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# The Levels of Student Questioning and Critical Thinking Ability in Acid-Base Topics and Correlation with Learning Outcomes

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## Abstract

*Acid-base material is often considered difficult for students because it is abstract, leading to misconceptions and poor learning outcomes. The ability to ask questions reflects cognitive engagement and is closely related to the critical thinking requirea to understand abstract concepts. Therefore, it is important to examine this skill to obtain evidence of its role in improving chemistry learning outcomes and as a consideration for teachers in determining the appropriate learning process. This study aims to analyze students' questioning skills and critical thinking abilities in acid-base learning and examine the relationship between these skills and students' learning outcomes. A quantitative descriptive approach was employed and conducted at SMAN 1 Dampal Utara. The research subjects comprised 30 students, including 17 females and 13 males. Male students. The sample was selected using a purposive sampling technique. The instruments used for data collection included the questioning skills test and the critical thinking skills test. The results indicated that students' questioning skills were categorized as moderate with a percentage of 57.5 %, similarly, their critical thinking abilities also fell into the mild category with a rate of 48.33 %. Correlation analysis revealed a significant relationship between questioning skills and learning outcomes ($r= 0.386$; $\alpha =0.035$). Meanwhile, the relationship between critical thinking and learning outcomes was shown to be insignificant ($r= 0.225$; $\alpha = 0.173$). These findings suggest that questioning skills can contribute to optimal learning outcomes.*

**Keywords:** Quantitative descriptive research, questioning ability, critical thinking, correlation analysis

## Introduction

Science learning is based on observations of facts in the surrounding nature. These observations lead to curiosity and a desire to observe and study these natural phenomena through scientific investigations. (Hadzigeorgiou, 2022; Laliyo et al., 2023). In learning science, including chemistry, students need real experiences to stimulate questioning, thinking, reasoning, processing, and behaving scientifically. These activities will improve their thinking skills, and the knowledge they gain will be meaningful. (Demircioglu et al., 2023; Idris et al., 2022).

In learning chemistry, students study matter and its changes in the molecular aspect. So, to understand the concepts of chemistry, students cannot be if students only rely on rote memorization (Muteti et al., 2021). Students need critical thinking skills because many chemical concepts, such as chemical bonds, ionization, and other submicroscopic aspects, cannot be directly observed. In addition, some chemical concepts are often misinterpreted, causing misconceptions (Ilyas & Saeed, 2018; Jusniar et al., 2020; Üce & Ceyhan, 2019). For example, the concept of pH with acid strength. Problems in the real world involving chemical concepts are also complex problems because they involve other aspects, such as the environment and industry. Therefore, the condition of students' critical thinking skills needs to be known before teachers design suitable chemistry lessons to train these abilities (Shanta & Wells, 2022)

The ability to ask questions also becomes an important element of understanding complex concepts in chemistry. Learning that trains this ability will require students to be actively, deeply, and reflectively involved in the learning process (Chin & Osborne, 2008; Jegstad, 2023). For example, after observing various pH levels of acid solutions in acid-base material, students do not necessarily conclude that pH 1 means a strong acid and more than one indicates a weak acid. However, students should be able to question the causes, analyse, prove, and evaluate the facts they observe scientifically until they understand that the strength of the acid is not only based on the pH value. This activity can run well if students are accustomed to questioning activities, encouraging them to clarify, explore new concepts, and connect prior knowledge with newly obtained information. Similarly, critical thinking allows learners to analyze, evaluate, and

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synthesize information in a structured manner, leading to more profound understanding and better learning outcomes (Bhuttah et al., 2024; Rusmin et al., 2024).

Currently, learning outcomes are the main standard in determining the success of the learning process. The desired learning outcomes are determined based on specific and measurable statements about what students are expected to know, understand, and do because of a learning experience. In the independent curriculum, learning outcomes are not only about mastering factual knowledge, but also include cognitive, affective, and psychomotor domains. Chemistry learning includes analyzing, thinking critically, and solving evidence-based problems. Achieving these learning outcomes requires developing high-level thinking skills like critical thinking and inquiry (Kollo & Suciptaningsih, 2024).

The study showed that critical thinking skills can improve high school students' learning outcomes in buffer solution material (Mahdian et al. 2024). In addition, it also affects scientific literacy and decision-making (Bramastia & Rahayu, 2023). Other studies indicate that students' questioning skills affect deep connections to the material (Chin & Osborne, 2008). However, based on the results of an interview with one of the chemistry teachers in class XI MIA SMA Negeri 1 Dampal Utara, it is known that no specific research has been conducted to determine the level of students' questioning and critical thinking skills in acid-base material. Such work is very important to do.

Acids and bases are conceptually difficult topics in high school chemistry education. (Ivanoska & Stojanovska, 2021; Soeharto & Csapó, 2022). Misconceptions also often occur related to pH, the difference between acid/base strength and concentration, and neutralization reactions (Drechsler & Schmidt, 2005).

Based on this background, research is necessary to determine the level of questioning and critical thinking skills of SMAN 1 Dampal Utara students in acid-base learning and analyze the extent to which these skills correlate with student learning outcomes. By focusing the study on specific chemistry topics, this research will produce empirical evidence useful in designing learning strategies to achieve the expected learning outcomes.

## Methods

This research used a quantitative descriptive research method (Magfirah et al., 2023; Taherdoost, 2022). It was at SMAN 1 Dampal Utara, Tolitoli Regency, Central Sulawesi. The population of this study was all students in XI grade at SMAN Dampal Utara. Samples were selected by using a purposive technique. It consisted of 30 students, 17 females and 13 males.

The instruments used in this study tested questioning and critical thinking ability. Both instruments are valid based on expert validation. The questioning ability test consists of 4 items that are based on phenomena in everyday life about acid-base. Students are asked to ask questions based on phenomena. Students' questions were then analyzed based on indicators of questioning ability (Santoso et al., 2018). Then it will be scored based on those indicators.

The test of critical thinking ability consisted of 5 items. The questions were arranged based on the indicator of critical thinking (Facione, 1990) Then, they were scored based on the critical thinking assessment rubric. Furthermore, the scores were then categorized into very high, high, moderate, low, and very low categories after being converted to percentages (Rahayu et al., 2018).

To determine the correlation between student questioning and critical thinking ability and learning outcome, Pearson's correlation test was conducted at a significance level of 0.05.

## Results and Discussion

### *Students questioning ability*

Student questioning ability categorized into not critical level or questions that require answers at level of knowledge (level 1), and critical level which are: questions that require answers at the level of thinking of understanding information/concepts and applying (level 2), questions that require answers at the thinking level: identifying/analyzing, categorizing, causes, effects, and relationships (level 3), and questions that require answers at the level of thinking assessing statements or other representations that are explained or descriptions of someone's perceptions, experiences, situations, decisions, beliefs, or opinions, predictions (hypotheses), plans, conclusions, decisions, recommendations, (level 4) (Santoso et al., 2018). **Figure 1** shows the result of students' questioning ability.

**Figure 1** shows that the ability to ask questions at level 1 (not critical) is 42.5 %, while at levels 2-4 (critical) it is 57.5 %. This means students' ability to ask critical questions falls in the moderate category. It also shows that students' questioning skills are mostly at level 1. This result indicates that the questions students create only require low-level cognitive skills, such as remembering and understanding basic information, without applying, analyzing, or evaluating it in a complex context. For example, when students are presented with facts in the form of ulcer drugs for stomach acid sufferers, the questions asked by students mostly revolve around what is in ulcer drugs, and some even focus on the causes of ulcer pain. However, some students who reach the critical level in asking questions can also ask about how ulcer drugs' mechanism of action in relieving stomach acid pain, and how to determine the pH of ulcer drugs.

This can be caused by students being passive in the acid-base learning process, potentially limiting the development of students' high-level thinking skills. In addition, another research showed that teacher behaviors can also limit students' ability to ask questions, such as teachers' reactions of not responding and not listening, which are considered obstacles for students while asking questions (Dogan & Yucel-Toy, 2022). To overcome this, teachers can apply strategies that encourage critical thinking and active student participation in learning (Good et al., 1987; Zuidema & Zuidema, 2021).

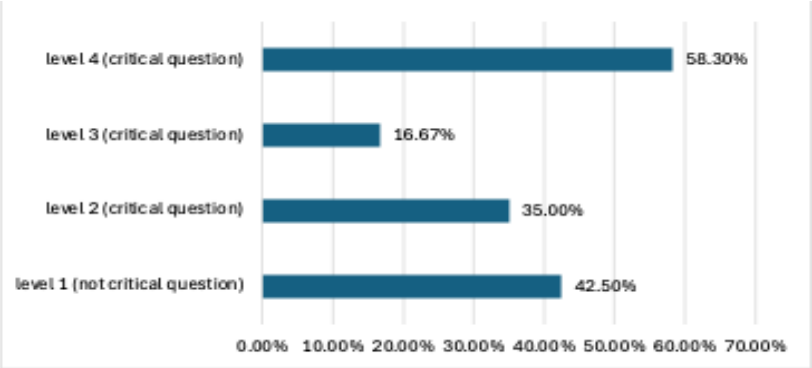


**Figure 1.** Students questioning ability

***Students' critical thinking ability***

Data on students' critical thinking ability were obtained from the answers of students who answered questions through questions of critical thinking skills. The question items are arranged based on indicators of critical thinking skills: interpretation, analysis, evaluation, and inference. The result of the students' critical thinking ability can be seen in **Table 1**.

**Table 1.** Students' critical thinking ability

| Critical thinking indicators | Percentages of categories (%) | | | | |
|---|---|---|---|---|---|
| | Very high | high | moderate | low | Very low |
| Interpretation | 0 | 0 | 43.33 | 56.67 | 0 |
| Analysis | 0 | 10 | 60 | 30 | 0 |
| Evaluation | 0 | 10 | 56.67 | 33.33 | 0 |
| Inference | 0 | 3.33 | 33.33 | 63.33 | 0 |
| Average | 0 | 5.83 | 48.33 | 45.83 | 0 |

**Table 1** shows that most students are in the moderate category for each critical thinking indicator, averaging 48.33 %. Slightly below that, 45.83 % of students are in the low category. This result shows that students' thinking skills have not been trained much in chemistry learning at SMAN 1 Dampal Utara.

In students with low critical thinking skills, it can also be seen in **Table 1** that most students are not yet proficient in interpreting and inferring. Interpretation means understanding and expressing the meaning of various experiences, data, events, or information. This includes skills in categorizing, interpreting, and clarifying information. Inference identifies and ensures the elements needed to draw logical conclusions, formulate hypotheses and relevant information, and conclude based on existing data and evidence. Likewise, other research also showed that not only in the classroom but also in the laboratory, most students have low critical thinking skills (Rahayu & Sari, 2023). Therefore, SMAN 1 Dampal Utara needs to implement learning that emphasizes developing critical thinking skills in the classroom and laboratory.

***Correlation between students' questioning ability and critical thinking on the learning outcome***

The Pearson correlation test determined the correlation between critical questioning ability and critical thinking in learning outcomes. The preliminary test indicated that the data on questioning ability, critical thinking, and learning outcomes were normally distributed (significance >

0.05). The Pearson correlation test results at a significance level of 0.05 indicated that the relationship between questioning ability and learning outcomes on the acid-base topic had a correlation coefficient of 0.386 and a significance score of 0.035. This means that there is a relationship between these two variables. However, the correlation coefficient value has not shown a strong positive relationship. This data also shows that the ability to ask questions is a communication tool and an important indicator of students' cognitive processes.

Meanwhile, the results of the correlation test on critical thinking ability and learning outcomes showed a correlation coefficient value of 0.225 and a significance score of 0.173. This data shows that there is no relationship between the two variables. In the same manner, other research in medical students also showed no significant association between critical thinking disposition and the students' grade point average (Shakurnia et al. 2021). This can be caused by measuring student learning outcomes at SMAN 1 Dampal not yet emphasizing the achievement of critical thinking skills. This further encourages learning and evaluation in chemistry learning to paying attention to students' critical thinking and questioning skills.

## Conclusions

The level of students' questioning ability on acid-base material is in the moderate category, with a percentage of 57,5 %, and the level of students' critical thinking ability on acid-base material is also at a moderate level, with a percentage of 48,33 %. The relationship between the two variables with learning outcomes based on the Pearson correlation test shows that at SMAN 1 Dampal Utara on acid-base topic, students' questioning ability is related to the achievement of learning outcomes ($r = 0.386$; $\alpha = 0.035$), while critical thinking ability does not show a relationship with learning outcomes ($r = 0.225$; $\alpha = 0.173$).

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