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Effects of Discovery Learning Assisted by WebGIS Media on Students' Critical Thinking Skills

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Abstract: Critical thinking skills are one of the essential competencies needed by students to face the challenges of 21st-century learning, particularly in geography learning, which requires students to analyze, evaluate, and solve various geographical problems. However, the critical thinking skills of students at SMA Negeri 1 Natar are still relatively low, indicating the need for innovative learning models and media to support the learning process. This study aims to determine the influence of the Discovery Learning learning model and WebGIS media on the critical thinking ability of grade XI students of SMA Negeri 1 Natar. This study uses a quantitative approach with a 2×2 factorial quasi experimental design. The research sample consisted of 141 students who were divided into four treatment classes. The instrument used was a multiple-choice test to measure students' critical thinking skills. Data were analyzed using Two-Way ANOVA. The results showed that the Discovery Learning learning model had a significant effect on critical thinking skills with a significance value of 0.000 (<0.05). WebGIS media also had a significant effect with a significance value of 0.000 (<0.05). However, there was no interaction between the learning model and the learning media, with a significance value of 0.706 (>0.05). The R Square value of 0.323 indicates that the learning model and media together contribute 32.3% to students' critical thinking skills. Thus, Discovery Learning and WebGIS are separately effective in improving students' critical thinking skills in geography learning.

Keywords: Discovery Learning; WebGIS; Critical Thinking; Geography Learning.

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Introduction

The development of science and technology in the 21st century has brought significant changes in various fields, including education. 21st century learning requires students to have high-level thinking skills to be able to adapt to global dynamics. One of the most important skills is the ability to think critically.

Critical thinking skills are the ability to think rationally and reflectively that focuses on making decisions about what to believe or do according to Ennis, 2011 in (Rachma and Siswono, 2024). This ability includes not only understanding information, but also processing, evaluating, and using information to solve problems and draw logical conclusions (Sulnas et al., 2023). Thus, critical thinking skills allow students to analyze information objectively, evaluate problems, and make rational and data-based decisions. However, the critical thinking skills of students in Indonesia are still relatively low. Based on results Programme for International Student Assessment (PISA) in 2022, Indonesia's science literacy score is at 383 and ranks 67th out of 81 participating countries (Lidiawati and Aurelia, 2023). In addition, according to research (Kintoko et al., 2024) Low reading literacy is also closely related to critical thinking skills. Therefore, low literacy can affect the low critical thinking ability of students.

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This low ability is also influenced by the learning process that takes place in the classroom. In the learning process, some students tend to be passive, only receiving information from the teacher without being able to ask questions, present arguments, or develop new critical ideas (Herdiansyah et al., 2024). This condition shows that learning has not fully provided space for students to develop critical thinking skills optimally. In fact, in the implementation of the Independent Curriculum, teachers are expected to play the role of facilitators who are able to create student-centered, meaningful, and contextual learning to support the development of critical thinking competencies (Anriani et al., 2025).

Teacher-centered learning (teacher-centered) is one of the factors that cause the low critical thinking ability of students. Dominant learning using the lecture method makes students less actively involved in the learning process. Theoretically, the conventional learning model according to Djamarah (1996) in (Suranda and Gaddafi, 2024) It is a traditional learning that emphasizes the delivery of material directly by the teacher so that students play a passive role. The lecture method as the main form of conventional learning is one-way and less interactive, so it can limit students' opportunities to develop critical thinking skills (Scott, 2025). This condition is not in line with the demands of the Independent Curriculum which emphasizes student-centered learning and strengthening critical, collaborative, and reflective thinking competencies. Therefore, learning that is able to activate learners and encourage deeper cognitive engagement is needed.

Regarding this, one of the subjects that plays an important role in developing critical thinking skills is geography. In the learning, students are invited to understand the relationship between humans and the environment and analyze spatial phenomena systematically (Septiana and Putra, 2024). Conceptually, geography demands analytical and evaluative skills in examining spatial data (Scott, 2022). One of the strategic materials is population, which not only requires memorization of data, but also the ability to analyze, evaluate, and draw conclusions on various population problems. These problems are also found in the geography learning process at SMA Negeri 1 Natar. Based on the results of initial observations, students tend to be passive, lack of expressing opinions, and are not used to analyzing problems in depth. This condition has an impact on the low achievement of student learning outcomes in geography subjects, as shown in Table 1.

Based on Table 1. The results of the 2024/2025 mid-semester assessment show that of the 178 students who took the ASTS geography, only 30 students (16.85%) have achieved the Minimum Completeness Criteria (KKM) of 78, while 148 students (83.15%) have not achieved completeness. This indicates the need for learning innovations that are able to activate students. The development of digital technology opens up opportunities to improve the quality of geography learning (Auliya and Safitri, 2024).

Table 1. Total Completeness of Grade XI Students of ASTS Geography Subject in 2024/2025

Completeness	Numbe of Students	Percentage (%)
Finished (>78)	30	16,85%
Incomplete (<78)	148	83,15%
Quantity	**178**	**100%**

Source: Research Data Processing, 2025

One of the alternatives is the Discovery Learning and WebGIS, which allows learners to explore spatial data directly (Wardhani et al., 2024). Research (Ariadila et al., 2023) shows that the application of Discovery Learning and WebGIS has a significant effect on improving students' critical thinking skills. According to (Annisa, 2021a), Discovery Learning is a learning model that encourages students to discover information, concepts, principles, through a process of exploration and direct experience. In this model, the teacher plays the role of a facilitator who guides students in the process of finding knowledge. Learning through discovery allows students to build their own cognitive structure so that understanding becomes deeper and lasts longer. In line with that,(Ansyori et al., 2024) stated that the Discovery Learning model has a significant effect on improving critical thinking skills compared to conventional learning. Students taught with this model obtained an average score of 72.04, higher than the control group of 63.08. In addition, research (Ariefyani and Astuti, 2023) also shows that the implementation of Discovery Learning able to significantly improve critical thinking skills.

Learning model Discovery Learning Placing students as active subjects in the learning process. Students build their own knowledge through the activities of discovering concepts, analyzing data, asking questions, formulating hypotheses, and drawing conclusions. This process is in line with constructivism which views knowledge as the result of individual construction and a generative learning process, which is to create meaning from the material learned (Mariska and Khobir, 2023). In this approach, the teacher plays the role of a facilitator who guides students towards a deeper understanding (Masgumelar and Mustafa, 2021).

Several studies suggest that Discovery Learning has a number of advantages. According to Hosnan (2014) in (Sartono, 2019), this model is able to improve cognitive skills, strengthen memory and knowledge transfer, develop problem-solving skills, and train students' learning independence. In addition, this model

encourages activeness, fosters an inquiry attitude, and improves reasoning and independent thinking skills. In line with that, Kurniasih and Sani (2014) in (Sartono, 2019) states that Discovery Learning can foster a sense of joy in learning, help students understand basic concepts more deeply, and encourage learning initiatives by utilizing various learning resources.

In addition to the learning model, the use of technology-based media is also a supporting factor in improving the quality of learning. One of the relevant media in geography learning is WebGIS. WebGIS is a web-based geographic information system that presents spatial and statistical data in an interactive manner (Yuniarti et al., 2024). According to (Juniardi and Azwansyah, 2014), WebGIS is a combination of graphic design mapping, digital maps with geographic analysis, computer programming, and a database that is interconnected into one part of web design and web mapping. The use of WebGIS in learning allows students to access and analyze population and regional phenomena through interactive digital maps and real-time. Spatial data visualization helps students understand the concept of geography contextually and accurately because it is sourced from official BPS data. Through WebGIS, students can explore data, analyze geographic patterns, and develop critical thinking and problem-solving skills (Amelia, 2024).

Critical thinking skills can be developed optimally when students are actively involved in the learning process and are given opportunities to explore real and contextual information. The Discovery Learning model encourages students to identify problems, collect and process data, verify findings, and draw conclusions independently. These learning stages are closely related to the indicators of critical thinking skills, such as analyzing information, evaluating evidence, making logical interpretations, and solving problems systematically. Meanwhile, WebGIS provides authentic spatial and statistical data that can be explored directly by students through interactive maps and digital visualization. The integration of Discovery Learning and WebGIS enables students to investigate geographical phenomena based on real data, formulate arguments supported by evidence, and make rational decisions. Therefore, the Discovery Learning model supported by WebGIS media is theoretically considered capable of fostering and improving students' critical thinking skills in geography learning.

The combination of the Discovery Learning model and WebGIS media has the potential to create active and meaningful learning. Discovery Learning stages such as stimulation, problem statement, data collection, data processing, verification, and generalization can be integrated with data exploration in WebGIS. Through this process, students not only receive information, but also discover concepts for themselves based on the analysis of available spatial data. This is expected to improve students' critical thinking skills in learning geography. Based on this description, this study aims to determine the influence of the Discovery Learning learning model and WebGIS media on the critical thinking ability of grade XI students of SMA Negeri 1 Natar. In particular, this study aims to analyze the application of Discovery Learning and WebGIS, determine the influence of the Discovery Learning model on critical thinking skills, determine the influence of WebGIS media on critical thinking skills, and determine the influence of interaction between models and media on students' critical thinking skills.

Method

Research Design

This study employed a quantitative approach with a quasi-experimental design, as the students were not randomly assigned to the class but rather used existing classes or intact groups (Di Fuccio et al., 2024) The quantitative approach was chosen because the data obtained were numerical scores analyzed using inferential statistics. The research design used was a 2x2 factorial, which aimed to test the effect of two independent variables and their interaction on the dependent variable. This study involved four classes, each receiving a different treatment based on the combination of learning models and media used. All classes were given a pretest before the treatment to determine students' initial critical thinking skills, and a posttest after the treatment to measure changes or improvements in these skills. This design allowed the study to simultaneously examine the influence of learning models and media on students' critical thinking skills. The research design is presented in Figure 1.

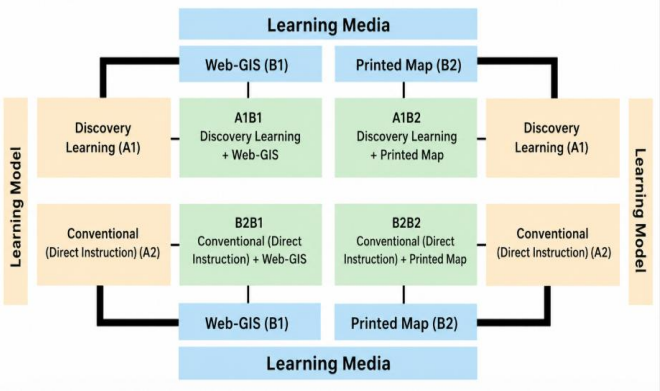


Figure 1. 2x2 factorial design adapted from (Wijaya et al., 2026)

The Discovery Learning model was implemented in the experimental classes following six stages, namely stimulation, problem statement, data collection, data

processing, verification, and generalization. In the stimulation stage, students were introduced to population issues through questions, maps, and statistical data. During the problem statement stage, students identified and formulated geographical problems related to population quantity and quality. Subsequently, students collected information from various sources, including WebGIS and printed maps, depending on the treatment group. In the data processing stage, students analyzed the collected information, interpreted spatial patterns, and discussed their findings in groups. The verification stage required students to compare their findings with relevant concepts and theories, while in the generalization stage, students drew conclusions and presented the results of their analysis. In contrast, the control classes employed conventional lecture-based learning in which teachers explained the material directly and students mainly received information and completed assigned exercises.

Participants

The research population was all 429 students in grade XI. The research sample was determined using a nonprobability sampling technique with a purposive sampling type, based on the consideration of relatively equivalent mid-semester assessment (ASTS) scores for Geography subjects. The sample consisted of four classes, namely grade XI 12 (A1B1) which was given the Discovery Learning and WebGIS model treatment, grade XI 11 (A1B2) which was given the Discovery Learning and printed maps treatment, grade XI 10 (A2B1) which was given the lecture and WebGIS treatment, and grade XI 5 (A2B2) which was given the lecture and printed maps treatment, with a total sample of 141 students.

Research Materials

The research material used in this study is in the form of WebGIS learning media developed as a digital learning resource based on geographic information systems. WebGIS (Web Geographic Information System) is a web-based geographic information system that allows users to access, analyze, and visualize spatial data online over the internet. In geography learning, GIS has an important role because it can support teachers and students in creating a more interactive and contextual learning process (Wijaya et al., 2023). WebGIS media contains spatial data and attributes related to population materials that can be accessed online by students through mobile devices and computers. This WebGIS is designed to support model syntax Discovery Learning, especially at the Stimulation, data collection, data processing, to Verification.

During the learning process, WebGIS was used as an interactive learning medium that enabled students to explore population data spatially and statistically. In the stimulation stage, the teacher displayed population distribution maps and related statistical data through WebGIS to stimulate students' curiosity and encourage them to identify geographical problems. In the data collection stage, students independently accessed WebGIS using smartphones or computers to obtain information regarding population quantity and quality across regions. Subsequently, during the data processing stage, students analyzed the spatial patterns and interpreted the information obtained from WebGIS through group discussions. In the verification stage, students compared their findings with geographical concepts and theories provided by the teacher to ensure the accuracy of their conclusions. Through these activities, WebGIS not only functioned as a visualization tool but also as a medium that facilitated students in analyzing information, evaluating evidence, and developing critical thinking skills. The main view of the WebGIS media and print maps used in this study is presented in Figures 2 and 3. WebGIS Link: (https://www.google.com/maps/d/viewer?ll=2.5803371996752884%2C115.79615423125003&z=4&mid=1uOhbXCHmw_r7qu613R6umVJL0ZnmlQ)

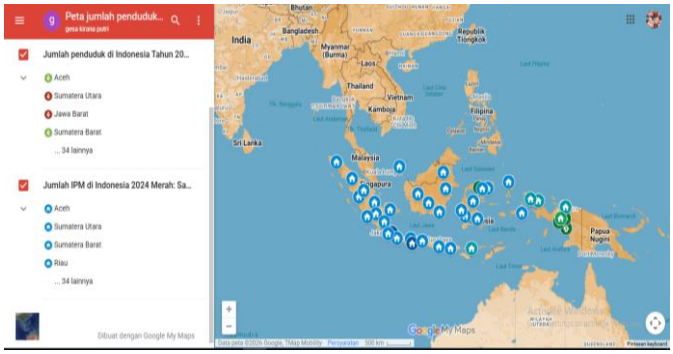
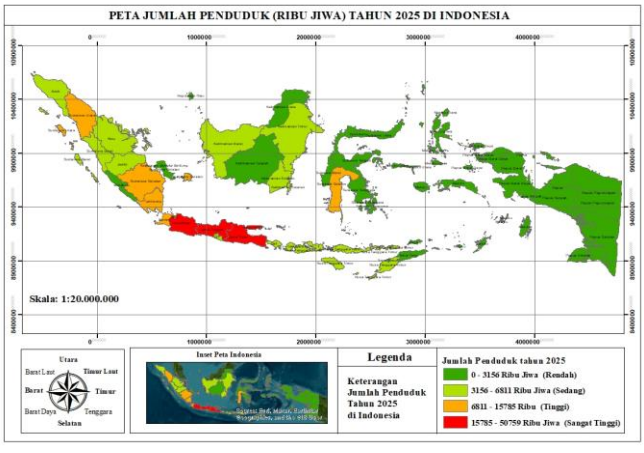


Figure 2. WebGIS Learning Media Display
(Source: Research Documentation, 2025)



In addition to WebGIS, the comparative teaching materials used are printed maps that contain spatial

information similar to the content in WebGIS, so the difference in treatment lies in the format and characteristics of the learning media used. The following is a display of printed map image media in classes A1B2 and A2B2.

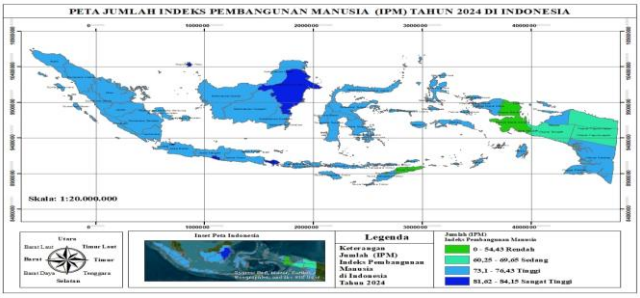


Figure 3. Print Map Learning Media Display
Source: Research Data Processing, 2025)

Instruments

The research instrument used was a critical thinking ability test consisting of 15 multiple-choice questions structured based on critical thinking indicators according to Peter A. Facione (1990), including interpretation, analysis, evaluation, inference, explanation, and self-regulation. The test instrument was administered as a pretest to determine students' initial abilities and a posttest to determine their final abilities after the treatment was administered. Scores were then calculated as a percentage and categorized into five levels: very high, high, medium, low, and very low. In addition to the test instrument, an observation sheet for the implementation of the learning model and a questionnaire containing students' responses to the implementation of the discovery learning model were also used as supporting data.

Table 2. Research Instrument Summary

z	Total Items	Valid Items	Invalid Items	Scale	α	Cronbach's
Achievement Test	30	15	15	Dichotomous		0.642

Note. α = Cronbach's alpha reliability coefficient.

Source: Research data analysis (2025).

Before use, the research instrument was tested for validity and reliability. The validity test was conducted using the Product Moment correlation using SPSS version 24 at a significance level of 5%. Of the 30 items tested, 15 had a calculated r value greater than the table r value (0.339), thus being declared valid and suitable for use as a research instrument. Meanwhile, the other 15 questions were declared invalid because the calculated r_value was smaller than the table r_value or could not be calculated. The following are the results of the reliability test using Cronbach's Alpha.

Data Analysis

The data analysis technique was conducted through several stages, namely prerequisite tests and hypothesis testing. The prerequisite tests included normality and homogeneity tests. The normality test was conducted to determine whether the data were normally distributed, with a significance criterion of >0.05. The homogeneity test was conducted to determine the equality of variance between groups, with a significance criterion of >0.05. Normality testing used the Shapiro-Wilk test, and homogeneity testing used the Levene test using SPSS version 24. The criterion for the prerequisite tests was a significance value of >0.05.

After both prerequisite tests were met, the research data could be tested using a Two-Way Analysis of Variance (Two-Way ANOVA), as the research design used was a 2x2 factorial design. The hypotheses in this study are as follows:

$H0_1$: Discovery Learning does not significantly affect students' critical thinking skills.

Ha_1: Discovery Learning significantly affects students' critical thinking skills.

$H0_2$: WebGIS learning media does not significantly affect students' critical thinking skills.

Ha_2: WebGIS learning media significantly affects students' critical thinking skills.

$H0_3$: There is no significant interaction effect between Discovery Learning and WebGIS learning media on students' critical thinking skills.

Ha_3: There is a significant interaction effect between Discovery Learning and WebGIS learning media on students' critical thinking skills.

The hypothesis-making decision is: if the significance value (Sig.) is ≤ 0.05, then H_0 is rejected and H_1 is accepted, indicating a significant effect on students' critical thinking skills. Conversely, if the significance value (Sig.) is ≥ 0.05, then H_0 is accepted and H_1 is rejected, indicating no significant effect.

Result and Discussion

Application of the Discovery Learning Model

This research was carried out in four meetings, in the second and third meetings were treated with Discovery Learning models and WebGIS media and lecture models and printed maps then the fourth

meeting for posttest. Before analyzing the pretest and posttest results, the implementation of the Discovery Learning learning model in grades A1B1 and A1B2 was first measured through a student feedback questionnaire. The results showed that the implementation of the Discovery Learning model was in the good to very good category. In class A1B2 (XI 11), 60% of students rated the implementation in the good category and 37.1% in the very good category. Meanwhile, in class A1B1 (XI 12), 54.3% were in the good category and 45.7% in the very good category.

These findings show that the Discovery Learning syntax has been well implemented during the learning process, so it is worthy of being used as a basis to analyze its influence on students' critical thinking skills. The results of the diagram of the category of student responses to the application of the Discovery Learning learning model with the categories of very good, good, adequate, lack, and very poor can be seen in Figure 4 below:

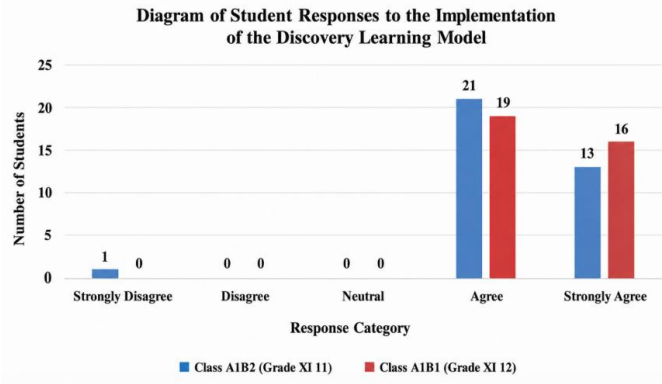


Figure 4. Category Diagram of Student Responses to the Implementation of the Discovery Learning Model (Source: Research Data Processing, 2025)

Pretest Posttest Data

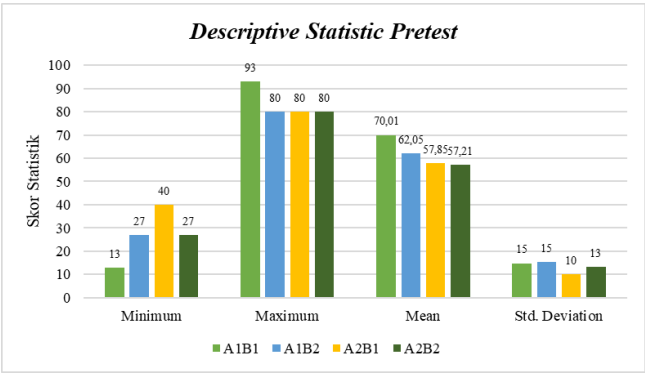


Figure 5. Descriptive Statistic Pretest (Source: Research Data Processing, 2025)

The results of the study showed an increase in critical thinking skills in all classes after being given learning treatment. To clarify the comparison of the average critical thinking skills of students before and after treatment, the data is presented in the form of a bar diagram in Figure 5 and Figure 6.

Based on Figure 5, the results of descriptive statistics, the average pretest score of students' critical thinking ability in class A1B1 was 70.01; A1B2 of 62.05; A2B1 of 57.85; and A2B2 by 57.21. All of these average scores are still below the Minimum Completeness Criteria (KKM) for the Geography subject at SMA Negeri 1 Natar which is set at 78. This shows that students' critical thinking skills before being given learning treatment have not reached the expected standard of completeness.

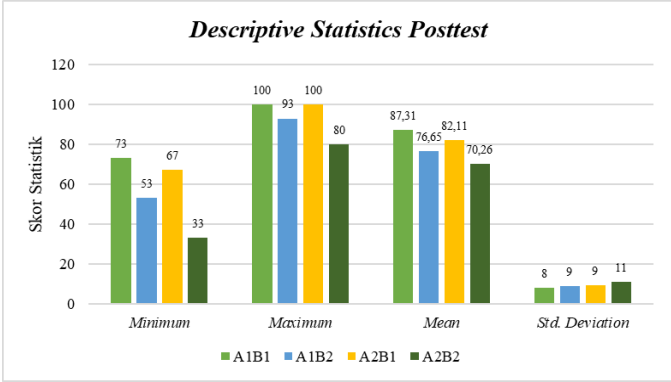


Figure 6. Descriptive Statistic Posttest (Source: Research Data Processing, 2025)

Based on Figure 6, the average posttest score in class A1B1 (Discovery Learning + WebGIS) was 87.31; A2B1 (lecture + WebGIS) of 82.11; A1B2 (Discovery Learning + print map) of 76.65; and A2B2 (lecture + print map) by 70.26. The comparison chart of the average posttest shows that class A1B1 obtained the highest score and has exceeded the KKM 78 set by SMA Negeri 1 Natar. Class A2B1 also surpassed the KKM, while A1B2 approached the KKM and A2B2 was still below the KKM despite the increase. Descriptively, there was an increase in grades from pretest to posttest in all classes, which shows that applied learning has a positive impact on students' critical thinking skills. In line with the increase in the average score, the analysis of the distribution of correct answers per question item also shows that there is an improvement in almost all critical thinking indicators. The following is a picture

Based on Figures 7 and 8, the distribution of correct answers per question item shows a change in the pattern of students' critical thinking skills from pretest to posttest. In the pretest stage, the indicators of interpretation (points 1–2) and inference (points 11–13) relatively obtained a higher number of correct answers compared to other indicators, while the indicators of analysis (3–5) and evaluation (6, 7, 9, 10) still showed

variation between classes. The self-regulation indicator (point 8) is the indicator with the lowest number of correct answers in almost all classes. After the learning treatment, there was an increase in the number of correct answers on almost all questions. Analysis and evaluation indicators showed a more even improvement compared to the initial condition, while interpretation and inference remained in the high category. Although the self-regulation indicator has also increased, the gain is still relatively lower than other indicators. These findings show the development of students' abilities to understand, analyze, evaluate, and draw conclusions based on the population phenomenon studied.

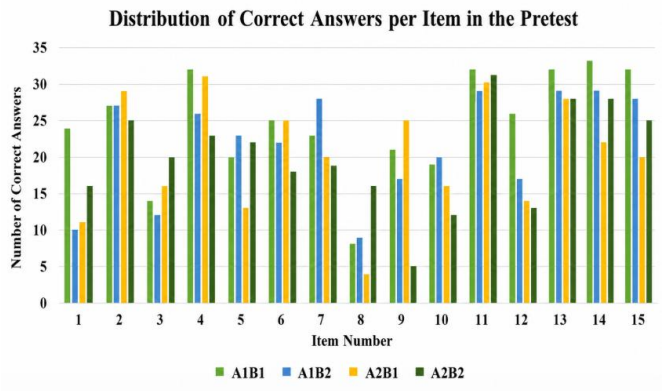


Figure 7. Distribution Diagram of Answers Per Item of Pretest Questions
(Source: Research Data Processing, 2025)

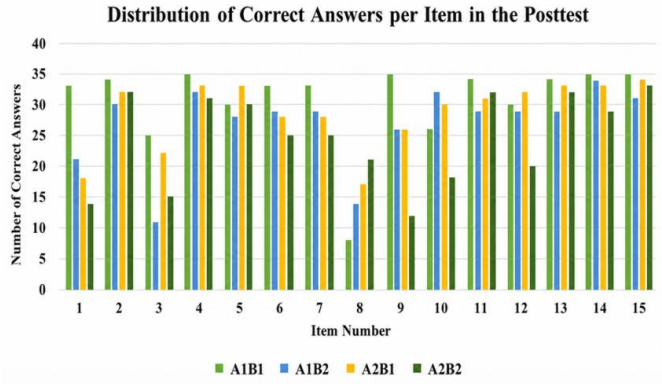


Figure 8. Distribution Diagram of Answers Per Posttest Question Item
(Source: Research Data Processing, 2025)

To determine the level of improvement in critical thinking skills quantitatively, an analysis was carried out using the N-Gain Score. The calculation results showed that the A1B1 class obtained an N-Gain of 0.547 (medium category), A1B2 of 0.356 (medium category), A2B1 of 0.572 (medium category), and A2B2 of 0.262 (low category). Thus, three classes are in the medium increase category, while one class is in the low category. The highest N-Gain value was obtained in class A2B1, followed by A1B1. In general, all classes experienced an increase in critical thinking skills after learning, although the rate of improvement was different. The critical thinking ability category is used as a reference to analyze the results of pretest and posttest students in four classes, namely A1B1, A1B2, A2B1, and A2B2. The grouping of this category aims to find out the initial and final level of ability of students after being given learning treatment. The criteria for the category of critical thinking skills are presented in Table 3.

Table 3. Category Critical Thinking Learners

Interval	Categories
$81.25 < X \leq 100$	Very high
$71.50 < X \leq 81.25$	Height
$62.50 < X \leq 71.50$	Medium
$43.75 < X \leq 62.50$	Low
$0 < X \leq 43.75$	Very low

Source: Setyowati, Subali, and Mosik 2011 in (Huzaimah, 2021)

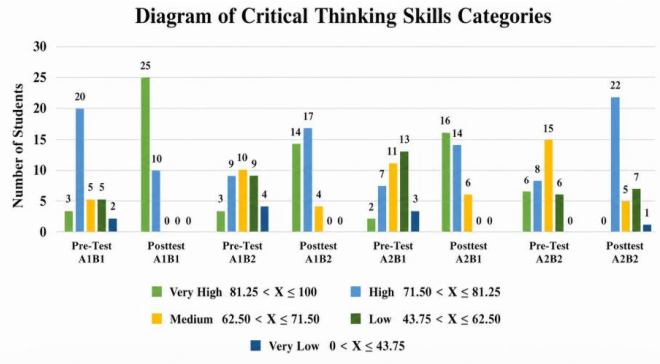


Figure 9. Critical Thinking Ability Category Diagram
Source: Research Data Processing, 2025

Based on Figure 9, in class A1B1, the pretest results are still dominated by the high category (20 students), with some in the very high (3), medium (5), low (5), and very low (2) categories. After treatment, there was a significant increase in the posttest, namely the very high category became dominant (25 students) and the low and very low categories no longer appeared. In class A1B2, the pretest results showed a relatively even distribution of categories from low to very high, with the dominance of the medium (10) and high (9) categories. In the posttest, there was an increase in the high (17) and very high (14) categories, while the low and very low categories were no longer found. In class A2B1, the pretest is dominated by medium (11) and low (13) categories.

However, in the posttest, there was a shift to a higher category, namely the very high (16) and high (14) categories, and there were no longer any low or very low categories. As for the A2B2 class, the pretest is dominated by the low category (15). After treatment, the

posttest showed an increase with the dominance of the high category (22) and an increase in the very high category (6), although there was still a small percentage in the medium (5), low (7), and very low (1) categories. Overall, the category diagram shows that the class using the Discovery Learning model experienced a more significant shift in the critical thinking ability category towards the high and very high category compared to the class with the lecture learning model.

Prerequisite Test

Before the hypothesis test is carried out, a prerequisite analysis test is first carried out which includes a normality test and a homogeneity test to ensure the feasibility of the data. The results of the normality test using Shapiro–Wilk in each group of learning models are presented in Table 4.

Table 4. Normality Test Results

Tests of Normality							
Variable	Learning Model	Kolmogorov-Smirnova			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Critical Thinking Skills	Discovery Learning	.207	70	.000	.929	70	.001
	Lecture	.205	71	.000	.918	71	.000

Source: Research Data Processing Results in 2025

Table 5. Homogeneity Test Results

Levene's Test of Equality of Error Variances[a]			
Dependent Variable: Critical Thinking Ability			
F	df1	df2	Sig.
.980	3	137	.404
Tests the null hypothesis that the error variance of the dependent variable is equal across groups.			
a. Design: Intercept + Model + Media + Model * Media			

Source: Research Data Processing Results in 2025

The results of the normality test using Shapiro–Wilk showed a significance value of < 0.05 in both groups so that the data was not normally distributed. However, since the sample count of each group is more than 30, parametric analysis is still used based on the principle of Central Limit Theorem (Abdussamad et al., 2025). Homogeneity test using Levene's Test obtained a significance value of 0.404 (> 0.05), so that the variance between groups was declared homogeneous. Thus, the data is eligible for testing Two-Way EDIT.

Based on Table 6, the results of the Two-Way ANOVA test show that the learning model has a significant effect on critical thinking skills with a significance value of 0.000 (< 0.05). Learning media also had a significant effect with a significance value of 0.000 (< 0.05). However, there was no interaction between the model and the learning media because the significance value of the interaction was 0.706 (> 0.05). The R Square value of 0.323 shows that learning models and media together contribute 32.3% to students' critical thinking skills, while 67.7% are influenced by other factors outside the study.

Hypothesis Testing

Table 6. Hypothesis Test Results

Tests of Between-Subjects Effects					
Dependent Variable: Critical Thinking Ability					
Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Models	1182.764	1	1182.764	13.752	.000
Media	4465.103	1	4465.103	51.916	.000
Model * Media	12.264	1	12.264	.143	.706
Error	11782.851	137	86.006		
Total	899702.080	141			
Corrected Total	17412.768	140			
a. R Squared = .323 (Adjusted R Squared = .309)					

Source: Research Data Processing Results in 2025

Based on these findings, it can be discussed that the Discovery Learning and WebGIS media separately affect the critical thinking skills of students at SMA Negeri 1 Natar. Class A1B1 (Discovery Learning + WebGIS) obtained the highest average (87.31) and was dominant in the very high category. This indicates that the syntax Discovery Learning i.e. stimulation, problem statement, data collection, data processing, verification, and generalization encourage students to actively analyze and evaluate population data. This finding is in line with the theory put forward by Jerome Seymour Bruner as the developer Discovery Learning in the 1960s. Bruner emphasized the importance of learning by doing, where learners actively discover concepts or knowledge for themselves. According to Bruner (1961) in (Khasinah, 2021b), knowledge discovered independently will be easier to remember and use in real situations, including in problem solving. Therefore, discovery learning makes knowledge more meaningful because it is obtained through the active involvement of students in the learning process. In addition, (Ilmiati, 2024) states that Discovery Learning Train students to build concepts through the process of observation and analysis, so that high-level thinking skills can develop optimally.

On the other hand, the use of WebGIS media has also been shown to improve critical thinking skills. classes that use WebGIS (A1B1 and A2B1) are on average higher than classes with printed maps. Interactive spatial data visualization helps students understand population patterns and inter-regional relationships in a more contextual manner. This is in line with the opinion (Amelia, 2024), that WebGIS supports dynamic map-based data exploration and analysis so as to strengthen students' conceptual and analytical understanding. Theoretically, the effectiveness of WebGIS can be explained through the cognitive function of the learning media. The media does not just convey information, but plays a role in facilitating understanding through structured visual representations (Gede et al., 2024). In the perspective of Levie and Lentz (1982) in (Suranda and Gaddafi, 2024), explaining that media has attentional, affective, cognitive, and compensatory functions. In this study, WebGIS plays a major role in cognitive and attention functions, which help students understand spatial data through interactive thematic map visualization and attract their attention to the geographical phenomenon being studied.

Furthermore, as a web-based development of Geographic Information Systems, WebGIS allows access and visualization of geospatial data in a wide and real-time manner (Hidayat et al., 2019; Wijaya et al., 2026). In geography learning, the use of GIS supports a more interactive and contextual learning process (Wijaya et al., 2023), so that students can interact directly with spatial data to understand patterns and relationships between regions. Thus, the use of WebGIS in this study does not only serve as a visual aid, but as a cognitive medium that stimulates the processes of analysis, evaluation, and inference which are the main indicators of critical thinking skills. These findings emphasize that the integration of spatial-based digital media in geography learning has a positive impact on the development of high-level thinking skills, especially in understanding population phenomena systematically and data-based.

Although the Discovery Learning model and WebGIS media each showed a significant influence on critical thinking skills, the results of the analysis also showed that the average score of class A1B2 (XI 12) using Discovery Learning and WebGIS was 87.31 and class A2B1 (XI 10) was 82.11. The difference does not show too significant a difference, so it can be interpreted that both treatments are equally effective in improving critical thinking skills. The absence of interaction does not mean that one of the variables is ineffective, but rather both work independently and optimally according to their respective functions. This means that the effectiveness of Discovery Learning in improving critical thinking skills remains consistent both when combined with WebGIS and with printed maps. Similarly, the use of WebGIS continues to make a positive contribution even though it is applied in learning models other than Discovery Learning.

These findings indicate that models and media have different but complementary roles in the learning process. Theoretically, the learning model functions as a pedagogical framework that directs the stages of students' thinking activities and cognitive strategies (Maduwu et al., 2025), while learning media acts as a means that clarifies the presentation of material and facilitates the understanding of concepts (Gede et al., 2024). Thus, models and media work independently in influencing critical thinking skills.

In the context of this study, Discovery Learning contributes through a systematic discovery process, while WebGIS supports through interactive spatial data visualization and exploration. Therefore, even though no statistically significant interaction was found, the application of discovery-based learning and the use of digital geospatial media (WebGIS) is still an effective strategy in improving students' critical thinking skills on population materials at SMA Negeri 1 Natar.

Conclusion

Based on the results of the research, it can be concluded that the Discovery Learning learning model has a significant effect on the critical thinking ability of SMA Negeri 1 Natar students. WebGIS learning media also has a significant effect on critical thinking skills. However, there was no interaction between the learning

model and learning media on critical thinking skills, so the two variables worked independently in improving students' critical thinking skills. Descriptively, classes using Discovery Learning and WebGIS obtained the highest average scores and showed a shift in the category of critical thinking skills towards very high. Thus, the application of Discovery Learning and the use of WebGIS can be an alternative learning strategy that is effective in improving critical thinking skills in population materials.

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