis*: Students are able to investigate a phenomenon, including conservation, utilization, and pollution of marine waters.	12	Essay

Source: Researcher Analysis, 2024

1. Normality Test

A normality test was conducted to determine whether the research data obtained were normally distributed. The data consisted of pretest and posttest data

from students in the experimental and control classes. In this study, the normality test was conducted using the Shapiro-Wilk test, considering the sample size of each class was 36 students (<50). According to Shapiro & Wilk (1965), the normality test can be conducted using the formula in equation1.

$$W = \frac{(\sum_1^n a_i x_i)^2}{(\sum_2^n x_i \bar{x})^2} \quad (1)$$

This test was conducted at a significance level of α = 0.05, using the hypothesis criteria shown in **Table 2**.

Table 2. Shapiro – Wilk Test Criteria Index

Significance	Hypothesis	Information
Sig. > 0.05	H₀ accepted	Normally distributed
Sig. ≤ 0.05	H₀ rejected	Abnormally distributed

Source: (Siregar, 2026)

2. T Test (*Independent Sample T-Test*)

The independent sample t-test aims to determine the difference in means between two independent data groups (Fitri et al., 2023).

The data were taken from the experimental class using SPACIA Journey and the control class using printed teaching materials. The formula for the independent samples t-test is shown in Equation 2.

$$t = \frac{X_1 - X_2}{Sp\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}} \quad (2)$$

This test was conducted at a significance level of α = 0.05 with the hypothesis criteria shown in **Table 3.**

Table 3. Independent Sample T-Test Criteria Index

Significance	Hypothesis	Information
Sig. < 0.05	H₀ rejected	There is a significant difference
Sig. > 0.05	H₀ accepted	There is no significant difference

3. N-Gain Test

Normalized gain score (N-Gain) test aims to determine the effectiveness of both SPACIA Journey and printed teaching materials in improving students'

spatial critical thinking skills. The N-Gain formula is shown in Equation 3.

$$N - gain = \frac{\%\ posttest - \%\ pretest}{100 - \%\ pretest} \quad (3)$$

The results of the n-gain calculation are then converted into a statement. To convert this into a statement, the N-Gain effectiveness index and its criteria, as shown in **Table 4**, are used.

Table 4. N-Gain Effectiveness Criteria Index

No.	Gain Index (g)	Criteria
1.	n-gain > 0.7	Tall
2.	0.3 < n-gain ≤ 0.7	Currently
3.	n-gain ≤ 0.3	Low

Source: Hake, 2002

RESULTS AND DISCUSSION

SPACIA Journey is a story map-based digital teaching material that integrates content differentiation to create a fun learning experience through an adventure in understanding spatial phenomena interactively and meaningfully. Meanwhile, the printed teaching materials in this study can be described as teaching materials in general that predominantly contain reading text. These characteristics are used as the basis for testing the effectiveness of the teaching materials to determine the extent to which the teaching materials can improve spatial critical thinking skills. This level of effectiveness can be tested through normality tests, independent-samples t-tests, and N-Gain.

1. Normality Test

This test was conducted using IBM SPSS version 27 software. The Shapiro-Wilk normality test showed that the pre-test and post-test data in both classes met the normality assumption. In the experimental class, the pre-test significance value was 0.721, and the post-test significance value was 0.539. Meanwhile, in the control class, the pre-test significance value was 0.923, and the post-test significance value was 0.075. The significance value in both classes was greater than 0.05, so H_0 was not rejected. This means that the pre-test and post-test data from both classes were normally distributed. The results of the normality test using the Shapiro-Wilk test for the pre-test and post-test are presented in **Table 5**.

Table 5. Results of Normality Test with Shapiro-Wilk Test in Pre-Test and Post-Test

		Kolmogorov – Smirnov*			Shapiro-Wilk		
Class	Evaluation	Statistics	df	Sig.	Statistics	Df	Sig.
Experiment	Pre-test	.056	36	.200*	.979	36	.721
	Post-test	.123	36	.188	.974	36	.539
Control	Pre-test	.093	36	.200*	.986	36	.923
	Post-test	.120	36	.200*	.945	36	.075

Source: SPSS Analysis, 2024

2. Independent Samples T-Test

This test was conducted using IBM SPSS software version 27. The test results showed that the significance value was 0.001, which is less than 0.05, so H0 $_{was}$ rejected, and H_1 was accepted. This means that there is a difference

There was a significant difference between the experimental and control classes in terms of increasing spatial critical thinking skills. This difference can be seen from the higher average scores of the experimental class compared to the control class. The results of the t-test (independent samples t-test) for the experimental and control classes are presented in **Table 6**.

Table 6. Results of the T-Test (Independent Samples T-Test) in the Experimental Class and Control Class

		T-Test for Equality of Means							
		t	**df**	**Significance**		**Mean Difference**	**Standard Error Difference**	**95% Confidence Interval of the Difference**	
				One-Sided p	**Two-Sided p**			**Lower**	**Upper**
Mark	Equal variances assumed	8.106	70	<.001	<.001	8.91667	1.09996	6.72287	11.11047
	Equal variances not assumed	8.106	69,870	<.001	<.001	8.91667	1.09996	6.72280	11.11054

Source: SPSS Analysis, 2024

3. N-Gain Test

This test was conducted using IBM SPSS version 27. The N-Gain test results showed that the experimental class produced a gain index (g) of 0.75 and was included in the high category ($g \geq 0.70$). Meanwhile, the control class produced a gain index (g) of 0.64 and was included in the medium category ($0.30 \leq g \leq 0.70$).

These findings indicate that the implementation of learning using SPACIA Journey in the experimental class is more effective in supporting the

improvement of spatial critical thinking skills in students, when compared with the control class that used printed teaching materials. The N-Gain test results for the experimental and control classes are presented in **Table 7**.

Table 7. Results of the N-Gain Test in the Experimental Class and Control Class

		N	Minimum	Maximum	Mean	Standard Deviation
Experiment	NGain_score	36	43	92	.7500	.10903
	NGain_percent	36	43.04	91.67	75,0025	10.90303
	Valid N (listwise)	36				
Control	NGain_score	36	.37	.76	.6431	.07763
	NGain_percent	36	36.94	76.28	64.3103	7.76340
	Valid N (listwise)	36				

Source: SPSS Analysis, 2024

SPACIA Journey offers advantages that printed learning materials lack. It is designed based on spatial critical thinking indicators. The main components of this learning material are guided map tours as spatial representations and storylines that make the material more contextual. Furthermore, content differentiation is implemented based on learning preferences, including visual (images, maps, diagrams), auditory (podcasts), read/write (text and written instructions), and kinesthetic (guided map tours) (**Figure 1**).

The variety of presentation forms aims to provide all students with the opportunity to choose the learning method that best suits their learning preferences, so that the teaching materials used will be more effective in optimally understanding the material.

This aligns with research by Ayu Wulandari & Setyo Wardhani (2024) on media and learning styles as strategies for effective learning. The results indicate that matching media to specific learning styles can create effective learning. This research emphasizes the importance of visual media for students with visual learning styles, as well as for students with other learning styles who need to adapt the media to their learning style.

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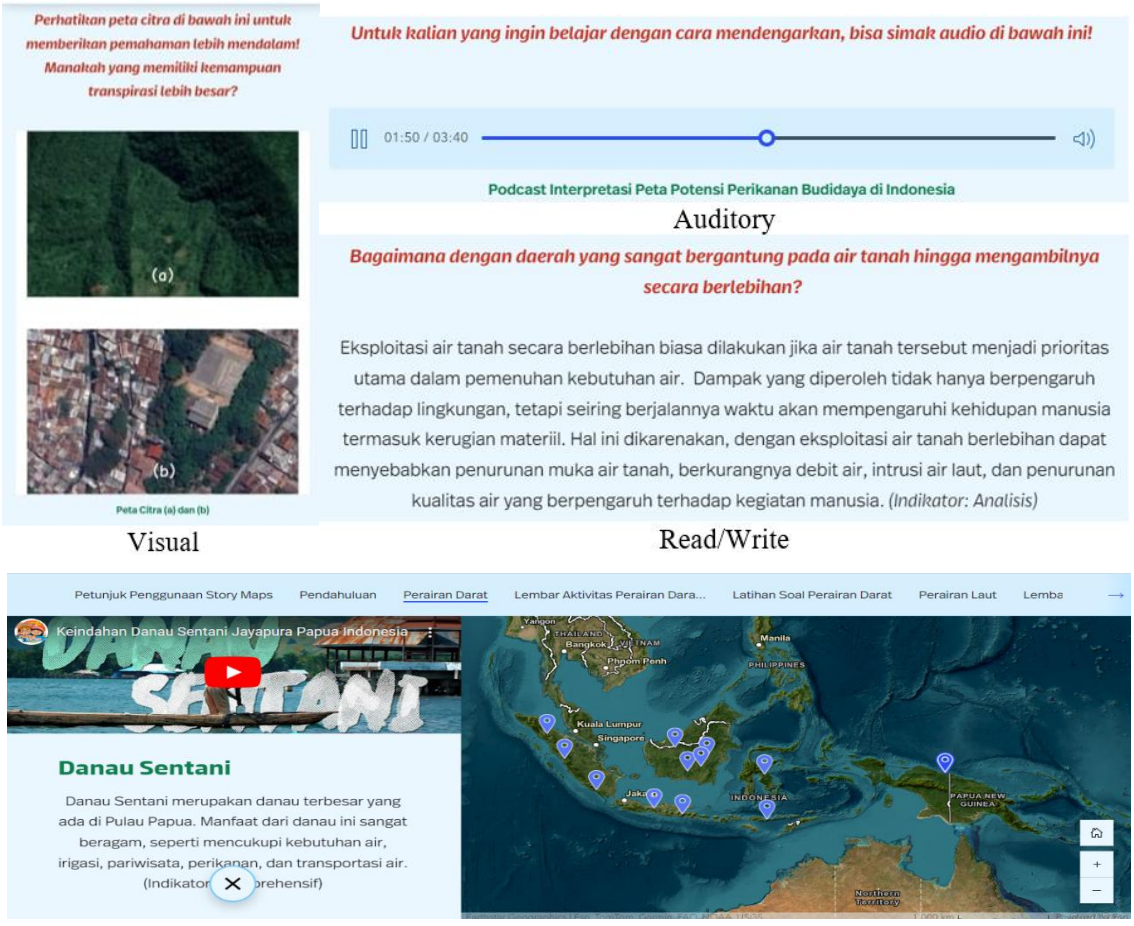

Figure 1. Display of Material Presentation on the SPACIA Journey according to VARK
Source: Development Analysis, 2024

SPACIA Journey has various features, but there are superior features in the form of tour maps, interactive maps, and other features that support presentation in visual form such as maps, images, graphs, and so on which are expected to influence spatial critical thinking skills through visual representations that support students in learning to recognize locations, navigate routes, and explore space contextually and build more interesting learning. This is in line with the advantages of story maps put forward by Kurniawan (2019) , stating that interactive maps are one of the advantages of story maps that can be developed to provide in-depth spatial analysis that other platforms such as Canva do not have. Meanwhile, Qolbi et al., (2026) , In their research, they stated that in addition to increasing spatial depth, through story maps students get

more real, interesting experiences, so they can increase motivation and understanding of the material.

SPACIA Journey was deemed optimal for improving students' spatial critical thinking skills across various learning styles (**Table 8**). Based on the scores obtained during both the pretest and posttest, it can be seen that all learning styles in both the experimental and control classes experienced improvements. However, the experimental class achieved higher scores than the control class. Although the greatest improvement was in the visual learning style, the use of SPACIA Journey was also able to accommodate other learning styles, resulting in improved student scores. Meanwhile, the control class used teaching materials that were not designed to accommodate all learning styles, so students with certain learning styles tended to experience learning difficulties, such as students with visual learning styles.

These results are consistent with Mulyani's (2024) research which states that content-based differentiated learning can improve student learning outcomes in Geography. Regarding learning outcomes based on learning styles, Revina & Ekwanda (2020) in their research stated that the auditory learning style group experienced the greatest improvement compared to the other two groups (visual and kinesthetic). This improvement was because students with an auditory learning style tended to actively ask questions during discussion sessions. This differs from the results of research using SPACIA Journey, which experienced the highest improvement in visual learning styles, while auditory learning styles experienced the highest improvement in the control class. SPACIA Journey focuses on improving spatial and critical thinking skills through various visual representations, while the control class relied on text and verbal explanations, resulting in the greatest improvement in the auditory learning style.

In contrast to the research of Asmi et al., (2026) and Zarwinda et al., (2015) which stated that the implementation of differentiated learning resulted in improvements in each learning style. The highest increase was in the kinesthetic learning style. This difference in results indicates that the use of teaching materials influences student learning outcomes based on their learning preferences.

Table 8. Results of Pretest and Posttest Scores Based on Student Learning Styles

Class	Learning Styles	Pre-test	Post-test	Difference
Experiment	Visual	40.25	88.13	47.88
	Auditory	39.7	85.42	45.72
	Read/Write	45.5	82.5	37
	Kinesthetic	43.33	83.94	40.61
Control	Visual	44.7	68.50	23.8
	Auditory	32.4	76.50	44.10
	Read/Write	40.4	82.1	41.7
	Kinesthetic	35.07	75.83	40.76

Source: Researcher Analysis, 2024

In addition, SPACIA Journey was considered superior in improving each indicator of spatial critical thinking. In the experimental class, there was an increase in the percentage of achievement from the pre-test to the post-test assessment from 45.71% to 91.26%. Conversely, the percentage of not achieved decreased from 54.29% to 8.74%. In the control class, there was an increase in the percentage of achievement from the pre-test, from 37.75% to 83.23% in the post-test. Conversely, there was a decrease in the percentage of not achieved from 62.25% to 16.77%. The increase in both classes shows that the experimental class has a higher achievement value than the control class, namely 91.26% compared to 83.23%. In addition, the experimental class has a lower not-achieved value than the control class. This shows that learning using SPACIA Journey teaching materials is more effective in improving students' spatial critical thinking abilities.

CONCLUSIONS

The SPACIA Journey teaching material is effective in improving students' spatial critical thinking skills with diverse characteristics in the hydrosphere material. This can be seen from the data obtained in the experimental class, which produced a gain index (g) of 0.75, including effective in the high category, and the independent-samples t-test obtained a significance value of 0.001, which means there is a difference between the experimental class and the control class.

SPACIA Journey contributes to providing geography teaching materials by combining spatial information and storylines that help students learn contextually. Consequently, SPACIA Journey can be used as an alternative teaching material based on story maps, presenting diverse content to support the

development of spatial critical thinking skills.

This study has several limitations, such as its limited scope of material to the hydrosphere with high school students as subjects, its failure to measure skills other than spatial critical thinking, and its reliance on the availability of devices and adequate internet access. Future research is recommended to expand the SPACIA Journey to a broader range of materials and educational levels and use it to test other relevant skills.

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