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Improving Students Ability to Evaluate and Conclude Through a Scientific Approach

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Abstract

This study aims to improve students' assessment and inference skills through the application of the scientific approach. The research was conducted with a pre-experimental design using the single group pretest-posttest method. The study population involved 85 students of class XI of SMAN 1 Blangpegayon, and 22 students of class XI science 2 were selected as samples using purposive sampling. Essay tests on sound waves were used to assess students' critical thinking skills through pretest and posttest. Data were analyzed using N-Gain test and paired sample t test. The results showed that students' evaluation ability had an N-Gain value of 0.97, while the ability to conclude reached 0.99, both of which were classified as high. Hypothesis testing showed a significant difference between pretest and posttest scores with a value of 0.001 <0.05, based on the paired sample t test. Thus, it can be said that employing a scientific approach to the learning process can enchance the capacity to evaluate and conclude students

Keywords: ability to conclude, ability to evaluate, scientific approach

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INTRODUCTION

One of the skills that students need to acquire in the modern era is critical thinking. This is in keeping with the increasingly complex demands made on students worldwide, wherein they must be able to accurately and precisely analyze, evaluate, and draw conclusions about the material in addition to being able to memorize and repeat it. Students need critical thinking abilities to overcome a variety of obstacles in the real world. A crucial component of education that aids in graduates' success is critical thinking (Damme et al., 2023). Critical thinking skills are the ability of individuals to analyze arguments, draw conclusions based on their reasoning, assess and evaluate problems, as well as make decisions and solve problems at hand. This skill can be measured through various indicators. Critical thinking skills are students' high skills in solving a problem (Shanta & Wells,

2020). Critical thinking skills can be measured through indicators developed by Ennis including evaluating and making conclusions (Liu et al., 2024).

Evaluation skills in the context of international education refer to the skills to judge, analyze, and make decisions based on available information. Bloom's Taxonomy places evaluation at the higher-order thinking skills level, where students are able to evaluate the quality, validity, and relevance of an argument or piece of data in addition to remembering or understanding it (Hui, 2024). Evaluation skills are also often associated with information literacy. The Association of College & Research Libraries (ACRL) emphasizes the importance of students having the ability to critically evaluate information sources, especially in contexts where information is easily accessible but not always valid or trustworthy (Faix & Fyn, 2020). This ability includes assessing sources in terms of authority, relevance and accuracy.

Evaluation is an important element of critical thinking, where individuals must be able to separate valid information from invalid, identify hidden assumptions, and make judgments based on evidence (Song et al., 2024). Meanwhile, according to Kidman and Chang (2022) Evaluation is a structured process that aims to collect, analyze, and interpret information to assess the effectiveness, quality, or progress of a program, activity, or individual. In the field of education, evaluation is usually used to assess student learning achievement, the effectiveness of teaching methods, and the overall quality of education. In education, evaluation skills are very important as they help students not to passively receive information, but to make critical judgments and come up with better conclusions.

Because summarizing requires in-depth information analysis before reaching a decision, it is a crucial component of the critical thinking abilities required in the learning process (Heim et al., 2022). An essential component of scientific inquiry and reasoning is the capacity for inference. In the context of science education, students are trained to evaluate data and draw conclusions based on valid scientific evidence (Holincheck et al., 2022) suggests that this ability involves the ability to interpret data, evaluate claims, and develop and design scientific research (Seeratan et al., 2020). Research results Yang and Zhang (2024) showed that students who have the ability to infer tend to be better at solving problems and have deeper thinking skills. However, in reality there are still many students who have difficulty in drawing conclusions appropriately, especially when faced with complex and conflicting information.

The truth is that pupils' academic critical thinking abilities remain in the low range (Mazrekaj et al., 2022). The critical thinking abilities of students are shaped by a multitude of factors. As posited Falloon (2024) these factors encompass the intrinsic characteristics of the students, pedagogical approaches, the integration of technology, and the environmental conditions within the school. Conversely, Ruano-Borbalan (2023) posit that students' critical thinking skills are also influenced by the learning methods applied by teachers, which tend to be conventional. In this approach, the teacher is more dominant, and students become passive, which results in students listening more, memorizing, and copying information without understanding. As a consequence, they have difficulty in solving problems that require analysis, manipulation, and strategy. In addition, learning

does not use practicum, teacher-centered learning, students tend to be more passive so that students are not enthusiastic about learning which makes it difficult for students to evaluate and conclude a lesson (Nelson, 2023). Program for International Student Assessment (PISA) 2022 data shows that Indonesia is ranked 68th. This low score includes students' critical thinking skills.

The results of preliminary observations at SMA Negeri 1 Blangpegayon show that there are still many students who do not have good critical thinking skills in evaluating and making conclusions. This is shown so far that learning still uses lecture and discussion methods without doing practicum which makes students inactive and less enthusiastic in learning which causes students difficulty in determining the final results of a lesson. Students are still confused if faced with questions that assign students to draw conclusions from a practicum or story.

The aforementioned issues highlight how poorly students understand physics when it comes to critical thinking, particularly when it comes to assessing and drawing conclusions.These two competencies are closely linked and crucial for enhancing students' critical thinking abilities, particularly in the context of science-based education. It has also been demonstrated that inquiry-based learning, which incorporates practical experimentation and problem-solving, is beneficial in enhancing these abilities (Li et al., 2024).

As a result, in order to enhance students' critical thinking abilities in the context of physics learning, an appropriate learning strategy is required. Applying specific educational interventions can foster the development of critical thinking (Elen & Verburgh, 2023). A scientific approach to teaching is being used in an effort to help students become more adept at critical thinking (Giri & Paily, 2020). Using a scientific approach to education can help students become more adept at critical thinking (Gómez & Suárez, 2020).

A scientific approach to learning can help students improve their ability to evaluate and draw conclusions. This is because a scientific approach to learning emphasizes exploration, elaboration, and confirmation, as well as observing, questioning, reasoning, trying, and communicating (García-Carmona, 2020). The scientific approach is a scientific method applied in the learning process with a focus on students. According to Heinze et al. (2023), this approach includes several phases, namely observing, formulating problems, formulating hypotheses, collecting data, analyzing data, and drawing conclusions. Meanwhile, Roldán Muñoz (2023) stated that the scientific approach allows students to experience the learning process through observation, questioning, data collection, associating, and communication.

The application of this approach is considered very appropriate in the context of learning. Research by Avci (2024) showed that the scientific approach is ideal for learning activities aimed at developing 21st century skills. Other findings from Khalil and Munshed (2024) show that learning with a scientific approach can train students' competencies. In addition, Erman and Wakhidah (2021) found that the implementation of the scientific approach in science learning had a very significant impact.

The scientific approach can influence students' critical thinking skills in improving their ability to evaluate. This aligns with the scientific approach's goals of improving students' intellectual

abilities, particularly their critical thinking skills (Kabataş Memiş & Çakan Akkaş, 2020). The scientific method encourages students to collect data and carefully evaluate it (The Curriculum, 2023). Through hands-on experiments, students learn about the methods they use to evaluate the accuracy of the data they collect, the accuracy of the results they get, and the quality of the results they get (Pieschacon et al., 2024).

The scientific approach can also improve students' ability to conclude. The scientific approach also improves students' ability to conclude based on existing evidence. Students are taught to analyze data, identify patterns, and draw scientifically valid conclusions. Programs such as PISA (Programme for International Student Assessment) emphasize the importance of inferential skills in evidence-based evaluation as an essential part of scientific literacy.

According to the description above, it is critical to use the appropriate learning strategy to improve students' ability to evaluate and draw conclusions about critical thinking skills, particularly in physics learning, so that researchers can use a scientific approach in this study. The purpose of this study was to determine how to improve the ability to evaluate and conclude students using a scientific approach.

METHOD

This study utilizes a pre-experimental research design. This research takes a quantitative approach, which is based on the presentation of numbers as measurement material (Sugiyono, 2017). This research will be conducted at SMA Negeri 1 Blangpegayon, which is located at Jl. Blangbengkik, Kec. Blangpegayon, Kab. Gayo Lues, Prov. Aceh.

In this study, researchers used one group pretest-posttest. This study used one class as an experimental class and a control class. Pretests were given before treatment to see students' initial ability to evaluate and conclude. Then after being given treatment using a scientific approach, a posttest was carried out to see the final ability of students so that it could be seen the improvement in the ability to evaluate and conclude students before and after treatment.

The population in this study consisted of all 85 students from class XI at SMA Negeri 1 in Blangpegayon. The sample was taken using purposive sampling technique, namely class XI science 2, with up to 22 students.

The data collection technique in this study is a test that assesses students' ability to evaluate and draw conclusions. The questions were arranged in the form of essays based on indicators of Ennis' critical thinking skills, specifically evaluating and drawing conclusions. Data analysis of students' critical thinking skills was carried out normality and homogeneity tests as a prerequisite test, followed by N-Gain test and hypothesis testing with paired samples t-test.

RESULTS AND DISCUSSION

This research was conducted first giving pretetst questions before being given treatment to see students' initial ability to evaluate and conclude. After receiving treatment in the form of a scientific

approach, students were given a posttest question to compare to their previous value in class IX science 2.

The results of the normality test with Shapiro Wilk show that the pre-test and post-test data have sig values greater than 0.05. The pre-test value is 0.191, and the post-test value is 0.116, indicating that all data is normal. The F test results show that the pre-test and post-test data are homogeneous (fhitung 1.4090 < ftabel 2.0841).

Furthermore, the N-Gain test yielded the average N-Gain value for class XI science 2 as an experimental control class. The N-Gain test results are shown in table 1 below:

Table 1. Analysis of N-Gain Results

Indicators	***Pretest***	***Posttest***	**N-Gain**
Conduct Evaluation	65	98	0.97
Make Conclusions	27.7	99	0.99

Following the N-Gain test, hypothesis testing was carried out. The hypothesis test in this study is a parametric statistical test, specifically paired sample t-tests. This test is used to make a decision whether the hypothesis is accepted or rejected, which is that there is a difference in the ability to analyze and conclude students after being treated with a scientific approach in class IX science 2.

Data analysis using SPSS revealed a sig (2-tailed) value of 0.001 <0.05, indicating that Ha is accepted. This suggests that there are differences in the ability to evaluate and conclude students before and after receiving scientific treatment for learning.Class XI science 2 students improved their ability to evaluate and conclude before and after receiving scientific treatment. The scientific learning approach aims to teach students how to recognize and understand various topics through observation rather than simply providing information. Learning using a scientific approach makes it easier for teachers to deliver material and increases student enthusiasm for learning (Zosh et al., 2024). This approach helps students find answers through a structured scientific process rather than wishful thinking (Spernes & Afdal, 2021).

The benefit of using a scientific approach to education is that the steps in the learning process are methodical and more student-centered, encouraging active learning. to make it simpler for educators to oversee the application of learning; offer chances for educators to express their creativity and encourage students to engage more deeply with a range of educational materials; The learning process involves cognitive processes that stimulate higher-order thinking skills; the learning steps involve science process skills in constructing concepts, laws, and principles; cultivate the character of students (Franco et al., 2020).

Students who have the attitude to always think critically are; looking for statements or questions that are clear in meaning; trying to be relevant in arguing; and looking for the basis for a Statement (Franco et al., 2020). The classroom learning activities that teachers carry out are nothing more than the lecture method of information delivery; by activating the teacher more while students passively listen and copy, where the teacher asks questions and students occasionally answer, students' critical

thinking skills are influenced by several factors (Li, Ismail, et al., 2024). A scientific approach to learning is being used in efforts to enhance critical thinking abilities (Zhang et al., 2021). The scientific method is a process of observation, inquiry, experimentation, and finally analysis or processing of data or information. After that, the data or information is presented, analyzed, and conclusions are made.

Because class scinence 2 was taught using a scientific method, it saw a faster increase after receiving treatment in class XI. Five stages comprise the scientific learning process: observation, questioning, trying, associating, and communicating. Students in the experimental class became more engaged and excited about learning when these five strategies were implemented. Students need to go through these five stages in order to arrive at the correct and logical conclusion.

The initial step is to observe. Edmonds (2024) define observation as the process of identifying an object by sense so that students can recognize an issue. In this approach in the experimental class, students are taught to start by observing a phenomenon in the form of a video about the doppler effect on YouTube. Students are then invited to identify problems based on the video and formulate hypotheses. This skill hones students' ability to see and organize problems systematically and logically. Observing activities can provide a fun and challenging experience for students, and make learning more interesting. In addition, through observation, students can discover facts that can stimulate their critical thinking (Butcher et al., 2023). The process of observing phenomena also encourages students to recognize problems and assess the information they see.

Followed by the questioning phase. According to Yeo (2022) questioning is an activity of asking questions about things that are not understood from what is observed. After observing, students are asked to ask questions about the YouTube video that has been shown. Students are invited to ask relevant questions, ask critical questions to clarify the problem, which helps them formulate the problem. Critical thinking ability can be enhanced through the development of observation skills. It allows students to explore their critical thinking abilities and encourages curiosity through questions that are based on facts. The scientific approach plays an important role in helping students find answers through a structured scientific process, not just imagination.

In the third phase, namely trying or doing experiments. In the experimental class, practicum activities are carried out to prove the hypothesis that has been made previously based on the video observed, then the problem is formulated and then a temporary conjecture or hypothesis is made. This hypothesis is answered through practicum so that the existing data is then analyzed and conclusions are drawn. The practicum was carried out using a virtual laboratory. Students are asked to carry out activities based on the LKPD that has been provided. After the practicum activities are completed, proceed to phase 4, namely associating.

Next, move on to the associating stage. Köhler (2025) states that sorting, classifying, counting, dividing, and organizing data into a more useful form is one method of processing it. Another is figuring out the data's source to make it more pertinent. Concept maps, tables, graphs, charts, modeling, and counting are examples of data processing types. Students examine data to compare or ascertain the connection between the processed data and accepted theories in order to draw a

conclusion. In order to reach a conclusion, students also examine data in order to compare or ascertain the relationship between the data they have processed and accepted theories. Associating activities can improve students' critical thinking skills in presenting arguments.

Students analyze and relate the information needed to draw conclusions and provide appropriate arguments, analyze results and relate them to theory. According to Kuhn (2019) the important characteristics of students who have an attitude to always think critically are trying to obtain the latest information, use and mention reliable sources, and try to be relevant in providing arguments.

Through data collection and analysis, students are trained to think analytically and critically. They learn to verify the truth of the information they receive, as well as evaluate the suitability of the data. The indicator of evaluating in the scientific approach can be improved in the steps of trying and associating. In order to reach a conclusion, students also analyze data in order to compare or ascertain the relationship between the data they have processed and the current theory. where students in the experimental class evaluated the experiment by examining the data collected in order to respond to the initial hypothesis.

The last phase is communicating. In the experimental class, after the data is analyzed, students conclude and present it in front of the class. After conducting an analysis and evaluating the practicum results, conclusions are drawn and linked to the coursework. From these five phases it can be seen whether the hypothesis made earlier is proven or not. The presentation of research results trains students to draw conclusions, provide arguments, and evaluate their own and others' work and make decisions based on results and analysis. After treatment using a scientific approach in learning, the indicator of conducting evaluation has increased with a high category. This is because in the scientific approach, students learn to collect data through planned and systematic experiments or observations.

After the application of the scientific approach in learning, the evaluation indicator showed a significant increase with a high category. This is due to the scientific method which teaches students to collect data through planned and systematic experiments or observations. According Zosh et al. (2024), the advantage of the scientific approach lies in its systematic learning steps, making it easier for teachers to manage the learning process. This process involves the ability to choose appropriate data collection methods and analyze the data obtained. Through data collection and analysis, students are trained to think analytically and critically, verify the truth of information, and evaluate the suitability of the data.

Evaluation indicators in the scientific approach can be improved at the trying and associating stages. According to Zosh et al. (2024), associating is the process of processing data through a series of physical and mental activities with the help of certain tools. Data processing can include classification, sorting, counting, dividing, and presenting data in a more informative form, including determining the source of the data to make it more meaningful. Examples of data processing include tables, graphs, charts, concept maps, calculations, and modeling. Furthermore, students analyze data to compare or determine the relationship between the data that has been processed and the

existing theory, so as to draw conclusions. After conducting experiments, students evaluate by analyzing the data obtained to answer the hypothesis that has been made before.

This huge increase in evaluation indicators occurred because during the learning process, the teacher accustomed students to solve problems by analyzing any information provided, as well as providing opportunities for students to solve problems on the blackboard and explain their answers. In addition, the teacher also gave additional assignments to do at home to familiarize students in solving calculation problems that require analysis.

Not only the ability to evaluate that experienced high improvement. This also applies to the improvement of students' ability to conclude. Where these two indicators have a very high increase. Critical thinking skills to make conclusions have increased 0.99 with a high category. Because summarizing requires in-depth information analysis before reaching a decision, it is a crucial component of the critical thinking abilities required in the learning process. An essential component of scientific inquiry and reasoning is the capacity for inference. In the context of science education, students are trained to evaluate data and draw conclusions based on valid scientific evidence suggests that this ability involves the ability to interpret data, evaluate claims, and develop and design scientific research. This is because in the experimental class using a scientific approach helps students find answers through a structural scientific process rather than wishful thinking. The reason the scientific method is called scientific is that it can help students develop critical, analytical, and precise thinking skills in recognizing, comprehending, resolving, and applying the subject matter.

Because the scientific method is student-centered, the high increase in indicators is the result of engaging learning activities in the experimental class, which encourages students to particsciencete more actively in their education. Learning with a scientific approach allows students to be more active and directly involved so as to make students happy and not feel bored. The indicator of making conclusions experienced a high increase because the implementation of the scientific approach in learning began at the introduction, core activities, and closing stages so that conclusions can be drawn to answer temporary conjectures made previously, especially through the process of associating and communicating after observing, questioning, and conducting experiments. With the aid of specific tools, associating involves processing data through a number of mental and physical actions. Students engage in communication when they describe and present the outcomes of their research.

In order to reach a conclusion in associating activities, students examine data in order to compare or ascertain the relationship between the data they have processed and the current theory. Students are trained to communicate the conclusions drawn from the outcomes of the conducted experiments after receiving communication instruction.

The steps of associating and communicating can improve students' critical thinking skills on the indicator of making conclusions. With the activities of associating and communicating students can analyze and associate information, which is needed to draw conclusions, then the presentation of research results trains students in drawing conclusions. Following the implementation of a scientific

approach to learning, the results demonstrated a notable enhancement in students' capacity to evaluate and draw conclusions. The scientific approach, which prioritizes active learning through observation, data collection, and analysis, has yielded a favorable impact on students' critical skills.

Students are instructed to conduct experiments and observe phenomena directly. They are engaged in a range of activities, from formulating research questions to drawing conclusions based on the data collected. By integrating students into the learning process, they become more active and engaged in learning, which contributes to the enhancement of their ability to evaluate the information obtained. Students are not only able to collect data, but can also better analyze and evaluate the information. They learn to consider different aspects of the data obtained and assess its relevance to the research question posed. This process develops their critical thinking skills, allowing them to conclude research results with greater precision and persuasiveness.

It can thus be stated that the implementation of the scientific approach in the learning process has resulted in an enhancement of students' capacity to evaluate and conclude. This illustrates the significance of active and engaged learning methodologies in fostering the development of critical thinking skills among students.

CONCLUSION

This study concludes that the application of a scientific approach significantly enhances students' ability to evaluate and draw conclusions. The results of statistical tests, including normality, homogeneity, N-Gain, and paired t-tests, confirmed that there was a meaningful improvement in students' critical thinking abilities after receiving treatment using the scientific approach. The learning process structured around the five phases of the scientific method—observing, questioning, experimenting, associating, and communicating—encouraged students to engage more actively, think critically, and analyze information systematically. Students in the experimental class demonstrated notable progress, particularly in the evaluation and conclusion-making indicators, which reached high improvement categories.

These improvements are attributed to the scientific approach's emphasis on structured inquiry, hands-on experimentation, and data-driven reasoning. By engaging students in observing phenomena, conducting virtual experiments, analyzing data, and presenting findings, the approach fostered analytical thinking and strengthened students' ability to assess information validity and draw logical conclusions. Ultimately, the scientific approach proved effective in promoting higher-order thinking skills, especially the ability to evaluate and conclude based on evidence. This student-centered methodology not only made learning more meaningful and enjoyable but also prepared students to engage in deeper levels of scientific inquiry and reasoning.

Based on data analysis and discussion of the research results, the average score of the pretest was 57.47 and the posttest was 79.79 and the n-gain value was 0.53 which was classified as a medium category, supported by the results of the student response of 88.61 classified as very good so that it can be concluded that the Problem Based Learning model is based on blended learning able to

improve the critical thinking skills of students of SMA Negeri Unggul Subulussalam, especially in physics subjects.

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