The relationship between critical thinking skills and students' learning motivation with students’ learning achievement about buffer solution in eleventh grade science program

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Abstract. This research was aimed to find out: (1) the relationship between students’ critical thinking skills with students’ achievement; (2) the relationship between students’ learning motivation with students’ achievement; and (3) the relationship between students’ critical thinking skills and learning motivation with learning achievement in learning about buffer solution. This was a quantitative research with a correlational approach. The populations were 178 students at eleventh grade science program from SMA Negeri 6 (senior high school) in Surakarta, Central Java, Indonesia, academic year of 2019/2020. One class with 36 students was selected as the sample by using cluster random sampling. The data were obtained through a multiple-choice test about critical thinking skills, a multiple-choice test about the buffer solution topic, and a questionnaire about students’ learning motivation. The data were analyzed by using Pearson Product Moment correlation, multiple correlations, and multiple regression analysis. The results showed that: (1) A positive and significant relationship between students’ critical thinking skills with students’ achievement was found, as shown by the correlation coefficient value of 0.871; (2) A positive and significant relationship between students’ learning motivation with their achievement was found, as shown by the correlation coefficient value of 0.884; and (3) A positive relationship between students’ critical thinking skills and learning motivation with their learning achievement, as shown by correlation coefficient value of 0.931. Regression analysis obtained the equation of \( Y = 10.416 + 0.423 X_1 + 0.487 X_2 \), and the value of coefficient determination was 0.845 or 84.5%.

1. Introduction

Continuous developments in education are needed to cope with the development of science and technology. Education cannot be separated from national development. The successful education process produces good quality human resources. The 21st-century education paradigm brings up various competencies and skills to be mastered by students, such as critical thinking, creativity, collaboration, and communicative. In the learning process, teachers are expected to train and develop students’ thinking skills. In the 21st-century, students must have higher-order thinking skills to face the challenges in life [1].

The observations at SMA Negeri 6 (senior high school) in Surakarta, Central Java, Indonesia, showed that in chemistry learning, the teacher still played the dominant role in class. When the teacher asked the students, students tend to stay silent. Also, the students’ curiosity was still low, as evidenced
by the students rarely ask the teacher. The students only accept and agree with the topics presented by the teacher. Students only listen to the lesson and do whatever the teacher instructs without trying to process them with their thinking system. It caused the topic only to be memorized and will impact the students’ achievement. Many students still unable to solve the problems in chemistry topics, and their achievements were unsatisfactory.

One important indicator of successful learning is learning achievement. Achievements are evidence of how successful a person’s efforts are [2]. Students’ achievements are influenced by various factors. One factor influencing learning achievement is critical thinking skills. If students have good critical thinking skills, then students have good learning outcomes [3]. Critical thinking skills are considered as an important skill in education because it has a crucial role in a successful life in today’s evolving world [4].

Critical thinking has become important skills to be mastered in the 21st-century [5]. The critical thinking processes are not just reflecting, drawing conclusions, and synthesizing information. It facilitates making proportional judgments or decisions, both in class and in everyday life. According to experts, critical thinking is an inseparable part of education at any level because needed by humans to face today’s world, which includes thinking about analyzing, evaluating, choosing, and providing solutions for the problems [6]. Critical thinking is the ability to consider fact from various sources, process them logically and creatively, and consider and analyze the information to reach correct conclusions [7]. Critical thinking is the ability to think reflective and reasoned that focuses on something to be believed or implemented. Aspects of critical thinking skills provide simple explanations, building basic skills, conclude, make further explanations, as well as strategies and tactics [8]. Critical thinking is one of the science skills that can be improved by writing laboratory report results because in this case students are required to participate in collecting existing evidence. From the analysis, it is known that critical thinking on the aspects of evaluating, explaining, and self-regulating are good [9]. In higher order thinking skills, this thought process, although not limited to reflecting, inferring and synthesizing information, enables people to make judgments not only in the classroom but also in everyday life [10]. By instilling critical thinking skills, it is expected that subject matter in various domains will be resolved with critical thinking and make it easier to solve other daily life problems [11].

Other than critical thinking skills, three factors also influencing the learning achievement, they are personality, age, and motivation [12]. Motivation is one main factor determining the success of students’ learning processes [13]. A motivated student will be involved in the learning process and can maintain that involvement without continuous encouragement or directions [14]. Motivation is like gasoline in a vehicle. It means it can provide strength or energy. It can bring enthusiasm to achieve the goals. The extent to which the person makes choices about which goals to pursue, and the efforts he will make to achieve them [15]. The existence of motivation can make someone interested in learning and participating directly in internal processes that aim to achieve the desired goals [16]. A motivated student will pay attention to the lessons and study the topic to get a better understanding [17]. It helps to “store” the topic in the students’ memory, and help them when they work on the test, so they can get good grades. Students with high motivation have the following characteristics: (1) prefers to do a task with a moderate level of difficulty; (2) have a desire to be the best (persistence); (3) likes to work with personal responsibility; (4) need feedback; and (5) creative-innovative in doing a task or job [18]. Students who have high self-confidence and motivation to learn can put more effort into getting better performance than those who are less confident and have no motivation [19].

Another factor causing the low student achievement is because chemistry is considered as a difficult subject by students. One topic in chemistry considered as difficult by students is the buffer solution. The buffer solution is a follow-up to the previous topic, the acid and the base, and related to everyday life. In the buffer solution topic, students will learn a concepts, types, pH, working principles and the benefits of buffer solutions in our lives. This topic need understanding and mastery of the initial concepts of calculation and theoretical basis regarding acid-base compounds and pH as
prerequisites. Also, students will encounter the concept of salt hydrolysis, which can often be confusing when they were presented simultaneously [20].

Many concepts in chemistry are abstract, and students have difficulty understanding them. Concepts in chemistry are very important because they serve as the basis for other subject matters [21]. In chemistry, abstract characteristics and other difficulties in learning suggested that chemistry learning requires a higher critical thinking skills [22].

Based on the explanation above, this research was aimed to prove positive relationship between students’ critical thinking skills and motivation on students’ achievement about the buffer solution. Thus, researchers are encouraged to conduct research entitled the relationship between critical thinking skills and student’s learning motivation with student’s learning achievement about buffer solution in eleventh grade science program from SMA Negeri 6 (Senior high school) in Surakarta, Central Java, Indonesia, academic year of 2019/2020.

2. Research Method

The quantitative approach with the correlational method was used as the research method. This research has two independent variables and one dependent variable. The independent variables were students’ critical thinking skills (X₁) and learning motivation (X₂). The dependent variable was student achievement.

The populations were all eleventh grade science program students in SMA Negeri 6 (senior high school) in Surakarta, Central Java, Indonesia, semester 2 of the 2019/2020 academic year (n= 178 students). The samples were chosen by using the cluster random sampling technique. The samples were one class randomly selected based on the homogeneity test. The selected class has total students of 36. The data were obtained through the multiple-choice test on critical thinking skills, multiple-choice tests about buffer solution, and questionnaires about students’ learning motivation. Data were analyzed using normality tests, linearity tests, and multicollinearity tests. Then the data were analyzed using simple correlation, multiple correlation and multiple regression.

3. Results and discussion

3.1. Results of the Prerequisite Analysis

3.1.1. Normality Test.

Normality test using Kolmogorov-Smirnov. Data were normal if the sig. >0.05.

Table 1. Normality Test Results with the Kolmogorov Smirnov Test

| No. | Variables                  | Sig   | Conclusions |
|-----|----------------------------|-------|-------------|
| 1.  | Critical Thinking Skills   | 0.200 | Normal      |
| 2.  | Student learning motivation| 0.200 | Normal      |
| 3.  | Learning achievement       | 0.130 | Normal      |

Table 1 showed the significant value of the critical thinking skills and student learning motivation were <0.05. So it can be concluded that all variables are normally distributed.

3.1.2. Linearity Test.

Linearity test was aimed to find out whether the independent variable and the dependent variable have linear or non-linear characteristics. The results can be seen in the deviation from linearity. The variables were linear if the sig. >0.05.
Table 2. Linearity Test Results

| No. | Variables                      | F    | Sig  | Conclusions |
|-----|--------------------------------|------|------|-------------|
| 1.  | Critical Thinking Skills      | 0.542| 0.814| Linear      |
| 2.  | Student’s learning motivation | 1.304| 0.527| Linear      |

Table 2 showed the sig. value critical thinking skills and learning achievement was 0.814. This value was greater than 0.05 which means that it has a linear relationship. For the students’ learning motivation and learning, achievement obtained the sig. value 0.527. This value was greater than 0.05, which means the relationship was linear.

3.1.3. Multicollinearity test.

Themulticollinearity test was aimed to find out the relationship between independent variables. This was done by looking at the tolerance and Variance Inflation Factor (VIF) values. The signs for multicollinearity were the tolerance value $< 0.1$ and the VIF value $> 10$.

Table 3 showed the tolerance value was 0.324 and the VIF value was 3.085. The tolerance value was $> 0.1$ and the VIF value was $< 10$. Thus, no multicollinearity between independent variables was found.

3.2. Results of Hypothesis Testing

3.2.1. First Hypothesis

First hypothesis was about the relationship between critical thinking skills ($X_1$) and learning achievement ($Y$).

Table 4. Results of Correlation Test of Critical Thinking Skills with Learning Achievement

| Critical Thinking Skills | Critical Thinking Skills Pearson Correlation Sig (2-tailed) | Learning Achievement Pearson Correlation Sig (2-tailed) |
|--------------------------|-------------------------------------------------------------|----------------------------------------------------------|
|                          | $N$ 36                                                      | $N$ 36                                                   |
| Critical Thinking Skills | $1$ 0.871                                                   | $1$ 0.000                                                |
| Learning Achievement     |                                                            |                                                          |
|                          | $N$ 36                                                      | $N$ 36                                                   |
| Learning Achievement     | $0.871 1$                                                  | $0.000 1$                                                |

The results shown in Table 4 showed the correlation coefficient value was 0.871 with a positive value and sig. value of 0.000 $< 0.05$. Which means a positive and significant relationship between critical thinking skills and learning achievement was found. The resulting correlation coefficient was positive. It means, if students' critical thinking skills are getting high, their learning achievement will increase, and vice versa.

Based on the correlation coefficient, it can be seen that the relationship between critical thinking skills and students' achievement was very strong. The coefficient of determination was obtained based
on the Pearson correlation value of 75.8%. The meaning is critical thinking skills contribute to students' learning achievement was 75.8%, and the remaining 24.2% was by other variables.

These results were supported by Pozhhan who showed a significant relationship between critical thinking and academic achievement, as shown by the correlation coefficient value of 0.744. It means the positive and strong correlation between critical thinking and learning achievement in male students were present[23]. Abbasi and Izadpanah showed that critical thinking has a significant and positive relationship with the academic achievement of English courses as shown by the correlation coefficient of 0.933 [24]. Many studies have shown that critical thinking skills can improve academic achievement [25].

Critical thinking skills affect students' learning process because the learning outcomes are a reflection of students' abilities, such as cognitive abilities (cognitive domain). As stated by Bloom, the cognitive domain is related to intellectual or logical aspects. It covers: 1) knowledge, including experience and knowledge stored in memory; 2) understanding; 3) application; 4) analysis; 5) synthesis; and 6) evaluation [26]. The first and second aspects were to be focused on. The first (knowledge) included memory, and the second (understanding) refers to the conceptual understanding or a thought processes (critical thinking) which includes analysis, synthesis, problem recognition and solving, conclusions, and assessments.

With critical thinking skills, the students can provide simple explanations, build basic skills, make the conclusion, make further explanations, think deeply and thoroughly to make correct decisions, and make proportional assessments or decisions to face the problem. For example, when students work on a test, deep and careful thinking is needed to choose or complete the answer correctly. And accuracy is needed because students still tend not to double-check their answers after completing the questions. The critical thinking skills are needed because with the critical thinking skills if students encounter difficult questions, they can think in-depth and careful in making decisions and answers to the questions.

3.2.2. Second Hypothesis

The second hypothesis was about the relationship between students’ learning motivation (X₂) and their learning achievement (Y).

| Table 5. Results of Correlation Test of Students’ Learning Motivation and Learning Achievement |
|-----------------------------------------------|
| Learning Motivation | Learning Achievement |
|---------------------|----------------------|
| **Pearson Correlation** | **0.884** | **1** |
| **Sig (2-tailed)** | **0.000** | **0.000** |
| **N** | **36** | **36** |

The results showed correlation coefficient value was 0.884 and the sig. the value was 0.000. It means a positive and significant relationship between student learning motivation and learning achievement was found. Correlation coefficient value was positive. Thus the higher the students’ learning motivation, the higher the students’ learning achievement will be, and vice versa.

The correlation coefficient value showed a strong relationship between students’ learning motivation and students' learning outcomes. Coefficient determination was 78.1%. It means that students' motivation contributes to student learning achievement by 78.1%. And the remaining 21.9% was determined by other variables.

This result was supported by Riswanto and Aryani. They found a positive correlation between learning motivation and students' achievement of STKIP PGRI Sukabumi with a correlation coefficient
value of 0.81 [27]. Agustin found the relationship correlation value of 0.305 between students’ motivation and their achievement in English lessons [28]. This is in line with the research of Ames & Archer which shows that there is a significant relationship between learning motivation and cognitive learning outcomes [29].

It means that learning motivation has a positive influence on students’ achievement. Learning motivation encourages students in learning activities. A motivated student can be directed to achieve learning goals [30]. Students with high motivation gave a higher performance in the learning process, so their learning outcomes will be higher. Motivation spurs up the efforts to do something [31]. Good learning motivation encourages the students to do something positive such as learning, and entice them to achieve their goals. This attitude has a positive influence on students’ achievement.

3.2.3. Third Hypothesis

The third hypothesis was about relationship between critical thinking skills (X₁) and students’ learning motivation (X₂) toward students' learning achievement (Y). The multiple correlation test was used to find out the relationship and direction of relationship between more than one independent variable and the dependent variables.

Table 6. Multiple Correlation Test about Relationship Students’ Critical Thinking Skills and Learning Motivation with Students’ Learning Achievement

| Model | R    | R Square | Std. Error of the Estimate | Sig  |
|-------|------|----------|---------------------------|------|
| 1     | 0.919| 0.845    | 4.843                     | 0.000|

The results showed correlation coefficient was 0.919 and the sig. value of 0.000. Thus, a positive relationship between students’ critical thinking skills and learning motivation with students’ learning achievement was found.

Table 7. Multiple Regression Test Results

| Model                        | Under standardized Coefficients | Standardized Coefficients | t    | Sig  |
|------------------------------|--------------------------------|---------------------------|------|------|
| (Constant)                   |                                |                           |      |      |
|                              | 10.416                         | 4.603                     | 2.263| .030 |
| Critical Thinking Skills     | .423                           | .115                      | .444 | 3.690|.001 |
| Student Learning Motivation  | .487                           | .131                      | .518 | 4.305|.000 |

The result showed relationship critical thinking skills and students’ achievement was 0.423 with the sig. value of 0.001. Relationship between students’ learning motivation and learning achievement was 0.487 with the sig. value of 0.000. Thus, the regression equation was:

\[ Y = 10.416 + 0.423 \times X_1 + 0.487 \times X_2 \]

Relationship between students’ critical thinking skills and learning achievement was shown in Table 7. It showed a value of 0.423. It means, for every one-point increase in critical thinking skills, the students' learning achievement will be increased by 0.423 points. The relationship between students' learning motivation and learning achievement got a value of 0.487. It means, if the students' learning motivation was increased by one point, then students' learning achievement will increase by 0.487 points. The regression equation is shown if the students’ critical thinking skills scores were increased to 100, the student learning achievement value was 52.716. If the students’ learning motivation was increased to 100, the students’ learning achievement was 59.116. The constant obtained from the equation was 10.416. It means, if the students’ critical thinking skills and learning motivation were 0, the student learning achievement will be positive 10.416.
The coefficient of determination ($R^2$) on the effect of critical thinking skills ($X_1$) and learning motivation ($X_2$) toward learning achievement ($Y$) was 0.845. It means that students’ critical thinking skills and learning motivation contributing 84.5% to the learning achievement. Meanwhile, the namely 15.5% are convinced by other factors that were not examined in this study. This means that relationship between students’ critical thinking skills and learning motivation toward their learning achievement was very strong.

Table 8. Result of Calculation of Effective Contribution and Relative Contribution

| Independent Variable     | Effective Contribution | Relative Contribution |
|--------------------------|------------------------|-----------------------|
| Critical Thinking Skills | 38.67%                 | 51.02%                |
| Student Learning Motivation | 45.79%             | 58.63%                |

Table 8 showed the effective contribution on critical thinking skills was 38.67%, while the students’ learning motivation was 45.79%. The relative contribution on critical thinking skills was 51.02%, and students’ learning motivation was 58.63%. The effective and relative contributions of learning motivation were greater than the critical thinking skills. It means that learning motivation makes a greater contribution to students’ learning achievement. Good learning motivation makes a positive impact on students. Students will be encouraged to be more active in learning activities and develop their thinking skills. Students can think deeply to solve problems. Thus, students must have motivation as the foundation to improve their good critical thinking skills.

4. Conclusion
A significant and positive relationship between students’ critical thinking skills and learning achievement was found. It was indicated by the correlation coefficient value of 0.871 and sig. value of 0.000 ($\rho <0.05$). A significant and positive relationship between students’ learning motivation and students’ learning achievement was found. It was indicated by the correlation coefficient value of 0.884 and sig. value of 0.000 ($\rho <0.05$). A significant and positive relationship between students’ critical thinking skills and learning motivation toward students’ learning achievement. It was indicated by the correlation coefficient value of 0.919 and sig. value of 0.000 ($\rho <0.05$). The multiple regression test results obtained the equation: $Y = 10,416 + 0.423 X_1 + 0.487 X_2$ and the coefficient of determination value was 0.845.

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