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Effects of Implementing the Discovery Learning Model on Students' Critical Thinking Skills in Fluid Material

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ABSTRACT

Twenty first century education requires students to possess critical thinking skills as part of their core competencies. This study aims to determine the effect of the Discovery Learning model on improving students' critical thinking skills in both affective and cognitive domains. The research employed a pre-experimental method with a one-group pretest-posttest design, and the sample was selected using a simple random sampling technique. The instruments used were observation sheets and tests designed to measure critical thinking skills in both domains. The results showed a significant improvement in students' affective and cognitive abilities after the implementation of the Discovery Learning model. In the affective domain, the average score increased from 67.50 to 83.33, with an N-Gain of 0.487 (moderate category) and an Effect Size of 1.174 (high impact). The cognitive domain showed improvement across four critical thinking indicators, with an average N-Gain of 0.660 (moderate) and an Effect Size of 5.633 (high). The hypothesis test result (t_h = 30.854 > t_t = 2.045) indicating a significant influence of the Discovery Learning model on the development of students' critical thinking skills. Thus, the implementation of the Discovery Learning model is proven effective in enhancing students' critical thinking skills in both affective and cognitive aspects.

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INTRODUCTION

Twenty-first-century education requires educators and education systems to prepare students to adapt to global challenges by strengthening 21st-century competencies. Increasing students' enthusiasm for STEM fields is one of its main goals (Rahim, 2022). The "4Cs" of modern education: creativity, critical thinking, problem-solving, communication, and collaboration can elevate the standard of today's classrooms. In order to prepare students for the modern world, it is crucial to raise educational standards, increase student engagement, adopt project-based learning, foster collaboration, and creativity, and use relevant real-world learning tools (Triani et al., 2023). In light of this fact, the Indonesian government is reassessing the country's educational system (Desnita et al., 2022).

Educators continue to utilize the curriculum as a guide to guarantee that students receive instruction aligned with designated learning objectives. Education is one domain experiencing transformation due to the rapid progression of scientific and technological advancements. Consequently, educational programs are perpetually revised to align with the requirements of contemporary society (Monica et al., 2020). Indonesia's educational curriculum has undergone a continuous evolution from 1947 to the present (Nadhiroh S & Anshori I, 2023). This Independent Curriculum, designed to tackle the challenges of modern education, exemplifies an innovative approach. The objective of the independent curriculum is to ensure that education is enjoyable for all participants, including both students and educators (Kollo & Suciptaningsih, 2024). According to experts, this Independent Curriculum empowers students to engage actively in their learning, focusing on a learner-centered approach that fosters character traits consistent with the Pancasila student profile. It is anticipated that this independent curriculum would raise pupils' standards in a number of areas, both academic and non-academic.

The Pancasila Student Profile serves as a foundational framework to guide students' character development and competence in line with national educational goals. Even when they are not in school, students should strive to live their lives in accordance with the principles stated in the Pancasila Student Profile (Susilawati et al., 2020)That profile is one instrument for realizing the country's educational goals. As a major resource for directing educational policy, educators can use the Pancasila student profile to help students develop their character and competence. According to Pancasila, there are six areas where students are expected to show competence: (1) faith, loyalty to God Almighty, and good morals; (2) cultural diversity; (3) peer cooperation; (4) independence; (5) analytical reasoning; and (6) creativity (Satria et al., 2024). The Pancasila Student Profile places an emphasis on critical thinking skills. Students that are good at critical thinking are able to do things like objectively process qualitative and quantitative data, make connections between various kinds of data, compare, contrast, and draw conclusions. A person's decision-making abilities are directly tied to their critical reasoning skills, which include activities like collecting and analyzing pertinent data and ideas and thinking deeply about one's own ideas and the logic behind them.

Improving students' scientific attitudes is crucial to enhance their critical thinking and problem-solving skills in order to achieve better learning outcomes. Many students struggle to comprehend and apply scientific attitudes, which might impair their ability to think critically and solve problems. (Ummah & Yohamitin, 2025). This is supported by the findings of Arianti et al. (2024), which showed that the students' average daily test score was 5.67, with 17 students meeting the competency standard and 13 not yet reaching the Criteria for achieving learning objectives benchmark. Observation results indicated a low level of students' critical reasoning dimension, highlighting the need for improvement in classroom instruction. Therefore, strengthening the critical reasoning dimension in the Pancasila Student Profile becomes essential to help students develop logical and objective thinking skills through the application of scientific attitudes, which encourage them to build a critical character and strong reasoning abilities (Ummah & Yohamitin, 2025).

Teachers encourage students to develop both critical and abstract thinking skills during classroom learning. This way, they can acquire the ability to think critically, which can be enhanced as they gain knowledge. One of the many important life skills that students should acquire in school is the ability to think critically. Success in life is related to one's thinking capacity since the former determines the latter's actions (Karim & Normaya, 2015). Gaining knowledge by engaging with the surrounding environment plays a vital role in developing thinking skills (Syahgiah et al., 2023). This suggests that teaching students to think critically as part of a school curriculum places an emphasis on developing their capacity to learn

independently, rather than just regurgitate information about a given topic. This skill keeps critical thinking, which encourages students to think deeply about a problem, assess its merits, and then organize their findings (Susilowati et al., 2017).

Critical thinking skills are essential for students to solve problems effectively and make informed decisions. Students that are able to think critically, solve problems effectively, and make reasonable decisions about what needs to be done are invaluable (Marlina et al., 2024). A student's ability to think critically depends on his or her capacity to reason logically, interpret, analyze, and evaluate information in order to solve problems in the classroom and beyond. A critical thinker will pose pertinent questions and problems, articulate them precisely, gather and evaluate pertinent data, maintain an open mind, make use of abstract concepts, and engage in active communication with others (Khasinah, 2021).

Students with strong critical thinking skills will be able to fully grasp the issue at hand, formulate a workable strategy for resolving it, and produce more realistic alternatives. Having the ability to think critically is essential if people are to effectively gather, evaluate, and use information (Ruhana et al., 2023). An ideal critical thinker is someone who is always eager to learn more, who is well-versed in the latest thinking, whose reasoning is solid and reliable, who is flexible and open to new ideas, who is balanced when evaluating, who is honest about their own biases, who takes their time making decisions and is willing to change their mind, who is honest about the problems they've encountered, who is intelligent and persistent in their pursuit of answers, who is focused and relentless in their investigation. claims that interference, analysis, interpretation, and evaluation are the four hallmarks of an ideal critical thinker (Karim & Normaya, 2015). Facione (2015) also proposes two abilities, the abilities of "explanation" and "self-regulation," in addition to the aforementioned four indicators; by this, he means the ability to articulate one's thoughts and the reasoning behind reasoning-based conclusions.

According to Karim & Normaya (2015), there are four main parts to critical thinking skills. The first is interpretation, which involves understanding and expressing the significance of various things like events, facts, assessments, habits, customs, opinions, rules, procedures, and criteria. The second indicator is analysis. Analysis is the skill of recognizing expected and actual inferential relationships between statements. The third definition of evaluation is the capacity to use one's own views, opinions, experiences, decisions, beliefs, and situations to determine the veracity of claims made in reports and descriptions. Evaluating the validity of assertions, descriptions, questions, or other expressions also entails checking their connections for logical validity. Fourthly, inference is the capacity to identify and collect relevant information in order to derive conclusions, assumptions, theories, evaluations, and outcomes from data, situations, queries, or other representations.

Students enhance their critical thinking and problem-solving skills through active involvement in learning activities. Students must optimize their involvement in the learning process so that their critical thinking skills can develop (Oktariani et al., 2020). Subjects with the capacity to seek, process, and apply knowledge are students (Rahim, 2022). Teachers, in their capacity as facilitators, should help students develop the skills necessary for autonomous and adaptable learning (Rahim et al., 2019). Students' low critical thinking skills reflect the fact that they are not taught to adequately analyze, synthesize, and evaluate facts, arguments, and information (Ardani & Suprapto, 2014). This highlights the need of learning strategies that actively involve students in the process of discovery and analysis of physics concepts, rather than merely delivering the material.

Students often experience difficulties in developing critical thinking skills when studying physics due to the abstract and complex nature of the subject. Learning about physics is a subject that is consistently linked to scientific principles (Laeni et al., 2022). Students' critical thinking abilities are enhanced by physics classes as well (Ruhana et al.,

2023). Nevertheless, many students find physics tedious due to the numerous calculations, formulas, and ideas involved, as well as the subject's abstract and complicated character. One issue that frequently arises in the classroom when teaching physics is students' inadequate critical thinking skills. Furthermore, the outcomes of Yulianti & Gunawan (2019), who found that high school students have low critical thinking abilities, further support this issue. According to the study's findings, students' exam scores did not meet the school-determined Minimum Completion Criteria, which was 70. On the physics test, students averaged just 56.6 points. The study by Ardiyanti & Nuroso (2021) found that out of the total number of students, 11 had extremely low critical thinking skills (30.6%), 20 had low skills (55.6%), and 5 had sufficient skills (13.8%). Not a single student exhibited either very high or high critical thinking abilities. According to the numbers, the majority of students still struggle when it comes to critically analyzing and solving physics problems. Because of this, a learning approach that is more problem-based and interactive is required.

This agrees with what researchers at SMA N 1 Batusangkar found through interviews and observations. According to an interview with a physics teacher at State Senior High School 1 Batusangkar, class XI students struggled to grasp fluid and wave concepts in the 2023–2024 school year, with average learning outcomes of 62 and 64, respectively. The teaching style of delivering information is common for fluid subjects; in this approach, the instructor takes center stage as the students sit quietly and take notes; next, the instructor provides typical questions and exercises. Because of their complexity, fluids necessitate familiarity with fundamental concepts and laws, such as the conservation of energy and Newton's laws of motion (Young & Freedman, 2002). This goes against the model that was utilized. Students still tend to commit physics formulas to memory rather than fully grasp the concept, which contributes to their underdeveloped capacity for critical thinking.

Considering the outcomes of the observation test of critical thinking skills in Senior High School 1 Batusangkar class XI 10 is low from several indicators of critical thinking skills. In the interpretation indicator the value obtained is 61.14% with a low category. In the analysis indicator the value obtained is 33.70% with a very low category. In the evaluation indicator the value obtained is 22.83% in the very low category. And in the interference the value obtained is 18.48% with a very low category.

These issues highlight the need for a student-centered learning model that encourages active participation from students. In turn, this aids students in fully realizing their potential, which in turn facilitates their comprehension of course material (Lendri & Asrizal, 2019). As part of their work to develop their critical thinking abilities, student-centered learning models have implemented tactics to get students more involved in the process of problem analysis, evaluation, and solution (Anwar et al., 2023). Students can enhance their critical thinking abilities through the utilization of learning models like problem-based learning, project-based learning, discovery learning, and scientific approaches. These models guide students in exploring concepts, engaging in discussions, and applying what they have learned in real-world scenarios (Sudirman et al., 2020). By doing so, they are able to connect the theory to real-world phenomena and gain a deeper understanding of it.

The Discovery Learning model helps students develop critical thinking skills through learning activities that involve scientific processes .Using the discovery learning model is one of the teaching strategies that truly helps students develop their critical thinking abilities. (Ruhana et al., 2023). Discovery Learning is a learning model that is expected to improve reasoning skills, especially in students, by using the discovery learning model. This learning model emphasizes student activities in learning. Because with this model, students can find concepts that are formed and developed through a scientific process and involve investigative or experimental activities as part of scientific performance (Lestari et al., 2019). Hosnan (2014) states that there are six syntaxes in discovery learning: stimulation, problem statement, data

collection, processing, verification, and generalization.

The discovery learning model supports students in building meaningful knowledge and developing critical thinking skills through active exploration. In the DL model, students are encouraged to construct new knowledge by drawing on what they already know (Laeni et al., 2022). Students are encouraged to define their own learning goals and actively seek out relevant information in this model, rather than receiving the concept in its entirety from the teacher. After collecting data, students organize and make sense of it to create knowledge that has meaning for them (Afiesta et al., 2022). Due to the fact that physics entails systematic and logical accumulation of knowledge through empirical investigations, the DL model is well-suited for use in physics education. In order to generate trustworthy results, this procedure necessitates the use of critical thinking skills (Masril et al., 2018).

The Discovery Model has a good effect on students in higher-order thinking. The advantage of this model is that the material studied can reach a high level of thinking ability and is durable because students are involved in the discovery process, where the results of the DL model have a better transfer effect compared to other methods and train students' cognitive skills to find and solve problems (Hosnan, 2014). In this way, students gain knowledge that was previously unknown, not through notification but by discovering it themselves, thereby enhancing pupils' capacity for critical thought (Jawad et al., 2017). Based on the description of the background and previous research studies, the formulation of the problem in the research is "how does the application of the DL model affect critical thinking skills in the affective and cognitive domains of students in the Fluid material?". This study is to ascertain and examine the impact of using the Discovery Learning model on students' critical thinking abilities in the emotional and cognitive domains of fluid material, in accordance with the problem formulation. Students must be able to independently observe, evaluate, and draw conclusions from information. Students should be actively engaged in their own knowledge exploration through the use of the Discovery Learning paradigm in order to maximize the development of their critical thinking abilities, which will help them grasp concepts and cultivate scientific attitudes.

METHODS

This research was conducted at SMAN 1 Batusangkar over a period of slightly more than one month in 2024. It consisted of six sessions in total. This research utilizes a pre-experimental design and is quantitative in nature. The study employed a pretest-posttest design involving a single group. The design is delineated as follow:

Tabel 1. One-Group Pretest-Posttest Design

Group	Pretest	Treatment	Posttest
Experiment	O_1	X	O_2

All grade XI pupils of SMA N 1 Batusangkar made up the study's population. Class XI-10 was chosen as the research sample from this group. The sample was selected using the fundamental random sampling technique. This technique is carried out by taking samples randomly which can provide an equal opportunity for each member of the population to be selected (Sugiyono, 2013). This technique was chosen because it is able to produce a representative sample and reflects the general characteristics of the entire population of grade XI students at the school.

Before conducting the research, several preparations were made. Among them were determining the research location, compiling important letters, compiling and validating research instruments, making instrument grids, then making instruments based on the grids

that had been made. The research implementation activities began with the implementation of a pretest given to the sample class to assess pupils' initial critical thinking skills. The pretest was given after the questions were evaluated based on validity, reliability, differentiating power, and level of difficulty. Assessment of students' Pancasila profile attitudes was carried out during the learning process through observation. After six learning meetings, students in the sample class were given a posttest to measure students' critical thinking skills after receiving treatment.

The information used in this study was gathered using instruments designed in the form of essays and observation sheets. These instruments were evaluated through testing procedures prior to their use, based on various analytical assessments. The evaluation included tests of validity, reliability, discriminative power, and item difficulty as integral parts of the testing process. The product moment correlation formula was used to measure validity, while reliability was tested using Cronbach's Alpha (Sundayana, 2018). These steps were carried out to ensure that the instruments were accurate and appropriate for measuring students' critical thinking skills and assessing critical reasoning attitudes.

Following the data collection, the subsequent step involved its analysis to derive conclusions. A normality test was employed during the analysis to ascertain whether the data distribution was normal. This study assessed the normality of the data utilizing the Liliefors test. To ascertain the disparity between the mean scores of the posttest and pretest, utilized a paired sample t-test alongside the Wilcoxon test (Sundayana, 2018). Effect size test and N-gain test were used to assess the transformation from pretest to posttest to evaluate the efficacy of the DL model in improving critical thinking skills. The N-Gain value is categorized into three groups: low (0.00 to 0.30), medium (0.30 to 0.70), and high (0.70 or greater) (Sukarelawan et al., 2024). An assessment of the DL model's impact on students' critical thinking abilities is referred to as an effect size test (ES). Effect sizes are categorized into three groups: low ($ES \leq 0.20$), moderate ($ES \leq 0.51$), and high ($ES \geq 0.80$) (Cohen, 1988).

RESULTS AND DISCUSSION

Results

The aim of this study is to ascertain how the discovery learning (DL) model affects students' emotional and intellectual reasoning abilities. The Pancasila Student Profile's critical reasoning dimension is the primary emphasis in the affective domain. Thirty samples were used in the study, which lasted for six meetings. Students develop an inquisitive mind, strong critical thinking abilities, and the ability to work independently when faced with challenges through lessons that stress the importance of students discovering information on their own. Consistent with the principles outlined in the Pancasila student profile of the critical reasoning dimension, this model promotes student agency, self-reflection, and accountability while they study (Arianti et al., 2024). The importance of the critical reasoning dimension's Pancasila student profile attitude is the primary subject of this research. Look at Figure 1 to observe the average increase in results from each meeting.

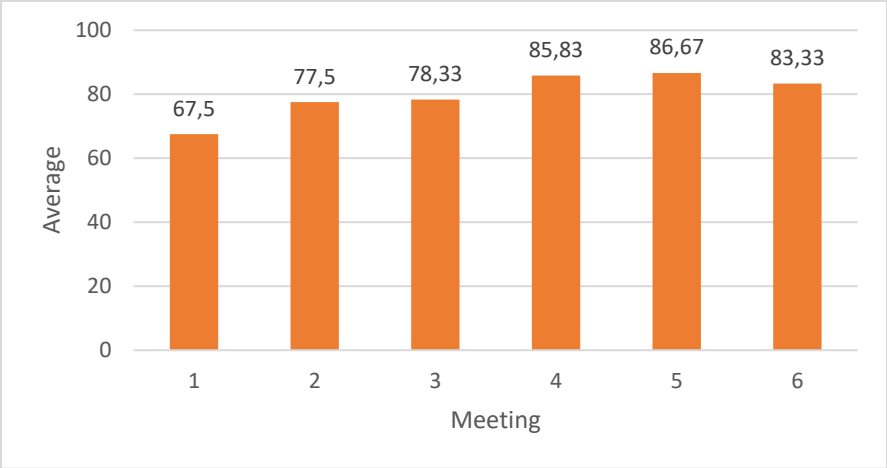

Figure 1. Pancasila Student profile Attitude Values Critical Reasoning Dimension

Students' critical reasoning scores on the Pancasila assessment are displayed in Figure 1. At each meeting, the value demonstrates that the Pancasila student profile's critical reasoning dimension changes. There was a noticeable uptick in students' performance on the critical reasoning subtest after the intervention. The critical reasoning dimension of the Pancasila student profile saw a significant improvement among the student body. Their average score increased from 67.50 before the test to 83.33 after it, representing a change of 15.83 points. From what we can see, the critical reasoning section of the Pancasila student profile is substantially enhanced by discovery learning after only six sessions. In accordance with At'haya et al. (2023), this is correct. Students' critical reason in regard to the Pancasila attribute can be enhanced through the use of the Discovery Learning model, according to the results. The learning model encourages student engagement, which in turn helps the critical reasoning component to grow. The DL model's impact on the Pancasila student profile's attitude values along the critical reasoning dimension was assessed using an N-Gain and Effect Size test. Table 2 displays the results.

Table 2. N-Gain and Effect Size results for the Pancasila Student Profile Attitude

Statistical Parameters.	Pretest	Posttest	Description
N-Gain	0.487		Medium
ES	1.174		High

Results from the N-Gain and effect size, as shown in Table 2, demonstrate that the Discovery Learning model can raise the critical reasoning attitude value of the Pancasila Student Profile. An N-Gain value of 0.487 indicates a moderate improvement in students' critical reasoning attitudes following treatment, and an effect size of 1.174 indicates a high level of influence from the Discovery Learning model on this improvement. The model emphasizes the importance of students actively seeking information on their own (Hosnan, 2014). This is consistent with the results of Arianti et al. (2024), which demonstrate that this method improves students' academic performance and fosters the growth of their Pancasila student profile character traits. Because they are encouraged to independently identify a problem with the question and its solution while working on it, students also do not experience boredom. In doing so, they can hone their capacities for critical thinking and creative thinking (Ummah & Yohamitin, 2025)

This study examines both the affective and cognitive domains, with the former focusing on students' critical reasoning skills and the latter offering a pretest as a first step in tracking their progress in learning fluid material. Students were given essay questions for the pretest without any instruction or background knowledge. This demonstrates that the fluid material covered in the pretest is still new to the students. The goal of this preliminary test is to assess the level of critical thinking proficiency among the students. Following instruction using the discovery learning model, students take a posttest to gauge how much they have improved their critical thinking abilities through the course of the learning process. This test focuses on four primary indicators: interpretation, analysis, evaluation, and inference. Students' strengths and areas for improvement in areas such as information processing, problem identification and analysis, reasoning with evidence, and data interpretation are highlighted by each indicator (Karim & Normaya, 2015). Table 3 displays the results of the N-gain and Effect Size tests, which indicate the degree to which the DL model improved and influenced the development of students' critical thinking skills

Table 3. N-Gain and Effect Size Results for Critical Thinking Skills Indicator

Indicators of Critical Thinking Skill	N-Gain	Description	ES	Description
Interpretation	0.673	Medium	2.103	High
Analysis	0.759	High	6.539	High
Evaluation	0.737	High	5.514	High
Interference	0.487	Medium	2.121	High

The results shown in Table 3 above demonstrate that the DL model successfully enhances pupils' critical thinking abilities across all indicators. Indicators of interpretation and interference have grown in the moderate category, according to the N-Gain test, with values of 0.673 and 0.487, respectively, while indicators of analysis and evaluation have grown in the high category, with values of 0.759 and 0.735, respectively. Interpretation, analysis, evaluation, and inference are the four indicators that show a high effect size in the results of the effect size test. When looking at the effects size and N-gain test results, the analysis indicator showed the greatest increase. This proves that teaching students to think critically through the Discovery Learning model significantly boosts their overall critical thinking abilities.

Research by Putri et al. (2024) supports this idea, as it describes the Discovery Learning model as an approach to education that places an emphasis on students' ability to learn by themselves by exploring new ideas. Meaningful learning experiences foster the natural development of critical thinking skills like interpretation, analysis, evaluation, and inference, and student participation in this process promotes the formation of scientific attitudes. After reviewing in detail critical thinking skills such as interpreting, analyzing, evaluating, and interpreting skills, a comprehensive picture can be drawn regarding the development of students' thinking skills in general in the learning process. The results of descriptive statistics can be seen in Table 4

Table 4. The results of the critical thinking skills data analysis

Statistical Parameters.	Pretest	Posttest
Mean	8.01	68.75
S	6.43	12.86
S^2	41.33	165.46

The descriptive statistical analysis shows that students' critical thinking skills improved between the pretest and posttest, with an average value of 68.75 and a standard deviation of 12.86, as shown in Table 4. There was a increase from the pretest to the posttest in terms of the average value of critical thinking abilities. This demonstrates that the critical thinking skills pre- and post-treatment scores differed following instruction in the Discovery learning model. Afiesta et al. (2022) also stated that the average value of critical thinking skills increased after this model was implemented. After performing the normalcy test, which was an initial requirement, hypothesis testing was conducted to support this analysis. The results can be found in Table 5.

Table 5. The Results of the Normality Test for Critical Thinking Skills Data

Statistical Parameters	Pretest	Posttest
α	0.05	0.05
L_0	0.130	0.094
L_t	0.161	0.161
Description	Normal	Normal

Results of the calculation of the normality test on the sample class's critical thinking skills are presented in Table 5. A normal distribution for the sample class data can be determined by running the Lilliefors test. If $L_0 < L_t$, then the data is said to be normally distributed, and if it is not, then the data is said to be non-normally distributed (Sri et al., 2023). The data showed that the L_0 values before the test were 0.130 and after the test were 0.094, with a L_t value of 0.161 for both. Both samples satisfy the criteria for normal distribution, as this suggests that $L_0 < L_t$ at a significant level of 0,05. According to Table 6, we can use the paired sample t-test to test our hypotheses because the data follows a normal distribution.

Table 6. Paired Sample t-test Result for Critical Thinking Skills

Statistical Parameters	Pretest	Posttest
α	0.05	
t_h	30.854	
t_t	2.045	

The calculated t-value (t_h) was 30.854, while the critical t-value (t_t) for degrees of freedom (df = n-1) was 2.045, both derived from the statistical analysis of the paired sample t-test data. At the 0.05 significance level, Hi is accepted since t_h exceeds t_t, indicating that the data resides within the rejection region of H_0. The findings indicate that the discovery learning model markedly enhanced students' average critical thinking skills relative to the period prior to its implementation. According to Laeni et al. (2022) this model facilitates students to think critically and analyze independently, thus enabling them to find general concepts or principles based on the material or data provided. It is also anticipated that pupils' critical thinking skills would grow as they gain information on their own. To determine the extent

to which the discovery learning model enhanced critical thinking skills and the magnitude of its influence, we employed N-Gain and Effect Size tests. The results of the N-Gain and Effect Size tests are shown in Table 7.

Table 7. N-Gain and Effect Size Results for Critical Thinking Skills

Statistical Parameters	Pretest	Posttest	Description
N-Gain	0.660		Medium
ES	5.633		High

Students' critical thinking skills improved to a moderate degree following the treatment, according to N-Gain and effect size tests (0.660), and the Discovery Learning model was highly influential in this improvement, bearing an effect size value of 5.633. Especially in topics like fluid materials that demand conceptual understanding and logical application, these results show that the learning model greatly improves the efficacy of the learning process and greatly increases students' critical thinking skills (Naijma et al., 2024). If students want to make the most of the information and abilities they already possess, discovery activities are crucial in assisting them in doing so (Yulkifli & Darvina, 2018). Further evidence for this comes from studies done by Rahmi & Firaina (2020), who found that the Discovery Learning model ranks second in terms of how effective it is when applied to the study of fluid material, among other areas of physics. It has been demonstrated that the Discovery Learning paradigm successfully improves students' critical thinking abilities.

Discussion

Education in Indonesia must develop students' personality and critical thinking skills to face the challenges of the 21st century. In facing the demands of the 21st century, education requires a learning model that focuses on developing both aspects in a balanced manner (Sudirman et al., 2020). Discovery Learning (DL) is a learning strategy that supports this objective by encouraging students to actively discover concepts through observation, data gathering, and conclusion-making (Hosnan, 2014). Through this process, students can increase their potential both in terms of attitude and knowledge (Maubana & Sakbana, 2020).

The Discovery Learning model influences student development in terms of affective and cognitive in an active and meaningful learning process. This Model helps students meet the Pancasila Student Profile in terms of emotion, particularly in the critical thinking component, where they learn how to assess evidence, examine material objectively, and develop knowledge using logical arguments (At'haya et al., 2023). When teachers allow students to find new ideas, theories, rules, or understanding via examples that are applicable to their everyday lives, the learning process can be characterized as effective and creative (Sulistyaningrum et al., 2024). This model prevents student boredom because they are directly involved in finding solutions to a problem. This process hones and develops students' attitudes in critical reasoning (Arianti et al., 2024)

Each stage in the Discovery Learning syntax is aligned with the development of critical thinking skills indicators. The increase in interpretation indicators in critical thinking is influenced by the provision of stimulus and the process of identifying problems in learning. The stimulation stage provides conditions for learning interactions through the display of videos or images of physics phenomena that arouse students' enthusiasm and curiosity (Hosnan, 2014). This encourages them to start formulating problems, providing arguments, and conducting evaluations. Furthermore, at the problem identification stage, students design problems in groups, formulate hypotheses, and discuss them. This process strengthens interpretation skills through initial stimuli that encourage collaborative problem formulation

(Afiesta et al., 2022).

The data collection and processing process impacts the improvement of analysis indicators in leaners' critical thinking. The development of students' critical thinking skills is greatly aided by both syntaxes. At this point, students learn to identify important pieces of information and organize them in a systematic way so that they can better comprehend ideas or solve problems (Anwar et al., 2023). Students can comprehend and resolve intricate mathematical issues by going through the steps of data collecting and processing. Students' critical thinking abilities are honed through this process, which entails thorough analysis of the collected data (Manurung & Pappachan, 2025). Students' critical thinking abilities, particularly in areas like information analysis and problem solving, are greatly enhanced during the data processing and collection phases of the Discovery Learning model, which aids in both content comprehension and overall academic success.

The verification process in learning promotes the enhancement of students' critical thinking evaluation skills by analyzing and testing the data that has been collected. An integral part of teaching students to think critically is having them go through the verification process, which in turn affects the improvement of evaluation indicators in their critical thinking (Afiesta et al., 2022). The next step is for students to use the data they have gathered and processed to test and validate their ideas or conclusions. As part of this process, students must evaluate the reliability, validity, and applicability of information and demonstrate their capacity to draw conclusions from available evidence (Anwar et al., 2023).

The generalization stage improves students' critical thinking skills in making conclusions based on data that has been analyzed. The generalization process, which is crucial to the growth of students' critical thinking abilities, has an impact on the rise in interference signs in leaners' critical thinking (Afiesta et al., 2022). At this point, students are expected to make inferences using facts and information that have already been gathered and examined. This process requires students to make logical and rational inferences, connect various information, and identify patterns or relationships that underlie the phenomena being studied (Hosnan, 2014). The inference aspect in students' critical thinking skills is needed to make conclusions with rational reasons based on the data that has been collected. This shows that the generalization stage in Discovery learning directly trains students in making in-depth and evidence-based inferences (Abdullah et al., 2021). As a result, this step in the discovery learning paradigm not only aids students in drawing conclusions about the content they have studied, but it also greatly enhances their critical thinking abilities, particularly with regard to drawing logical and fact-based conclusions.

Teachers improve students' critical thinking skills by applying the Discovery Learning model. that emphasizes problem solving and initial hypothesis formation in an active learning process based on direct experience. One definition of critical thinking ability is the capacity for in-depth, reasoned thought that results from the ability to assess and evaluate a problem using appropriate and reliable evidence. New, more complex, and solution-oriented ideas can be generated through this process (Karim & Normaya, 2015). Through an active learning process that emphasizes problem-solving and the development of initial hypotheses, students are supported in the Discovery Learning model's implementation to enhance their critical thinking abilities. This paves the way for improved conceptual understanding and the development of knowledge through first-hand experience (Afiesta et al., 2022).

The application of the Discovery Learning model has a significant impact on improving students' critical thinking skills through their active involvement in discovering and constructing their own knowledge. Students' capacity for critical thinking is significantly impacted by the Discovery Learning model's implementation, according to Bahtiar et al. (2022). When compared to students educated using more traditional methods, those whose lessons included the Discovery Learning model showed marked improvements in their

capacity for critical thinking. This is due to the fact that students' critical thinking skills are enhanced and fully developed when they are encouraged to actively seek, discover, and build their own knowledge through the Discovery Learning model. This is in line with what Ruhana et al. found, which is that the process makes students more autonomous in their learning and encourages them to take an active role in their own education. The process of analyzing and trying to solve problems teaches students to think critically as well (Ruhana et al., 2023).

Active and meaningful learning experiences in the Discovery Learning model shape students' character and attitudes in line with the critical thinking dimension of the Pancasila Student Profile. Through the use of the Discovery Learning paradigm, students' attitudes and character characteristics are molded in line with the Pancasila Student Profile in the critical thinking dimension. Additionally, an engaging and relevant learning experience helps pupils develop their critical thinking abilities. The balanced development of students' critical thinking abilities and character values is promoted when they are involved in independently locating concepts. This lines up with the educational requirements that teach pupils to be globally competitive through competencies in attitude, knowledge, and skill (Monica et al., 2020)..

CONCLUSION

Based on the research results, the discovery learning model has been proven to have a positive influence on improving students' critical thinking skills both from the affective and cognitive aspects. From the affective aspect, there was an increase in students' critical attitudes as reflected in the dimensions of the Pancasila student profile, especially in the critical reasoning indicator. Meanwhile, from the cognitive aspect, there was a significant increase in all indicators of critical thinking skills, namely interpretation, analysis, evaluation, and inference. The overall hypothesis test results also show that value $t_h = 30.854 > t_t = 2.045$. This confirms that the DL model has a major influence on students' emotional and cognitive development in critical thinking. These findings highlight the importance of implementing discovery learning in classroom activities. Educators are encouraged to adopt this model to foster a deeper and more reflective learning experience.

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