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Challenges in secondary school education: profile of physics students' critical thinking skills

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ABSTRACT

For students to be able to compete and overcome challenges in the future, critical thinking is essential. The study's descriptive methodology aims to describe the students' critical thinking abilities. Every high school in a South Sulawesi district made up the research population. Based on school accreditation, with the use of a proportionate stratified random sampling technique, 150 students were chosen to comprise the research sample. The test instrument used is an essay distributed online. The indicators for the description questions are interpretation, analysis, and interpretation thinking skills. According to the study's findings, students' critical thinking abilities in static fluid material have an average score in the medium category of 73.09. In terms of school accreditation, students' physics critical thinking abilities average 73.87 for schools with A accreditation, 72.43 for schools with B accreditation, and 68.47 for schools with C accreditation. The percentage of each indicator of critical thinking skills is 34.58 in inference, 33.70 in analysis, and 31.71 in interpretation. It is anticipated that this study will give a broad picture of students' critical thinking competencies for teachers to choose and implement the most suitable stimulus to aid students in developing their critical thinking abilities.

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1. INTRODUCTION

Currently, the progress of science and technology has significantly transformed the global civilization. Currently, we are in the fourth phase of the industrial revolution in terms of progress and advancement. This revolution is characterized by the advent of diverse cutting-edge technologies, including drones, autonomous vehicles, and innovative robots capable of performing nearly all human tasks, as well as enhanced sophistication and rapid information acquisition. Naturally, the benefits of convenience are not the only outcomes we can expect; we will also encounter challenges and problems. In order to adequately prepare for all potential scenarios, it is imperative for the government to augment its human resources.

Creative human resources do not grow naturally but through a systematic, consistent, professional, and continuous process through education. Education makes a major contribution to the progress of a nation [1]. In improving human resources, the most basic thing is to change the nature and mindset of students in developing technological literacy competencies in facing the fourth-generation revolution [2]. For this reason, schools must process the ability to produce active learning and implement technology-based innovations in learning activities. To face the competition and challenges of the fourth-generation revolution, one of the ways taken is through improving the quality of education. Students must be equipped with 21st-century skill competencies. The term “4C” refers to a set of 21st-century skills that include: i) creativity and innovation, ii) critical thinking and problem solving, iii) communication, and iv) collaboration [3].

Even in post-secondary education, Indonesian students’ critical thinking abilities are still lacking in the elementary and high school grades. In a 2016-2017 World Economic Forum (WEF) opinion survey, Indonesia came in at number 41 out of 138 countries with a global competitiveness index, behind only Malaysia and Thailand. These results are influenced by the educational background of Indonesian staff members, especially their capacity for critical and analytical thought [4]. Kids’ critical thinking skills in school may indicate that an employee lacks critical thinking skills because employees typically attend formal education before looking for a career [5].

Physics is a science subject that contains various logical concepts that can shape the human mindset in developing science. The process of changing science learning both at the tertiary level and at the high school level is directed at efforts to train students to use their thinking potential. One of the physics learning competencies contained in Permendikbud Number 64 of 2013 is developing critical thinking abilities via physics education. This assessment shows that the process and evaluation of learning physics must be oriented toward developing the thinking skills needed by students [6], [7].

So far, teachers only focus on student learning outcomes [8], and the ratings used. As a result, students do not have a sense of curiosity about physics and do not have the skills to communicate new ideas or thinking skills to solve a physics learning problem. Conventional physics learning makes students sometimes rich in learning concepts but poor in terms of the application or application of science [9]. Even though in everyday life there are many activities related to the concepts and theories of physics. Concept mastery and the critical thinking abilities of students regarding physics concepts as indicators of the success of a learning process from various studies are generally lacking [10].

Based on the problem description above, it is necessary to assess students' critical thinking skills at the secondary level. Critical thinking is a systematic approach that enables students to examine the facts, assumptions, logic, and language that underpin other people's arguments. Essential thinking skills teach children how to approach problems in life logically. Students who can think critically will be better equipped to face life's challenges and make sound decisions. Critical thinking is divided into three parts: what questions should be asked, how to answer questions through reasoning, and confidence in the results of reasoning. Developing a critical thinking attitude in students while they learn is an attempt to improve their learning outcomes and achievements. Learning can help students develop the necessary thinking skills by requiring them to conduct practicums and solve problems in small group discussions.

2. LITERATURE REVIEW

Facione identified six critical thinking skills, namely interpretation, analysis, evaluation, inference, explanation, and self-regulation [11]. This crucial thinking indication from Facione has been refined and reorganized [12]. Further described indicators: i) interpretation is a person's ability to understand, explain, and give meaning to data and information [13]; ii) Analysis is one's ability to analyze and identify data relationships used to express thoughts or opinions; iii) Evaluation is one's ability to test the truth; iv) Inference is a person's ability to conclude, formulate hypotheses, look for alternative solutions, and consider; and v) explanation is a person's ability to explain or express thoughts based on evidence [14].

The test instrument used to evaluate critical thinking abilities at the high school and tertiary levels is difficult to complete. The content of critical thinking skills in schools is gradually directed to encourage students to think, examine a case or data, and then consider the best way to resolve it. For example, the teaching and learning process for incorporating ethnoscience, technology, engineering, and mathematics (STEM) problem-based learning (PBL) begins with a critical question. A question might be, "What are the different types of soy milk colloidal systems?" Another study examined how flipped classroom learning based on disaster map visualization affected students' self-efficacy and critical thinking skills in disaster mitigation materials in 2022. This study used an open essay test to assess students' critical thinking skills. The exam questions selected fall within the cognitive domains C4 to C6 [15], [16]. Similarly, at the postsecondary level, professors use essay tests to evaluate prospective teacher candidates' critical thinking abilities. The essay test is designed to assess the indicators of critical thinking skills [17]. In biology lectures at tertiary institutions, the teaching team assesses biology teacher candidates' critical thinking skills using essay test instruments and critical thinking-oriented skill evaluation rubrics [18].

The author presents a research problem based on the information provided: "What are the characteristics of students' cognitive abilities in interpreting, analyzing, and drawing conclusions from static fluid material?" This study seeks to examine the critical thinking abilities of students in a static fluid material, based on the problem formulation. The anticipated advantage of this research is to acquire data regarding the cognitive abilities of secondary school students. The writer formulates a research question based on the provided description: "What is the profile of students' cognitive abilities in interpreting, analyzing, and inferring information from static fluid material?" The objective of this study is to evaluate the critical thinking abilities of students in a static fluid environment, as determined by the problem statement. The purpose of this study is to gather data on the cognitive abilities of secondary school students. The data can be utilized by high school physics professors as reference or supporting material to stimulate pupils' physics critical thinking skills.

3. METHOD

This research is a type of descriptive research that seeks to collect information about variables from a set of objects [19], then describes the profile of critical thinking skills of high school students in one of the districts in South Sulawesi. The population of this research is all senior high schools in a district in South Sulawesi, both public and private schools. The sampling technique used was proportional stratified random. Samples are taken based on level [20], [21], in this case, school accreditation, namely 13 schools with A accreditation, 20 schools with B accreditation, and 19 schools with C accreditation. Five schools were randomly selected to represent each level of accreditation. Then choose 10 students randomly for each school. Thus, the number of samples is 150 people.

This study employs essay questions as a testing tool. The critical thinking skills exam assesses Facione's critical thinking abilities. In this study, essay questions are used as a testing instrument. The critical thinking skills test refers to Facione's proposed skills. The instrument validity test results revealed that only 12 of the 19 items tested in field trials at one of the schools that comprised the study population were declared valid. Table 1 shows the results of the reliability test calculations. Table 1 shows the data reliability results obtained with the SPSS version 25 application. Table 1 shows that the Cronbach alpha value of the test instrument is 0.741. This means that the critical thinking skills test instrument has a Cronbach's alpha value of 0.700, indicating reliability. Because the study took place online (due to the COVID-19 coronavirus pandemic), the critical thinking skills test instruments were distributed online using the Google Form application.

Furthermore, descriptive statistics were used to analyze the data and identify the critical thinking skill profile of high school students in one of the districts in South Sulawesi. The analysis used the IBM SPSS version 25 application. In addition, the research data were also analyzed through the Excel application to create a profile graph of students' critical thinking skills for every critical thinking skill indicator examined. Assessment is carried out based on the answers given by students, referring to the criteria in Table 2, which have been determined below. Criteria Table 2 shows three levels of critical thinking skills categories, namely low, medium, and high categories.

Table 1. Results of data reliability calculations with SPSS version 25

Cronbach's Alpha	N of items
0.741	12

Table 2. Assessment categories

Score range	Criteria
$X \geq M + 1SD$	High
$M - 1SD < X < M + 1SD$	Medium
$X \leq M - 1SD$	Low

4. RESULTS AND DISCUSSION

Critical thinking is a higher-order thinking talent that is not easily activated by traditional learning [22], particularly when tackling hard physics idea problems [23], [24]. Critical thinking is a person's proclivity to form opinions regarding conclusions based on evidence [25]. Students can use critical thinking to organize, change, adjust, and make acceptable judgments. Students with strong critical thinking skills may analyze any phenomenon that occurs. Furthermore, critical thinking skills play a crucial part in the process of learning, particularly in the study of physics [26].

A description-based Google Forms test measures students' critical thinking skills. Table 3 maps critical thinking skills test questions. The critical thinking test assesses interpretation, analysis, and inference. Facione identified six critical thinking indicators [27]. Interviews with subject teachers revealed that class eleven basic competency subjects in senior high schools in Physics only addressed critical thinking skills up to interpretation, analysis, and inference. Interpretation, analysis, and inference skills are found in the description test instrument's indicators and sub-indicators. Each indicator has two sub-indicators, each described by one question. Data on question count was analyzed using descriptive statistics in SPSS version 25. Table 4 shows the analysis results. Table 4 shows research data statistical parameter distribution. The statistical parameters are minimum, maximum, mean, and standard deviation.

Descriptive statistical data about students' critical thinking abilities in a South Sulawesi district can also show their range. After Table 1, Table 5 shows the assessment categories and critical thinking scores of students in one South Sulawesi district. Student critical thinking in one South Sulawesi district is mapped in Table 5. Criteria for critical thinking include low, medium, and high. Based on static fluid content, students' critical thinking skills in physics are medium (60.00%), according to Table 5. Additionally, the researcher examined students' critical thinking skills in physics learning in relation to their school's accreditation. Using school accreditation, Figure 1 shows students' critical thinking in physics. To assess students' critical thinking in physics, researchers examined each sign of thinking ability. Figure 2 shows physics students' critical thinking percentage. Interpretation, analysis, and inference are shown in Figure 2 to demonstrate students' static fluid critical thinking.

Table 3. Mapping questions on the critical thinking skills test instrument

Indicators	Sub indicators	Item number	Number of questions
Interpretation	Interpret concepts based on tables	1.8	2
	Interpret concepts based on events	2.4	2
Analysis	Analyze events based on physics equations	3.5	2
	Identify reasons	7.10	2
Inference	Draw conclusions based on events	9.11	2
	Finding alternative solutions based on problems	6.12	2

Table 4. Descriptive statistics of studens' physics critical thinking skills

Value	N statistic	Minimum statistic	Maximum statistic	Mean statistic	Std. deviation statistic
Valid N (listwise)	150	55.00	88.33	73.0896	8.46630

Table 5. Categorization of students' critical thinking skills profile on static fluid material

Score Range	Category	Frequency	Percentage
$X \geq 81.53$	High	41	27.33
$64.65 < X < 81.53$	Medium	90	60.00
$X \leq 64.65$	Low	19	12.67

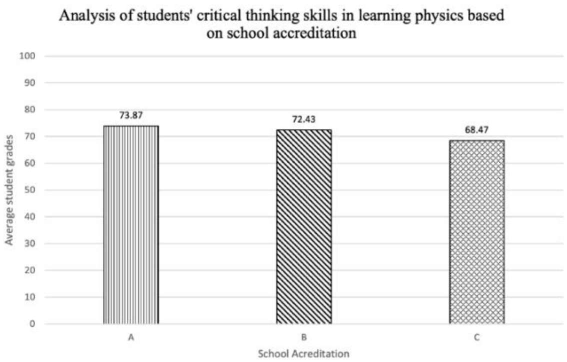

Figure 1. Analysis of students' critical thinking skills in physics learning based on school accreditation

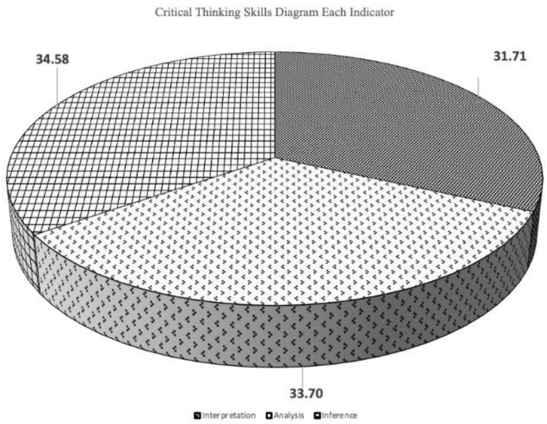

Figure 2. Diagram of students' critical thinking skills in physics learning for each indicator

In Table 4, descriptive statistics for many statistical factors based on research on physics students' critical thinking skills are shown. Statistics include mean and standard deviation. Average research data value is 73.09, standard deviation 8.44. The research sample's standard deviation shows data distribution. This study's standard deviation indicates a good sample data distribution near the mean. Table 5 shows that the categorization of students' physics critical thinking ability profiles in physics learning, as represented by static fluid charges, falls into the medium category. This is consistent with research on the critical thinking abilities of middle school students in China. The study discovered that students' critical thinking skills in China do not meet the curriculum's norms and needs, and they are generally dissatisfied with their critical thinking abilities [28]. Ekamilasari *et al.* [29]conducted similar research and discovered that students' critical thinking skills were low, and students were unable to provide reasons for questions in the form of descriptions that asked for reasons based on the answers given [29]. As a result, it is critical that secondary school education focus on improving and developing critical thinking skills. As a result, researchers in several countries, particularly Australia, have looked into how primary and secondary school students can develop critical thinking skills through active participation in collaborative team challenges. This activity focuses not only on implementing learning, but also on extracurricular activities in schools [30].

Accreditation also assesses physics critical thinking. Researchers sampled five schools per accreditation level. There are five A, five B, and five C-accredited schools. Figure 1 shows student physical critical thinking analysis results. As shown in Figure 1, students' critical thinking analysis skills in physics learning vary by school accreditation. Schools with A accreditation have the highest average score for students' physics critical thinking skills, 73.87; B accreditation, 72.43; and C accreditation, 68.47. The students' average physics critical thinking skills are similar. District schools allow information to flow smoothly online and offline. High school physics teachers in the district also hold weekly meetings. Physics teachers met separately in a focus group discussion (FGD) either online or in person at one of the schools. Head of the physics teacher's FGD facilitated bold FGD activities during the pandemic.

This study analyzes students' physics critical thinking skills for each indicator of critical thinking skills and describes their overall profile based on school accreditation. Figure 2 shows students' critical thinking in physics learning for each indicator. Each indicator of critical thinking skills has almost the same percentage: interpretation 31.71, analytical 33.70, and inferential 34.58. According to percentage, inference is the best indicator of critical thinking. Students use inferential thinking to identify and choose elements for logical conclusions. This is consistent with research that found students' inferential thinking skills were medium due to their lack of concept-finding activity. A number of online inference indicator essay questions were answered correctly but without logical justification. Students only see the physics formula as a mathematical equation and not as a practical tool. Practical work should be given more often in the learning process to improve students' understanding and inference skills.

Analytical thinking skills were the most prevalent after inferential thinking skills. Case studies or student practicum worksheets without detailed practicum stages can help students develop analytical thinking skills by identifying and analyzing a process or situation. Where students identify and analyze practicum stages based on the worksheet's problem formulation and objectives. Providing physics questions with scientific facts or phenomena from case studies can also improve analytical thinking. After small group discussions, students discussed this phenomenon in class using percentages [31]. Isnaeni's Android-based learning research shows this. Students' analytical skills improved after being taught using android media with virtual practicums and worksheets, as shown by an average pretest score of 53.65 and 88.83 [32]. Interpretive thinking skills are the least common critical thinking skill. Learning physics requires interpretive thinking. Interpreting concepts from tables or case examples requires thinking skills [33]. Virtual reality can improve students' interpretive thinking [34].

Critical thinking is a science learning competency. According to [35], [36], students need critical thinking skills to succeed in the changing times and revolution of society 5.0. Higher critical thinking skills lead to higher Physics concept mastery. Critical thinking helps students build knowledge into great ideas [37]. Other research on critical thinking skills found that elementary clarification, basic support, inferring, advanced clarification, and strategies and tactics affect learning. Basic support is strongest and inferring weakest. Clarifying the problem's focus and supporting skill identification and assessment with reason [38]. Concluding allows students to evaluate field facts and relate them to previous knowledge. Further clarification requires defining the term and applying appropriate criteria [39].

5. CONCLUSION

The research findings indicate that the mean score of pupils' critical thinking abilities in their physics classes in a district in South Sulawesi is 73.09, placing it in the medium group with a percentage of 60.00%. The mean score of pupils' critical thinking abilities in physics, as determined by school accreditation is highest in schools with A accreditation (73.87), followed by schools with B accreditation (72.43), and lowest in schools with C accreditation (68.47). Then, for each indicator of critical thinking skills assessed, the highest was inferential thinking skills, while the lowest was interpretative thinking skills. This study provides an overview of the profile of students' physics critical thinking skills in a district in South Sulawesi; therefore, this research is relevant so that teachers can find the right stimulus in developing students' critical thinking skills in physics learning, not only in South Sulawesi but also in secondary schools throughout Indonesia and the world. The intended stimulus is the selection of learning models, media, or teaching approaches that can stimulate and increase students' critical thinking skills.

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