Influence of PBL-based multimedia and learning motivation on students’ critical-thinking skills in elementary schools

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Abstract. This research aims to determine the effect of the use of the PBL-based multimedia and learning motivation on the students’ critical-thinking skills in elementary school. This research method is quasi-experimental with the 2x2 factorial design of ANOVA. The sample in this research consisted of 66 students with 31 control-class students and 35 experimental-class students with a total sampling technique. The data collection techniques were the open-ended critical-thinking skill test and learning motivation questionnaire. The data analysis technique used was a prerequisite test and research hypothesis test. The prerequisite tests include normality and homogeneity tests. The research hypothesis test used a Two-Way ANOVA. The results of this research showed that there is the influence of multimedia-based PBL in the experiment class on students’ critical-thinking skills. The mean score of the experimental class is 69±2.890 and of the control class 51±3.071. There is the influence of high and low learning motivation on the students’ critical-thinking skills. The mean score of the students with high motivation is 68.572 and those with low motivation 52.171. There is no interaction between the PBL-based multimedia and the learning motivation on the students’ CTS.

1. Introduction

Critical thinking skill is one of the 21st-century life skills that students must have to be successful in solving future problems. Some researchers and practitioners recommend that the education focuses on the 21st-century life skills by being included in the school curriculum. Through the 2013 curriculum, which is now being implemented in Indonesia, the government hopes students can be familiarized and trained to hone 21st-century skills with one of their soft skills, namely critical-thinking skills [1].

Critical thinking skill is a process of the argument analysis, judgement or evaluation of claims for making inferences to solve a problem using deductive and inductive reasonings in order to be an active and informative society [2][3]. Someone is called as a critical thinker if they have two main characteristics: (1) having curiosity about the world with high awareness and not easily accepting what is seen before looking for additional information about it and (2) being sceptics by thinking analytically and synthesizing the truth or value of an idea or belief before they assure [4][5]. Critical thinkers should able to raise basic problems and vital questions, assess relevant information, analyze assumption and biases, think open-mindedly, make well-reasoned conclusion or well-reasoned solution, and communicate effectively [6][7]. This research used the interpretation, analysis, inference, explanation from [3].

However, the CTS of Indonesian elementary school students are still low. According to the data from the Program for International Student Assessment (PISA), Indonesia ranks 60th out of 65 countries that take the high-order thinking skills test which also includes critical-thinking skills. Based
on the survey conducted by the researcher, from 11 elementary schools in Surakarta, Central Java, Indonesia, the average number of students who can think critically is less than half of the survey sample. The average score of 354 students who took the test was only 61, while the minimum standard score for elementary schools in Surakarta is 70. Thus, it can be concluded that around 256 or 72% of students who scored below the minimum standard score. The survey results showed in Table 1.

| CTS Category | Score Range | n  | N   | Percentage |
|--------------|-------------|----|-----|------------|
| Low          | 20 - 28     | 6  | 67  | 19%        |
|              | 29 - 37     | 33 |     |            |
|              | 38 - 46     | 28 |     |            |
| Medium       | 47 - 55     | 54 |     |            |
|              | 56 - 64     | 58 | 201 | 57%        |
|              | 65 - 73     | 89 |     |            |
| High         | 74 - 82     | 59 |     |            |
|              | 83 - 91     | 22 | 86  | 24%        |
|              | 92 - 100    | 5  |     |            |
| Total        | 354         | 354| 100 |            |

Based on the survey results, it was found that only about 86 students or 24% of 354 students had high critical-thinking skills. The results from several studies [8][9][10][11] also show that Indonesian students’ CTS are still at a low level.

Many factors can influence students in learning and developing their thinking skills in the classroom. Learning motivation is one of the factors that play an important or key role in determining student achievement and success. Learning motivation is a change in a person caused by needs and characterized by reactions/actions to achieve the learning goal [12][13][14]. The indicators of learning motivation in this research are: (1) there is a desire to succeed in learning by using learning media; (2) there is encouragement and need to use learning media as a learning tool; (3) perceiving and tenacious in facing tasks; (4) happy to solve problems in their duties; (5) the hopes and aspirations of the future; (6) there is an appreciation in learning; and (7) feeling confident in learning [15][16].

Ideal learning to develop 21st-century life skills is learning that emphasizes social interaction, uses digital media and expands cross-disciplinary thinking. According to [17] and [18], electronic communication information technology that is interesting, fun and contains authentic materials for the digital society is a key factor in the success of the 21st-century learning environment. Multimedia is a combination of various types of digital media such as point set, text, sound, images, and videos into interactive applications or presentations by presenting verbal and non-verbal information to the audience [18][19].

An interesting learning model that also supports the development of students’ CTS like Problem-Based Learning model must be accompanied by multimedia. PBL is a learning model that actively engages students in authentic problem solving from actual life, develops a variety of student skills such as critical-thinking, communication, problem-solving, learning motivation and increases collaboration [20][21][22]. Through the multimedia that contains complex materials and can attract attention and PBL that provides authentic problems for students and can emphasize on the acquisition of CTS, it is expected that the students can improve those skills [23].

There are several papers [24][25][26] that discuss about critical-thinking skills and PBL model or critical-thinking skills and multimedia. However, there are not many focusing on using multimedia with a PBL strategy to improve students’ CTS and not paying attention to other aspects, such as learning motivation that might affect elementary-school students’ CTS. So, this paper discusses the
use of multimedia as the medium to increase students’ CTS with the PBL strategy. Based on the problems, this research aims to examine the effect of PBL-Based Multimedia and Learning Motivation on the Students’ Critical-Thinking Skill in Elementary Schools.

2. Methods
This research method is a quasi-experimental research. It used total sampling technique. The sample consisted of the experimental class with 35 students and the control class with 31 students. The experimental class was taught using the PBL-based multimedia while the control class was taught using modules. The independent variables in this research are the PBL-multimedia and learning motivation and the dependent variable is the critical thinking skills. The instrument used was the open-ended CTS question comprising of 8 items with the indicators of CTS [3] including Interpretation, Analysis, Inference, and Explanation. The students’ CTS are measured using the answers with a score range of 1-4. To measure the student motivation in this research, a learning motivation questionnaire consisting of 24 statements was used using the Likert scale with a score range of 5-1 for positive statements and 1-5 for negative statements. The research instrument has been tested for its validity and reliability. This research used an assumption test for ANOVA comprising normality and homogeneity tests, followed by two-way ANOVA with 2 x 2 factorial design to analyze the CTS data.

| Variable | Learning Media (A) |
|----------|--------------------|
| Learning Motivation (B) | PBL-Based Multimedia (A₁) | Module/book (A₂) |
| High (B₁) | A₁B₁ | A₂B₁ |
| Low (B₂) | A₁B₂ | A₂B₂ |

3. Results and Discussions
This research’ data are taken from the students’ CTS test results and the comparison of the students’ CTS test results in the experimental class and the control class based on the learning motivation. The description of the CTS showed in Table 3.

| Statistical Description | Experimental Class | Control Class |
|-------------------------|--------------------|--------------|
| Mean                    | 69.070             | 51.673       |
| Median                  | 72                 | 44           |
| Mode                    | 71.875             | 71.875       |
| Std. Deviation          | 2.890              | 3.071        |
| Variant                 | 299.370            | 406.754      |
| Minimum                 | 38                 | 25           |
| Maximum                 | 100                | 91           |

The students’ CTS score in the experimental class are mean = 69.070, median = 72, mode = 71.875, standard deviation = 2.890, variant = 299.370, minimum score = 38, and maximum score = 100. On the other hand, the students’ CTS score in the control class are mean = 51.673, median = 44, mode = 71.875, standard deviation = 3.071, variant = 406.754, minimum score = 25, and maximum score = 91. To see the students’ CTS score in the experimental class, the interval of the scores between the absolute frequency of the number of students and the relative frequency of CTS percentage score is used. The data are presented in the frequency distribution list as in Table 4.

From Table 4 above, students’ CTS in the experimental class can be categorized as average, above-average, and below-average skills. Based on the categorization of the data, 14 students (40%) have average skills, 10 students (28%) have above-average skills, and 11 students (31%) have below-average skills.
Table 4. Frequency Distribution List of Students’ CTS in Experimental Class

| Interval Class | f_{absolute} | f_{relative} (%) |
|----------------|--------------|------------------|
| 35 - 45        | 4            | 11               |
| 46 - 56        | 7            | 20               |
| 57 - 67        | 2            | 6                |
| 68 - 78        | 12           | 34               |
| 79 - 89        | 5            | 14               |
| 90 - 100       | 5            | 14               |
| Total          | 35           | 100              |

The data of the students’ CTS in the experimental class are showed in Figure 1.

![Figure 1. Histogram of Students’ CTS in the Experimental Class](image)

Table 5. Frequency Distribution List of Students’ CTS in The Control Class

| Interval Class | f_{absolute} | f_{relative} (%) |
|----------------|--------------|------------------|
| 25 - 36        | 10           | 32               |
| 37 - 48        | 6            | 19               |
| 49 - 60        | 3            | 10               |
| 61 - 72        | 8            | 26               |
| 73 - 84        | 2            | 6                |
| 85 - 96        | 2            | 6                |
| Total          | 31           | 100              |

Based on Table 5 above, the researcher grouped the students’ CTS scores in the control class into average, above-average, and below-average skills. Based on the categorization of the data, 11 students (36%) have average skills, 4 students (12%) have above-average skills, and 16 students (51%) have below-average skills. The data of the students’ CTS in the control class showed in Figure 2.
Figure 2. Histogram of Students’ Critical-Thinking Skills in the Control Class

3.1. Test of Assumptions for ANOVA
Before testing the hypothesis, the data of students’ CTS must be tested for normality and homogeneity. For parametric data, Kolmogorov-Smirnov’s normality test was performed and the homogeneity test was performed using Cronbach’s Alpha or Levene’s tests in SPSS.

3.1.1. Normality Test.
The summary of the normality test analysis is described in Table 6. In this normality test, whether the data are normally distributed or not can be seen from the significance value obtained.

| No. | Group                                           | Sig.  | Conclusion |
|-----|-------------------------------------------------|-------|------------|
| 1.  | Students’ CTS in the experimental class          | 0.315 | Normal     |
| 2.  | Students’ CTS with high motivation in the experimental class | 0.319 | Normal     |
| 3.  | Students’ CTS with low motivation in the experimental class | 0.549 | Normal     |
| 4.  | Students’ CTS in the control class               | 0.419 | Normal     |
| 5.  | Students’ CTS with high motivation in the control class | 0.866 | Normal     |
| 6.  | Students’ CTS with low motivation in the control class | 0.877 | Normal     |
| 7.  | Students’ CTS with overall high motivation in the experimental and control classes | 0.499 | Normal     |
| 8.  | Students’ CTS with overall low motivation in the experimental and control classes | 0.699 | Normal     |

Table 6 shows that the data of students’ CTS in all category classes are from normally-distributed population, which is indicated by Sig. > 0.05 according to the normality test with the Kolmogorov-Smirnov analysis.

3.1.2. Homogeneity Test
The homogeneity test of variance was conducted to determine whether the sample variance came from a homogeneous population or not. Table 7 below showed the summary of the homogeneity test analysis.

| F  | db1 | db2 | Sig.   | Conclusion |
|----|-----|-----|--------|------------|
| 4,458 | 1   | 58  | 0.157  | Homogeneous |

Table 7. Summary of Homogeneity Test Analysis
3.2. Two-Way ANOVA

The hypothesis in this research was tested using Two-Way ANOVA. This test aims to verify the influence of learning media, learning motivation and the interaction between all research variables. This is line with the theory of [31], which states that in the process of examining the main and interactional effects of independent variables on the dependent variable, the researcher can use ANOVA. The results of the Two-Way ANOVA test using SPSS program are presented in Table 8.

Table 8. Results of Two-Way ANOVA

| Source                  | Sum of Squares | Df  | Mean Squared | F      | Sig. | H_0   |
|-------------------------|----------------|-----|--------------|--------|------|-------|
| Learning Media          | 497.018        | 1   | 4971.018     | 15.128 | 0.000| Rejected |
| Learning Motivation     | 4418.086       | 1   | 4418.086     | 17.022 | 0.000| Rejected |
| Media*Motivation        | 28.598         | 1   | 28.598       | 0.98   | 0.755| Accepted |

3.2.1. First Hypothesis

The first hypothesis is the results of students’ CTS in the experimental class are higher than in the control class. The statistical hypothesis is:

- **H_0**: µA1 = µA2
- **H_1**: µA1 > µA2

If the p-value > 0.05, then H_0 is accepted; if the p-value < 0.05, then H_0 is rejected.

The p-value based on learning media with the SPSS analysis is 0.000, so H_0 is rejected and H_1 is accepted (0.000 < 0.05). It can be concluded the students in the experimental class taught with the PBL-based multimedia have higher results of CTS than those in the control class. The average score of the students’ CTS in the experimental class (X̄ = 69.070) is higher than in the control class (X̄ = 51.673).

Based on Table 8, we can conclude that the PBL-based multimedia can improve students’ CTS. The students who are taught with the PBL-based multimedia get higher scores compared to those who were only taught with modules. The application of the PBL-based multimedia offers a new learning experience to students by presenting an entertaining media that contains complex and complete information that makes students interested in learning and enhances their satisfaction and motivation [18].

In addition, the aspects of PBL in this multimedia require students to be active in developing their thinking skills to solve problems around them in fun ways. This is because the use of multimedia in learning has several advantages [27] including: (1) providing a complex multi-sensory learning experience; (2) presenting the well-structured and interesting information; (3) optimal representation to improve thinking skills; and (4) actively encouraging information processing.

3.2.2. Second Hypothesis

The second hypothesis is the students’ CTS with high learning motivation are higher those who have low learning motivation. The statistical hypothesis is:

- **H_0**: µB1 = µB2
- **H_1**: µB1 > µB2

If the p-value > 0.05, then H_0 is accepted; if the p-value < 0.05, then H_0 is rejected.

The p-value based on learning motivation with the SPSS analysis is 0.000, so H_0 is rejected and H_1 is accepted (0.000 < 0.05). It can be concluded that the CTS of the students with high learning motivation are higher than those with low learning motivation. The CTS average score of the students who have high motivation (X̄ = 68.572) is higher than of those who have low motivation (X̄ = 52.367).

Based on the ANOVA analysis in Table 8, it can be concluded that the students who have high learning motivation have higher test scores compared to those who have low learning motivation. The
students with high motivation will try to succeed and be actively involved in learning more than the students with low motivation. Active students will have greater opportunities to grow, advance, develop and practice their thinking skills than the passive ones because learning motivation is a contributing factor to the development of CTS. The students’ higher motivation will increase their critical thinking [28]. Many studies have shown that learning motivation affects students’ CTS [29][30].

3.2.3. Third Hypothesis

The third hypothesis is there is an interaction between learning media and learning motivation on critical-thinking skills. The statistical hypothesis is:

\[ H_0: \Delta \beta = 0 \]

\[ H_a: \Delta \beta \neq 0 \]

If the p-value > 0.05, there is no interaction between learning media and learning motivation; if the p-value < 0.05, then there is an interaction between learning media and learning motivation. The p-value of the interaction between learning media and learning motivation is 0.755, which is higher than the sig. value of 0.04, so \( H_0 \) is accepted and \( H_a \) is rejected. Thus, there is no interaction between learning media and learning motivation on students’ critical-thinking skills, which means that the factors of learning media and learning motivation do not give a significant effect on students’ CTS. Meanwhile, the two factors have a partial effect on students’ critical-thinking skills. To ascertain whether there is an interactional effect or not between the learning media and learning motivation on critical-thinking skills, see Figure 3.

![Estimated Marginal Means of Critical Thinking Skill](image)

**Figure 3.** Chart of Interactional Effect between Learning Media and Learning Motivation on Critical-Thinking Skill

There are two types of variable effects in the experimental research. The main effect is the direct effect of an independent variable on a dependent variable [31]. The interactional effect is the effect of the two or more independent variables on a dependent variable. If two lines of the chart intercept each other, there is an interaction between the two factors. Based on Figure 3, it can be concluded that there is no interaction between learning media and learning motivation on students' critical-thinking skill.

4. Conclusion

Based on the results and discussion of this research, we can sum up that (1) there is the influence of the PBL-based multimedia on CTS. The mean of the experiment class is 69±2.890 and the control class 51±3.071, (2) there is the influence of learning motivation on CTS. The mean of the students
with high motivation is 68.572 and with low motivation 52.171, and (3) there is no interaction between learning media (PBL-based multimedia) and learning motivation on CTS. In other words, there is no difference in CTS in the learning media with high or low learning motivation.

Based on acceptance of the first hypothesis that there is an influence of the PBL-based multimedia on CTS, it is necessary to consider to applying the PBL-based multimedia to other subjects. This can make the learning process more effective, so the learning objectives can be achieved as expected. Based on the second hypothesis that there is an influence of the learning motivation on CTS, the teacher should be able to accommodate well and attract the students’ attentions with fun learning like the PBL-based multimedia. It is recommended that the further extend the sample size, so that the results can be generalized more. Furthermore, there is still a need for research to analyze the difference of critical-thinking skills by comparing between other learning media, innovative learning model, and student internal characteristics.

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