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Analysis of Vocational High School Students' Critical Thinking Skills in Clean Water Management in Banyuasin

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ABSTRACT (9 pt)

This study aims to analyze the critical thinking skills of vocational high school (SMK) students in Banyuasin Regency in the context of clean water management through the topic "substances and their changes" in the Science and Social Studies (IPAS) subject. A descriptive quantitative approach was employed, involving 196 students selected using purposive sampling from seven SMK schools. Data were collected through a critical thinking test based on five indicators : (1) basic clarification; (2) basis for decision; (3) inference; (4) advanced clarification; and (5) assumptions and integration complemented by semi-structured interviews with 22 IPAS teachers. Quantitative data were analyzed using descriptive statistics, while qualitative data were analyzed thematically. The results showed an average student score of 50.67, indicating a moderate level of critical thinking, with the highest achievement in decision-making (63%) and the lowest in inference (30%). Sub-indicator analysis revealed strengths in asking clarification questions (70%) and weaknesses in making and evaluating value judgments (22%). Teacher interviews revealed that students showed high enthusiasm and creativity when dealing with real-life issues but struggled with deep scientific understanding. The novelty of this study lies in its analysis of SMK students' critical thinking in addressing local environmental issues, particularly clean water management. The findings suggest the importance of integrating local relevance with STEM-based instructional media to enhance students' critical thinking skills.

INTRODUCTION

Banyuasin is one of the regencies in South Sumatra Province, Indonesia, geographically located between 1°37'32.12'' to 3°09'15.03'' S and 104°02'21.79'' to 105°33'28.587'' E, with a total area of 11,832.99 km², accounting for approximately 12.18% of the province's total area. Administratively, it consists of 19 sub-districts, 16 urban villages, and 288 rural villages. According to the regional environmental performance accountability report (2020), around 80% of Banyuasin's topography is lowland comprising coastal areas, tidal swamps, and wetlands while the remaining 20% is dryland. Due to seasonal flooding and erosion sedimentation across most districts, the available water sources in the region tend to be acidic, dark brown to black in color, and contain elevated levels of iron and aluminum.

Research has confirmed the poor quality of water in several sub-districts. Ulfah & Sugiri, (2023) found high concentrations of iron and acidity in the water sources of Selat Penuguan. Similar issues were also reported in Tanjung Lago (Hafiddin et al., 2018) and Banyuasin I (A. Wahyudi, 2015). Furthermore, Fatimura et al., (2019) reported laboratory results from Banyuasin I showing that the water had a pH of 3, an iron content of 5.98 mg/L, turbidity of 20 NTU, and a strong odor none of which met the national clean water standards. In addition to geological factors, water pollution in Banyuasin is worsened by agricultural, industrial, and mining activities. For instance, Putri et al., (2019) noted the presence of lead (Pb) in the water sources of Sungsang due to nearby industrial activities. Although the levels remained below the critical threshold, they still posed a concern for daily use. Similarly, water in the Gasing River in Talang Kelapa showed physical and chemical pollution due to industrial waste, with pH levels ranging from 2.9 to 4.05 and classified as lightly polluted (Pitayati et al., 2017).

If left unaddressed, the use of contaminated water can lead to health risks such as diarrhea, digestive tract infections, and heavy metal poisoning.

The challenge of managing clean water in Banyuasin is not limited to chemical or physical pollution but also reflects limited purification efforts at the community level. Low adoption of basic technologies such as filtration or sedimentation, along with limited awareness about water sanitation, exacerbates the problem (Sriyanti et al., 2022). Moreover, the lack of integration between scientific and social approaches in water resource management continues to hamper progress. Therefore, sustainable clean water management requires both scientific knowledge and active community involvement, including contributions from students.

In this educational context, critical thinking is a key skill that should be cultivated early, especially in vocational high schools (SMK) (Hardianti & Suharti, 2022). It involves the ability to analyze, evaluate, and solve environmental issues logically, systematically, and based on data (Wahyudi et al., 2019). As future skilled workers, SMK students are expected not only to understand concepts but also to respond effectively to real-life challenges, including clean water issues (Rahmadani et al., 2023). Contextual and environment-based learning has proven effective in fostering awareness and responsibility toward local ecological problems.

The Science and Social Studies (IPAS) plays a strategic role in promoting students' critical thinking by integrating scientific and social concepts (Nisa et al., 2024). A particularly relevant topic in IPAS is "substances and their changes," especially the subtopics on separation methods such as filtration, sedimentation, and distillation. This content can be directly linked to students' local water pollution issues, making learning more meaningful and encouraging real-life application. IPAS has been shown to significantly enhance environmental awareness and students' critical thinking (Choiro Siregar et al., 2024)

Based on these conditions, this study aims to analyze the critical thinking skills of SMK students in Banyuasin within the context of clean water management, particularly through the IPAS topic of substances and their changes. This research employs a descriptive quantitative approach involving 198 SMK students, complemented by semi-structured interviews with 22 IPAS teachers to explore their perspectives on students' abilities. The findings are expected to contribute to the development of context-based IPAS learning strategies that not only improve science literacy but also cultivate a generation that is environmentally conscious and responsible for sustainable natural resource management.

RESEARCH METHOD

This study employed a descriptive quantitative approach aimed at analyzing the critical thinking skills of vocational high school (SMK) students in Banyuasin Regency within the subject of Science and Social Studies (IPAS), focusing particularly on the topic of "substances and their changes." This approach was selected to provide a detailed numerical description of students' critical thinking performance based on predefined indicators. The study also incorporated qualitative elements through teacher interviews to provide context and triangulation for the quantitative results.

A total of 196 students from seven vocational high schools in Banyuasin Regency participated in the study. These schools were selected using purposive sampling based on the relevance of their curriculum and access to environmental issues. The schools included SMKN 1 Tungkal Ilir, SMKN 1 Makarti Jaya, SMKN 1 Air Kumbang, SMKN 1 Banyuasin III, SMKN 1 Suak Tape, SMKN 1 Tanjung Lago, and SMKN 1 Rambutan. In addition, 22 IPAS teachers from the same institutions were involved in semi-structured interviews to provide qualitative insights into students' critical thinking development and classroom practices.

The primary data collection instrument was a multiple-choice critical thinking test developed based on five indicators proposed by Ennis, (2011): (1) Basic Clarification; (2) Basis for Decision; (3) Inference; (4) Advanced Clarification; and (5) Assumptions and Integration. Each item was carefully constructed and reviewed by subject-matter experts to ensure validity and alignment with the IPAS curriculum. The test was administered to students through Google Forms during scheduled instructional hours.

To enrich the quantitative data, the researchers conducted semi-structured interviews with 22 IPAS teachers. These interviews explored teachers' perspectives on students' problem-solving abilities, engagement with real-life environmental issues, and instructional strategies used to foster critical thinking. Interviews were conducted either in person or online, depending on the accessibility of the schools.The data collection followed three stages: (1) administering the online critical thinking test to students, (2) conducting and recording semi-structured interviews with teachers, and (3) organizing the data for subsequent analysis. Quantitative data were analyzed using descriptive statistical techniques. The results were presented in terms of average scores and percentage achievements for each critical thinking indicator, allowing for classification based on students' performance levels.Meanwhile, qualitative data from the teacher interviews were processed using thematic analysis. Transcripts were coded and categorized into major themes related to student strengths, challenges, and instructional approaches. These findings served to complement and validate the statistical results, offering a more holistic view of the students' critical thinking abilities within the local environmental context.

Table 1. Categories of Critical Thinking Skill Levels

Score Range	Description
0-20	Very Low
20-40	Low
40-60	Moderate
60-80	Good
80-100	Very Good

RESULTS AND DISCUSSION

Respondent Data Description

An analysis of respondent characteristics was conducted based on demographic data, including gender and specialization in vocational study programs.This information provides an initial overview of the background of students involved in the study and helps to understand patterns of distribution based on gender and vocational interest.

The distribution of respondents by gender is shown in Figure 1, while the distribution of students' vocational specialization preferences is presented in Figure 2.

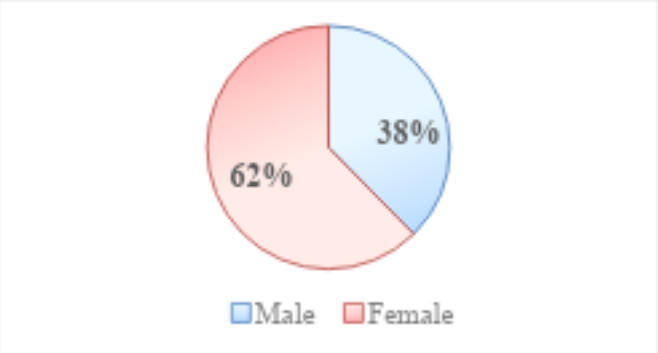

Figure 1. Gender Distribution of Respondents

Figure 1 presents data on the gender distribution of respondents in the form of a pie chart. Based on the figure, it is evident that the majority of respondents are female, accounting for 62% of the total participants, or 122 students. Meanwhile, male respondents make up 38%, totaling 74 students. This indicates that female participation in this study is higher compared to that of males. The difference in proportion suggests that the perspectives represented in the collected data are predominantly from female students.

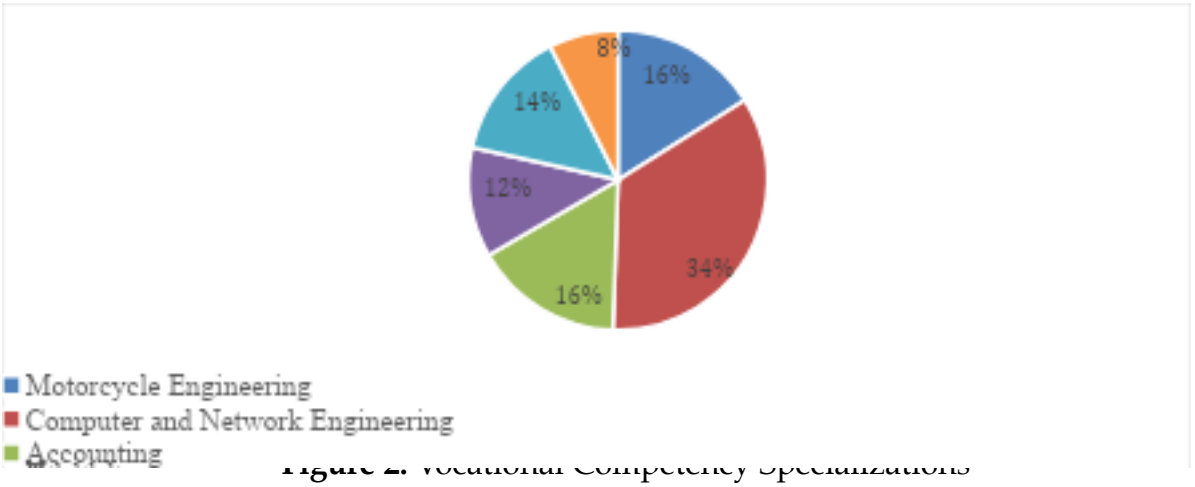

Figure 2. Vocational Competency Specializations

Figure 2 presents the distribution of respondents based on the vocational competency specializations of SMK (vocational high school) students involved in this study, with a total of 196 participants. The data show that the largest number of respondents came from the computer and network engineering specialization, totaling 67 students, or 34% of the sample. This is followed by Motorcycle Engineering and Accounting, each with 31 students (16%). Additionally, 24 students (12%) specialized in health sciences, 27 students (14%) in agriculture, and the remaining 16 students (8%) came from various other specializations, grouped into the "Others" category.

This distribution reflects the diverse vocational backgrounds of the respondents participating in the study. Such diversity is important for identifying and analyzing

students' critical thinking skills in the context of clean water management, as each area of specialization may offer different approaches and perspectives in understanding and responding to environmental issues, particularly those related to clean water.

Critical Thinking Ability

Descriptive statistical analysis was conducted to describe the level of critical thinking ability of students at SMKN 1 Air Kumbang in the context of clean water management. The data analyzed includes the mean, median, standard deviation, range, as well as minimum and maximum scores. The results of the statistical calculations are presented in **Table 2**.

Table 2. Statistics of Critical Thinking Skills of Students

	Mean	Median	Std. Deviation	Range	Minimum	Maximum
Critical Thinking Ability	50,67	54	2,21	80	8	88

Table 2**.** shows that the average (mean) score of students' critical thinking skills is 50.67, while the median score is 54, based on a 0–100 scale. The small difference between the mean and median suggests that the data is not highly skewed, and most students have relatively similar critical thinking abilities. The mean score also places students' critical thinking skills in the moderate category. The standard deviation of 2.21 indicates low data variability, meaning most students scored close to the average. This suggests that critical thinking skills among the students are relatively uniform and do not vary greatly between individuals. However, there is a minimum score of 8 and a maximum of 88, resulting in a range of 80. This wide range indicates significant disparities in critical thinking abilities among some students. After establishing this general overview, a more detailed analysis was conducted based on individual indicators to identify students' strengths and weaknesses. These are illustrated in Figure 3.

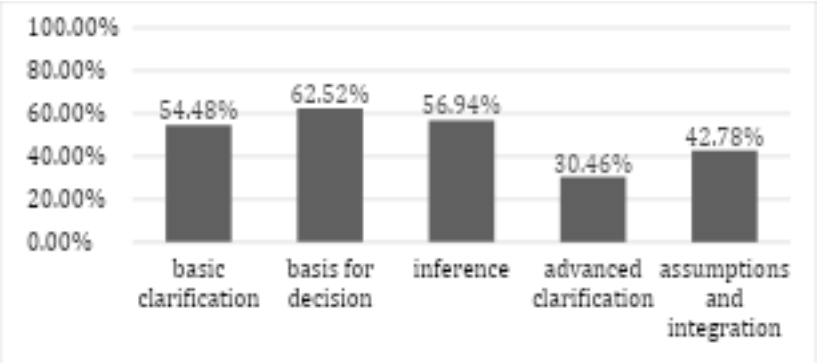

Figure 3. Diagram of Critical Thinking Skills by Indicator

The decision-making indicator had the highest achievement level, with 63%, or 123 students, indicating that students are fairly capable of using information and logical reasoning in making decisions related to clean water management. This was followed by the advanced clarification indicator at 57% (112 students) and the basic clarification indicator at 55% (108 students), suggesting that students are relatively proficient in understanding and explaining fundamental information before making judgments or

taking further actions. Meanwhile, the assumption and integration indicator scored 43% (84 students), implying that students still face difficulties in building coherent arguments and predicting the consequences of their decisions. The lowest-performing indicator was inference, with only 30% (59 students), reflecting weak abilities in drawing logical conclusions from available data or information. To further clarify the aspects that students have or have not mastered, an analysis was conducted on the achievement of sub-indicators within each critical thinking indicator. The results are presented in Table 3.

Table 3. Sub-Indicator Analysis of Critical Thinking Skills of Students

Indicator	Sub-Indicator	Percentage
Basic Clarification	Focusing on questions	47%
	Analyzing arguments	69%
	Asking and answering clarification questions	70%
Basis For Decision	Evaluating the credibility of sources	61%
	Observing and fairly assessing observational reports	56%
	Using their own pre-established conclusions	50%
Inference	Drawing conclusions and evaluating deductions	65%
	Making justified material conclusions (generalizations)	56%
	Making and evaluating value judgments	22%
Advanced Clarification	Defining terms and evaluating definitions	40%
	Attributing unstated assumptions	37%
Assumption and Integration	Reasoning from and considering disagreeable premises	52%
	Integrating dispositions and other skills in decision making	39%

The analysis results show that the highest achievement was found in the sub-indicator of asking and answering clarification questions, with a percentage of 70%, or equivalent to 137 students, followed by analyzing arguments at 69%, or 135 students, both from the basic clarification indicator. Next, the sub-indicator of drawing and evaluating deductions reached 65%, or 127 students, from the inference indicator. These achievements indicate that students are relatively strong in clarifying basic information and drawing logical conclusions. On the other hand, the lowest achievement was found in the sub-indicator of making and evaluating value judgments, which reached only 22%, or about 43 students, from the inference indicator. In addition, low achievements were also found in the sub-indicator of attributing unstated assumptions at 37%, or 73 students, from the advanced clarification indicator, and integrating dispositions and other abilities in decision-making from the assumption and integration indicator at 39%, or 77 students.

Findings from Teacher Interviews

In addition to quantitative data, the researcher also conducted interviews with teachers who taught the topic "substances and their changes" to gain an in-depth perspective on students' critical thinking abilities in the classroom. The thematic analysis of the interviews revealed several key themes that reflect teaching practices, challenges, and strategies for developing critical thinking. A summary of these findings is presented in Figure 4.

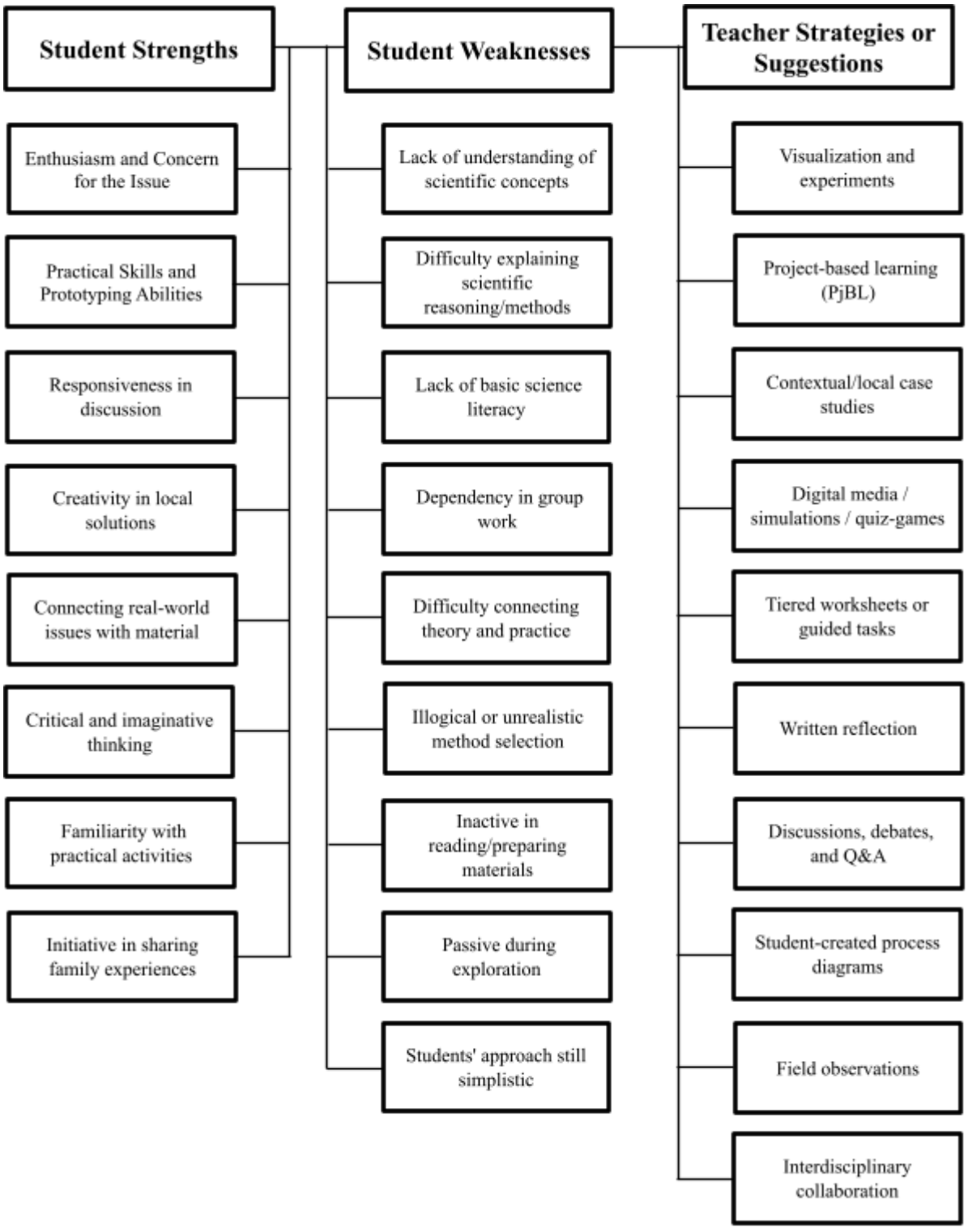

Figure 4. Coding Map of Teacher Interview Results

The coding map analysis revealed three major categories that served as the core of the interviews: students' strengths, students' weaknesses, and teachers'

strategies/suggestions in teaching the topic of substances and their changes, particularly related to clean water management. These three categories are interrelated and form a comprehensive understanding of the teaching and learning conditions in the field. In the category of students' strengths, the majority of teachers appreciated students' enthusiasm when presented with real-world contexts such as case studies or clean water issues in their local environment. Students were considered highly curious, responsive during group discussions, and creative in developing local solutions, such as simple water filter prototypes. Some teachers also mentioned that students were able to connect their family experiences to the lesson materials and showed critical and imaginative thinking during brainstorming sessions.

On the other hand, the category of students' weaknesses reflects several challenges encountered. Many students struggled to understand and explain the scientific concepts underlying separation methods. For instance, they frequently failed to differentiate between filtration and distillation, or they believed that filtration alone could separate all substances. Some teachers observed that students still relied too heavily on memorization or help from peers during group work. A lack of basic scientific literacy and limited initiative to explore further also hindered students from applying concepts logically and contextually.

In response to these conditions, teachers offered various strategies and suggestions for teaching. Many utilized project-based approaches and local case studies to make learning more contextual and meaningful. Digital media tools such as simulations and game-based quizzes were also used to enhance student engagement. In addition, teachers encouraged students to create process diagrams, write reflections after experiments, and participate in discussions and debates as part of critical thinking training. Some teachers also recommended cross-subject collaboration and field observation activities to enrich students' understanding of the importance of clean water management.

According to Dennett & DeDonno (2021), gender can influence learning styles and responses to contextual teaching approaches, including in the development of critical thinking skills. Liu & Pásztor (2023) further explain that female students tend to exhibit higher emotional and social engagement in problem-based learning, potentially enhancing their critical thinking abilities. Based on the demographic characteristics of the respondents, this study was dominated by female students, accounting for 62% (122 students). However, Hayudiyani et al., (2017) state that statistically, there is no significant difference between male and female students in terms of critical thinking ability, indicating the need for further analysis based on local contexts.

In addition to gender, students' vocational majors also showed variation. Most respondents came from the Computer and Network Engineering (TKJ) major, representing 34% (67 students), followed by Motorcycle Engineering, Accounting, Agriculture, and Health majors. This diversity of disciplines enriches students' perspectives in addressing clean water management issues, as each field brings different approaches and priorities to the problem.

Level of Critical Thinking Skills

Descriptive statistics show that the overall critical thinking ability of vocational high school students in Banyuasin is in the medium category, with an average score of 50.67 and a median of 54 on a scale of 0 to 100. The low standard deviation (2.21) indicates that the data is relatively evenly distributed. However, the wide range of scores (from 8 to 88) suggests significant gaps among students, likely influenced by both internal and external learning factors. Similar findings were observed in other studies analyzing students in vocational technical majors whose critical thinking was still low (Lestari et al., 2020). Parallel trends were also identified in studies across subjects such as mathematics (Baidowi et al., 2021), biology (Nawawi et al., 2020), chemistry (Muntari et al., 2022), and physics (Susanto & Daya, 2022).

Analysis of Critical Thinking Indicators and Sub-Indicators

Indicator analysis reveals that students performed best in the "Basis for Decision" indicator, with an achievement rate of 63%, indicating a moderate ability to use information and logic in decision-making. The lowest score was in the "Inference" indicator, at 30%, which shows a weakness in drawing logical conclusions from available data. At the sub-indicator level, students performed well in "asking and answering clarification questions" (70%) and "analyzing arguments" (69%), which fall under the "Basic Clarification" indicator, as well as in "assessing deduction" (65%) under the "Inference" indicator.

These findings are consistent with a study conducted by Kurniawan et al., (2021) in Malang, where vocational students also performed excellently in deductive reasoning (98%). However, the most prominent weaknesses were seen in the sub-indicator "making and assessing value judgments" (22%) under the "Inference" indicator and "attributing unstated assumptions" (37%) under "Advanced Clarification." According to Permata et al., (2019), these results indicate that students still struggle with abstract reasoning and drawing conclusions from implicit information. Previous studies also suggest that "Advanced Clarification" tends to be the most challenging aspect of critical thinking for students.

Validation of Findings Through Teacher Interviews

The quantitative findings in this study were reinforced through semi-structured interviews with teachers, analyzed using a thematic approach. Most teachers stated that students show high motivation and engagement when learning is linked to real-world issues in their environment, such as clean water management problems. In such contexts, students demonstrate creativity by developing practical solutions, such as prototypes of simple water filtration tools. This illustrates that contextual learning approaches, especially Contextual Teaching and Learning (CTL), effectively facilitate the development of students' critical thinking skills in vocational education (López et al., 2023).

Furthermore, the use of instructional media such as experiment videos, digital simulations, and locally relevant problem-based projects was considered highly beneficial in helping students understand material more deeply and practically. These media promote active engagement, clarify abstract concepts, and bridge the gap between theory and practice. However, some teachers also identified learning challenges, such as persistent misconceptions, especially in distinguishing between

filtration and distillation processes, and students' reliance on rote memorization or peer assistance. These barriers reflect the continuing issue of low basic science literacy, which remains a limiting factor in developing critical thinking (Abd-El-Khalick & Lederman, 2000)

According to Indar (2016), teachers also emphasized that students' critical thinking skills are not only shaped by classroom learning processes but also by external factors such as socioeconomic conditions, general literacy levels, learning attitudes, and cultural background. Therefore, there is a need for learning approaches that are interactive, responsive, and involve students actively through relevant and meaningful media. Strategies such as problem-based projects, collaborative discussions, and integration of learning technologies have been proven to foster the growth of critical thinking in vocational education settings (López et al., 2023)

CONCLUSION

The findings of this study indicate that the critical thinking ability of vocational high school (SMK) students in Banyuasin regarding clean water management falls into the moderate category, with an average score of 50.67. Although the majority of respondents were female students, no significant difference was found in critical thinking performance based on gender. The diversity of vocational majors contributed to enriching students' perspectives on contextual issues, such as clean water management. Analysis of critical thinking indicators showed the highest achievement in the *basic decision-making* indicator, while the lowest performance was found in the *inference* indicator, particularly in evaluating values and attributing implicit assumptions. These results were supported by teacher interview findings, which revealed that student enthusiasm increased when learning was connected to local contexts and supported by learning media such as experiment videos, simulations, and simple water filter projects. This demonstrates that the use of contextual and digital-based learning media can stimulate student engagement and enhance critical understanding. However, challenges remain, including scientific misconceptions and low scientific literacy. Therefore, appropriate, interactive, and real-life-relevant learning media are essential to comprehensively strengthen vocational students' critical thinking skills.

Based on the research findings, it is recommended that SMK teachers, particularly in the IPAS (Science and Social Studies) subject, intensively integrate contextual and digital-based learning media. Tools such as experiment videos, interactive simulations, and real-world problem-solving projects have been proven to enhance student engagement and improve their critical thinking, especially in understanding local issues like clean water management. Moreover, improving students' basic science literacy should be a key focus, as misconceptions especially regarding scientific processes such as filtration and distillation remain prevalent. This can be addressed through reinforcement of fundamental concepts, laboratory practices, and the use of visual aids that concretely illustrate abstract concepts. Furthermore, developing project-based and locally contextual learning should be prioritized so that education not only aligns with industry demands but also fosters awareness and solutions to environmental issues. Interdisciplinary collaboration among vocational majors in learning activities is also

recommended to integrate multiple perspectives and enrich students' approaches to problem-solving, particularly in the context of clean water management.

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