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# The Analysis of Students' Critical Thinking and Scientific Literacy Skills

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**ABSTRACT**

This research aimed to determine critical thinking and scientific literacy skills for the tenth-grade students of Bireuen Public High School 2 (SMAN 2 Bireuen). This research used a quantitative approach with a descriptive research design. There were 27 tenth-grade students of the second science class who selected samples through the purposive sampling technique. Descriptive analysis is a research type that does not provide the treatment, manipulation, or modification on the independent variables, but it describes an actual condition. The instrument used in this research was a test adapted from PISA questions. The results showed that the critical thinking and scientific literacy skills of tenth-grade students of SMAN 2 Bireuen were in the fair category. Therefore, it is necessary to apply learning approaches/models that can train students' scientific literacy skills to get used to carrying out scientific activities, solving scientific problems, providing explanations for a phenomenon scientifically, and using scientific evidence to explain a fact.



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## I. Introduction

The development of science and technology becomes a challenge in the educational field, making human resources more qualified and competing. This can happen if it is supported by good quality education. The rapid development of science and technology today is one of the impacts of globalization. The mindset of human resources is increasingly critical [1]. Education is one aspect of life that affects the development of science and technology.

Science and technology education is essential in preparing students to think critically, logically, creatively, and responsively to issues developing in everyday life [2]. Then, Wirnati et al. [3] it states that science education is a process that can shape human resources to think critically and creatively. The development of science and technology education requires sensitivity in analyzing various problems in life. Human resources are needed to have reading, writing, counting, and scientific literacy [4].

Based on OECD 2014 obtained the domain of scientific literacy consists of context, knowledge, competence, and attitudes [5]. The PISA assessment assesses students' knowledge and science skills from school and applies them in everyday life. Therefore, PISA scientific literacy questions only focus on situations related to the individual, social, and society in general. Indonesia's involvement in participating in the Program for International Student Assessment (PISA) is an effort to compare the development of educational programs in Indonesia with other countries in the world. This is very important for Indonesian children in developing educational programs to compete with other countries. Indonesia, from 2000 to 2018, has had the Program for International Student Assessment (PISA). The results obtained are that Indonesia is still very far from the expected results, so it takes effort and hard work to get better results, especially in critical thinking skills and science.

In general, students at this time still have not been able to develop skills in reasoning such as reading while thinking so that they can receive information clearly in solving various problems. Critical thinking, logical thinking, and adaptation to various changes and developments can teach students scientific literacy skills [6], [7]. Based on this, it can be assumed that critical thinking and scientific literacy skills have an attachment.

Critical thinking skills play an essential role in science education because they involve solving problems, making decisions, analyzing, and conducting various studies. Critical thinking skills in science learning are fundamental to be mastered. Students are trained in expressing opinions, making decisions, or becoming experts in studying the sources used. Furthermore, scientific literacy is a thinking process that includes problem-solving or critical thinking [8]. Scientific literacy can also be expressed as a skill to understand a concept or principle and thought process in solving problems that occur in everyday life [9], [10]. Students' scientific literacy includes the skills of analyzing, predicting, and applying various concepts.

There are several studies related to critical thinking skills and scientific literacy. Research from Fatah et al. [11] showed a significant effect of the argument-driven inquiry learning model on cognitive skills and scientific literacy on the concept of plant tissue in the experimental class. Then, research from Rahayuni et al. [12] pointed out such things as; a strong correlation between critical thinking and scientific literacy skills, and the Science Technology Community model is better than the Learning-Based model to improve critical thinking and improve students' scientific literacy skills. Furthermore, Juhji and Mansur [13] showed that critical thinking and scientific literacy skills affect the mastery of basic concepts of biology, which obtained a value of 56.8%. This shows the importance of developing critical thinking skills and scientific literacy skills in science learning activities. Furthermore, research from Azrai [14] reported that critical thinking and scientific literacy skills have a close relationship, where critical thinking skills can contribute 19.9% to the scientific literacy process. Based on the previous description, this study explores critical thinking skills and scientific literacy skills at Bireuen Public High School 2 (SMAN 2 Bireuen).

## II. Theory

### Science Learning

Science learning seeks to increase students' interest in developing various knowledge and improving skills and abilities to think about the universe. Science learning contains facts, theories, and concepts that must be mastered and memorized and includes various activities that use reason and scientific attitudes to study these aspects. The process must be carried out thoroughly in science learning because if it only contains facts, concepts, and theories, the learning process is incomplete. Science learning includes three critical components: scientific attitudes, scientific processes, and scientific products.

The form of the incomplete science learning process is often used in the science learning process. As a result, the achievement of the scientific literacy process as a science learning goal is hampered. This is contrary to science learning objectives, where success or failure in achieving it depends on the learning activities that occur in the classroom and are experienced directly by students. Science learning has complex characteristics because it requires critical thinking skills in analyzing a problem. Critical thinking is a result that can be produced from science learning because the nature of science learning is not only focused on remembering material and understanding concepts. However, science learning must provide direct and meaningful learning experiences to students to be applied in everyday life. Meaningful learning in science learning can be done by applying scientific literacy to be helpful in the problem-solving process in students' lives [15].

### Critical Thinking Skills

Critical thinking skills in the learning process can make students understand themselves, the world, and others. Students who can think critically will quickly analyze their thoughts so that their decisions are accurate [16]. Critical thinking skills can be obtained through the science learning process or other learning. Many studies on critical thinking skills have been carried out. Salbiah [17] stated that students' critical thinking skills at Public High School in West Java on colloidal material were classified as very good. However, this contradicts the research results by Susilowati et al. [9], which states that students' average critical thinking skills at Magetan Islamic Senior High School (MAN Magetan) are in a low category.

Several things influence the quality of students' critical thinking skills. For example, the selection of an inappropriate learning model, the lack of students' skills in identifying problems, and students often find it difficult to develop strategies when faced with different difficulty levels. This is following the opinion expressed by several researchers. They stated that critical thinking skills were still low because students could not identify known variables, ask questions, and be given problem-solving strategies [18]–[20]. Thus, it can be concluded that critical thinking skills are skills in thinking about things reflectively based on their experiences. The teacher's role is very influential in the process. Critical thinking skills can show students' cognitive abilities and must continue to be developed because these aspects are directly related to everyday life.

### Scientific Literacy Skills

The skills of students' scientific literacy in the learning process are to apply concepts from natural science and various natural phenomena that occur in life based on scientific activities, including identifying, collecting, and analyzing the concepts so that the conclusion can be


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obtained based on their findings. In developing scientific literacy skills, teachers are expected to implement a learning process centered on student activeness in understanding concepts about the various problems. Students need scientific literacy skills in analyzing problems and being able to relate to scientific facts in life. This is carried out to make decisions about problems related to various natural phenomena [21].

In the learning process, by applying scientific literacy, students' skills are assessed using scientific knowledge and understanding, such as students' skills to search, interpret, and analyze evidence. The Program for International Student Assessment (PISA) tests the following aspects: recognizing scientific questions, identifying evidence, drawing conclusions, communicating conclusions, and understanding scientific concepts. Furthermore, the assessment of scientific literacy skills is not only based on mastery of the material but also guided by thinking skills, life skills, and the skills to carry out scientific processes in everyday life.

## III. Method

This research used a quantitative approach with descriptive research design, which meant the study did not provide treatment, manipulation, or alteration of the independent variables but described the actual condition. The population of this research was all students of the tenth grade of Bireuen Public High School 2 (SMAN 2 Bireuen). The sample was 27 students of the tenth grade of second science class selected through the purposive sampling technique.

The sample used in this study was selected by considering the inclusion and exclusion criteria. Inclusion criteria are criteria or characteristics that each member of the population needs to be met that can be taken as a sample [22]. Inclusion criteria include male or female students in class X at SMAN 2 Bireuen and Willing. Exclusion criteria are characteristics of population members that cannot be taken as samples [22]. Exclusion criteria in this study were not present at the time of data collection, were sick at the study, and were not willing to be respondents.

The instrument used in this research included critical thinking and student scientific literacy skills test adapted from PISA questions. Both were measured through six indicators. For the critical thinking skill test, the indicators consisted of Interpretation, Analysis, Evaluation, Inference and Explanation, and Self-regulation. For the literacy skills test, the indicators are: identifying valid scientific opinions, understanding research design elements and their impact on findings/conclusions, make good graphs based on data, being able to solve problems based on scientific phenomena, understanding and interpreting basic statistics, and being able to make inferences, predictions, and draw conclusions based on the data.

The instrument used in this research has passed the process of content validity testing, test item difficulty level, distinguishing power, and reliability testing. The content validity test for critical thinking and scientific literacy skills test instruments was carried out by experts. The validation results of the instrument were 87.7% and 89.9% for each aspect, which indicated that the test instrument was valid. The validity test of the difficulty level was carried out to classify the criteria for easy, medium, and difficult questions and the distinguishing power to determine the questions that can be used or discarded. Reliability test results also showed a good percentage. Reliability for scientific literacy was 0.82, and for critical thinking skills was 0.78, which meant the test results were high so that the questions can be used for research. The data analysis technique in this research was descriptive with the percentage technique.

This research was conducted to provide critical thinking and scientific literacy tests to 27 students of the tenth grade of second science class. This test was given within 2 hours of the school time lesson (2 x 45 minutes). The percentage of critical thinking and scientific literacy skills achievement was displayed descriptively based on the student learning criteria proposed by Arikunto [23] as in Table 1.

**Table 1**. Interpretation of students' critical thinking and scientific literacy skills

| No. | Percentage | Criteria |
|---|---|---|
| 1. | 80-100 | Very Good |
| 2. | 66-79 | Good |
| 3. | 56-65 | Fair |
| 4. | 40-55 | Low |
| 5. | 30-39 | Very Low |

## IV. Results and Discussion

### Students' Critical Thinking Skills

Critical thinking skills are skills that must be possessed by students, especially in high schools. In this research, critical thinking skill was measured through 6 indicators distributed in each question. Details of questions for each indicator can be seen in Table 2.

**Table 2.** Distribution of questions about critical thinking skills

| No. | Sub Concept | No. Item of Question |
|---|---|---|
| 1. | Interpretation | 1, 3 and 5 |
| 2. | Analysis | 2 and 12 |
| 3. | Evaluation | 7, 11 and 14 |
| 4. | Inference | 6, 9 and 13 |
| 5. | Explanation | 4 and 10 |
| 6. | Self- Regulation | 8 and 15 |

Table 2 shows that the number of questions for the critical thinking skills test are 15 questions. Each indicator consists of 2-3 questions according to the items' validity and reliability test results. The total achievement of critical thinking skills was obtained by calculating the average percentage of students who answered questions correctly on each critical thinking skill test indicator.


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Table 3 shows the percentage of students' critical thinking skills achievement.

**Table 3**. The average level of achievement of students' critical thinking skills

| No. | Indicator | Percentage (%) | Category |
|---|---|---|---|
| 1. | Interpretation | 63.55 | Fair |
| 2. | Analysis | 55.78 | Fair |
| 3. | Evaluation | 57.98 | Fair |
| 4. | Inference | 57.77 | Fair |
| 5. | Explanation | 56.18 | Fair |
| 6. | Self-Regulation | 60.18 | Fair |
| | **Average** | **58.57** | **Fair** |

Table 3 shows that students' critical thinking skills achievement was fair from six indicators used in the research. The average level of achievement of critical thinking skills was 58.57. Among the six indicators of critical thinking skills, the interpretation indicator has the highest percentage, which was 63.55%. The inference is the skills to identify and obtain the elements required to make a logical conclusion [24]. With this skill, students can understand and state the meaning or purpose of experiences in various situations, data, events, decisions, conventions, beliefs, rules, procedures, or criteria. In addition, tenth-grade students of SMAN 2 Bireuen also had good self-regulation skills with a percentage of 60.18%. Self-control skills are related to a person's awareness of controlling their mindset, especially by evaluating his skills to conclude the terms of questions, confirmations, validations, and corrections [9].

This finding is in line with the report of Sari et al. [24]. They stated that several things caused the high student self-control indicator. For example, students can review results, explore material in-depth, and have other ways to obtain quality information. Assagaf [25] stated that several factors caused the high self-regulation indicator. For example, trying to remember and repeat the material, dig deeper into the material, determine learning objectives, have strategies for obtaining information, and evaluate the quality of the work that has been completed.

Overall, the critical thinking ability of class X students of SMAN 2 Bireuen is still low. It can be seen from the results of the student's critical thinking ability test. This is because students are not used to solving critical thinking skill questions. Students need more time to solve problems. Critical thinking skills can be built when students are given a problem. The problems can make the students construct their knowledge to find the right truth to solve it [26]. One of the learning models that can lead to problem-solving learning is the Problem Based Learning (PBL) model. Pamungkas et al. [27] showed that the problem-based learning model improved students' critical thinking skills. Through the problem-based learning model, students can solve problems in a structured way [26]. In addition, Alvionita et al. [28] stated that the problem-based learning model made students more active in solving the problems directly. Students are more accessible in developing their critical thinking skills.

Critical thinking skills are needed to face the development of the industrial revolution 4.0. It trains the students to be independent and careful, logically and thoroughly [26]. Critical thinking is a directed, clear and structured process used in solving problems, making decisions, and analyzing assumptions [2]. With critical thinking skills, students are trained to get used to facing various problems with logical and directed problem-solving skills.

## Students' Scientific Literacy Skills

Six indicators are used to assess scientific literacy skills, which are described in fifteen questions. Table 4 shows the distribution of questions for each indicator in detail.

**Table 4.** Distribution of questions on students' scientific literacy skills

| No. | Indicator of Students' Scientific Literacy skills | No. Item of Question |
|---|---|---|
| 1. | Identify valid scientific opinions | 1 and 9 |
| 2. | Understand the elements of research design and their impact on findings /conclusions | 7 and 12 |
| 3. | Make the graphics accurately from data | 2, 6 and 15 |
| 4. | Be able to solve questions based on scientific phenomena | 4, 8 and 14 |
| 5. | Understand and interpret basic statistics | 3 and 10 |
| 6. | Be able to make an inference, predict, and draw conclusions based on data | 5, 11 and 13 |

Table 4 shows that each indicator of students' scientific literacy skills consists of 2 and 3 questions. For indicators of identifying valid scientific opinions, understanding the elements of research design and their impact on findings/conclusions, and understanding and interpreting the basic statistics, each consists of 2 questions. For indicators of making graphs appropriately from data, being able to solve problems based on scientific phenomena, and making inferences, predictions, and drawing conclusions based on data, each consisting of 3 questions. As for the critical thinking skills, the total achievement of scientific literacy skills was obtained by calculating the average percentage of students who answered questions correctly on each indicator of students' scientific literacy skills. Analysis of the achievement of students' scientific literacy skills can be seen in Table 5.

Based on Table 5, it can be seen that the scientific literacy skills of tenth-grade students of SMAN 2 Bireuen were fair. Among the six indicators measured, the indicators of solving questions based on scientific phenomena and understanding the elements of research design and their impact on findings/conclusions get the


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lowest percentage. This showed that students were still not able to explain occurred scientific phenomena to explain a fact. Students were also not familiar with activities using scientific steps. Thus, students have not used scientific steps to solve problems and communicate experimental results to prove a fact.

**Table 5.** The average level of achievement of students' scientific literacy skills

| No. | Indicator | Percentage (%) | Category |
|---|---|---|---|
| 1. | Identify valid scientific opinions | 58.77 | Fair |
| 2. | Understand the elements of research design and their impact on findings/ conclusions | 56.86 | Fair |
| 3. | Make the graphics appropriately from data | 62.57 | Fair |
| 4. | Be able to solve questions based on scientific phenomena | 56.36 | Fair |
| 5. | Understand and interpret basic statistics | 59.00 | Fair |
| 6. | Be able to make an inference, predict, and draw conclusions based on data | 58.08 | Fair |
| | **Average** | **59.38** | **Fair** |

The students' inability showed that the science learning (Physics, Chemistry, Biology) at SMAN 2 Bireuen had not been implemented according to the nature of science. This indicated that it is necessary to strengthen learning, especially science, to improve scientific literacy skills with a supportive learning approach.

In general, the students' scientific literacy skills are still low. This can be seen from the results of students' literacy skills tests. Students could only determine problems but could not explain the solutions to these problems scientifically. One of the factors that cause the low literacy skills of students is that students are not used to solving questions related to literacy skills, the questions related to science process skills, or problem-based questions, which are the main part of scientific literacy.

Based on the analysis of students' scientific literacy skills at SMAN 2 Bireuen, it is necessary to apply a learning approach/model to train students' scientific literacy skills to do scientific activities. In addition, the practitioner can also practice scientific problem solving, explain phenomena scientifically and get used to using scientific evidence to justify a fact. One approach that can be applied is the scientific approach. Asyhari and Hartati [29] states that learning with a scientific approach improved students' literacy skills in competence and knowledge. In line with what was conveyed by Setiawan [30] that the scientific approach can be applied in learning to train students' literacy skills. The scientific approach will encourage students to be active in learning [31]. In line with Suryani et al. [32] who applied the 5E learning model integrated with a scientific approach to the reproductive system material. They succeeded in improving students' scientific literacy skills. According to Saputro et al. [26], the results showed that the application of problem-based learning science literacy learning tools had a significant effect on students' critical thinking skills.

## V. Conclusion

This research shows that the critical thinking and scientific literacy skills of tenth-grade students of SMAN 2 Bireuen are fair. This can be seen from the percentage of achievement in each indicator. The six indicators for each skill in this research showed that the average level of achievement of critical thinking skills was 58.57%, and the average level of achievement of scientific literacy skills was 59.38%. Based on the results of the analysis of the scientific literacy skills of students at SMAN 2 Bireuen, it is necessary to apply learning approaches/models that can train students' scientific literacy skills so that students are accustomed to carrying out scientific activities, solving scientific problems, providing explanations of a phenomenon scientifically and are accustomed to using scientific evidence to explain a fact.

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