Developing student’s critical thinking skills through implementation of problem based learning approach

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Abstract. Problem based learning is an educational approach which used problem as a context for learning in order to develop multidisciplinary skills including critical thinking. However, limited research has been conducted regarding the impact of problem based learning on student’s critical thinking skills in class. This research is a developmental research (R&D) using ADDIE model that aims to develop student’s critical thinking skills through the implementation of student activity sheets that use problem based learning approach. The subject of this study were 2nd year students of science and mathematics programme in SMA Negeri 2 Sleman. Using pre-experimental with pretest-posttest design, the data were analyzed descriptively using N-gain indicator and analyzed parametrically using T-related sample test. Student’s critical thinking skills were observed by observer and analyzed descriptively using percentage comparison. The study found that the problem based learning approach has significant impact in improving student’s critical thinking skills. Student’s critical thinking skills in terms of analyzing, interpreting, evaluating, and concluding were increased. These criteria indicated that problem-based learning approach effective to develop student’s critical thinking skills.

1. Introduction

The development of the 21st century requires everyone to have a variety of skills in order to live in a global society. Asrari states that one of the skills that is needed is critical thinking skills [1]. Partnership for 21st Century Skills (P21) also emphasized that 21st century learning must be able to create students who have the ability to think critically, solve problems, communicate, and collaborate [2]. As a developing country, progressing toward more democratic society and economically, Indonesia has realized its role in world matter. To play more role in this manner, Indonesia require qualified human resource. Education is one of the potential fields to produce human resources who could bring the country to a greater prosperity. Through education, young Indonesian are expected to be critical, creative, innovative, confident, tolerant, socially sensitive, democratic, and responsible [3]. These are some of the qualities clearly stated in the Regulation of the Republic of Indonesia Number 17 Year 2010. The Government through the Ministry of Education and Culture in Indonesia applies the 2013 curriculum with various improvements, one of which is intended to improve critical thinking skills so that it can encourage students to think broadly and deeply about learning material [4].

When it comes to educational management and administration as educational objectives, however, there seem to be some constraints on achieving these stated objectives. In fact, the ability of students in Indonesia is still very low. Based on the results of Program for International Students Assessment (PISA) 2015, it was found that out of the 6 levels of ability formulated in the PISA, only 31% of Indonesian students mastered the lesson to 4th level. Indonesia ranked 62nd out of 70 countries that participating in
PISA 2015 [5]. As stated in the PISA analysis, students in Indonesia have a low ability in: (1) linking science to everyday life; (2) interpret data; (3) analyze and solve problems; (4) conducting investigations; (5) concluding based on logical reasons; and (6) understanding complex information [3].

It may not be easy to produce people with the aforementioned qualities and to make people aware of the importance of them if practitioners in education are not clearly directed toward those goals. The development of critical thinking skills does not appear to have been seriously support in secondary education throughout the country. This idea supported by Alfianti which states that learning in Indonesia has not included the content of critical thinking. Teachers have not encouraged critical thinking skills in learning, so students are not challenged to think critically [6]. Most teachers in Indonesia have not clearly understood what critical thinking is and how to incorporate critical thinking into their teaching [7].

Aside from failing to encourage critical thinking, Indonesian school teacher still utilize traditional teaching methods, for example, teachers read from textbook, dictate, or write on the whiteboard while student listen and copy [8]. Education in Indonesia requires a new paradigm in the learning process, including learning biology. Biology as a science is not just knowing and memorizing about biological concepts, but the process of learning biology is expected to foster the skills of critical thinking, work, and scientific attitude [9].

The result of the observations conducted in November 2017 on SMA Negeri 2 Sleman showed that biology learning activities in the classroom mostly use expository method. The teacher explain and demonstrates, then the students hear, take notes, and do the task according to what the teacher instructs. Learning activity mostly oriented to remembering information contained in the textbooks without connecting in to real life. Learning methods applied by the teacher do not get an active response from students. This condition seen during the learning process, most students are less involved in learning and choose to do other activities such as chatting with friends.

The topic in this research, immune system, is chosen because the characteristic of immune system material required the student to think critically in order to understand the material. Immune system contain complex physical and chemical mechanisms. Immune system also has a causal mechanism and physiological processes, so that in learning the material, students need critical thinking skill in order to mastering abstract concept [10]. Learners in studying immune system need the ability to understand the mechanism of physiology and link it causally to the phenomena of the immune system. Accurate conception and critical thinking about the immune system are important for the development of reasoning skills. Such material characteristics became a challenge for the student because it is hard to understand the concept with memorization [11].

Suhartono states that problems related to immune system learning include learning strategies. Teachers find difficulty to design learning strategies because of the short time to teaching immune system material, so that teachers tend to use the lecture method. Lecture learning strategies have the potential to cause student’s low critical thinking skills [10]. One of the effective learning approach to improving critical thinking skills is problem based learning. Problem based learning is a learning approach that uses problem as a context for students to learn through critical thinking and problem solving processes. Learners who learn to solve problem problems will make them apply the knowledge they have or try to know the knowledge they need. Learning can be more meaningful and expanded when students are faced with situation where the concept is applied. Learners integrate knowledge and skills well and continuously, and can apply them in relevant contexts. Problem based learning can also improve critical thinking skills, foster initiative in work, internal motivation to learn, and can develop interpersonal relationship through working in group [12].

Several previous studies have proven that through problem based learning implementation, student’s critical thinking skills can be developed. Problem based learning is used to improve critical thinking skills by using human physiology cases into nursing learning [13]. The results of the Experimental Biology workshop in Washington DC states that to improve critical thinking skills in learning physiology, problem based learning is used by using real-life cases that contain basic physiological concepts [14]. Abraham states that learning physiology can be done by linking physiological research to real life problems so it can produce enthusiasm and motivation to learn and to show the relevance of
the basic concepts of physiology in the real life of students. The basic elements of integrating basic physiological concepts can be put in the form of critical thinking questions and case studies on the topics taught [15].

2. Research Method
This research is developmental research (R&D) using ADDIE model.

2.1. Subject of research
Subject of this research were all of 2nd year students (64 students) in science and mathematics programme in SMA Negeri 2 Sleman.

2.2. Development of learning devices
The development of learning devices includes: student activity sheets, lesson plan, and research instrument used to measure the student’s critical thinking skills. The learning devices were developed by the researcher using ADDIE model and had passed validity test with valid result by the expert judgement.

2.3. The instrument, data collection techniques, and data analysis techniques
The instrument for collecting data were a test (pretest and posttest) and critical thinking skills observation sheet. Pretest and posttest consisted of essay question that adjusted to the indicators of critical thinking and validated by the expert. The teaching and learning process were carried out for 4 meetings supported with learning devices that had been developed. The learning steps which used in this research based on Hmelo-Silver syntax consisting of problem orientation, formulate and analyze problem, generate hypotheses, identify knowledge deficiencies, apply knowledge, and abstraction [16].

2.3.1. Analysis of critical thinking test
Student’s learning outcomes were analyzed descriptively using N-gain indicator and analyzed parametrically using T-related sample test. Student’s learning outcomes categorized according to Setyowati & Mosaik [17] which presented in Table 1.

| Score       | Criteria          |
|-------------|-------------------|
| 81.25-100   | Very Critical     |
| 62.50-81.25 | Critical          |
| 43.75-62.50 | Less Critical     |
| 25.00-43.75 | Very Less Critical|

2.3.2. Analysis of observation sheet
Critical thinking skills observation sheets were analyzed by calculating the percentage of student’s critical thinking skills at each meeting. The percentage of student’s critical thinking ability is calculated by the formula:

\[
T = \frac{\text{Total score of item } i}{\text{Total maximum score}} \times 100\%
\]

The criteria are according to Widoyoko [18]:

- \(80 < SA \leq 100\) : very good
- \(60 < SA \leq 80\) : good
- \(40 < SA \leq 60\) : good enough
- \(20 < SA \leq 40\) : poor
- \(2 \leq SA \leq 20\) : very poor

3. Result and Discussion

3.1. Learning devices and research instrument
The learning devices and research instrument were validated by five validator which included the experts in immune system material, educational expert, and educational practitioner. The learning devices is
declared “valid” and can be used with minor revisions. The preview of learning devices are presented on Figure 1 until Figure 4.

**Figure 1.** Problem orientation

**Figure 2.** Formulate and analyze problem

**Figure 3.** Apply new knowledge

**Figure 4.** Abstraction
3.2. Student’s critical thinking test result

The result of pretest and posttest according the level of critical thinking are presented in Table 2.

| Score        | Criteria      | Pretest        | Posttest       |
|--------------|---------------|----------------|----------------|
|              | Frequency     | Percentage (%) | Frequency      | Percentage (%) |
| 81.25-100    | Very Critical | 0              | 0              | 0              |
| 62.50-81.25  | Critical      | 0              | 46             | 70.875%        |
| 43.75-62.50  | Less Critical | 2              | 18             | 28.125%        |
| 25.00-43.75  | Very Less     | 62             | 96.875%        | 0              |

Table 1 shows that in the pretest, 64 students categorized as very less critical and 2 students as very less critical. While in the posttest, 46 students categorized as critical and 18 students as less critical. These result prove that problem based learning approach effective to develop student’s critical thinking skill, despite there are still some students that achieved the minimum score and none of student achieved the maximum score that had been set. This condition can be caused by some factors, such as the students still not familiar with problem based learning activity, difficulty to understand the concept, and other internal factors.

3.3. Comparison of average pretest and posttest scores

The average score of student’s critical thinking skills are presented in Table 3.

| N      | Minimum | Maximum | Mean     | Std. Deviation | Variance |
|--------|---------|---------|---------|----------------|----------|
| Pretest| 64      | 10.00   | 55.00   | 29.5703        | 110.626  |
| Posttest| 64     | 54.00   | 83.30   | 70.3542        | 51.353   |

These data shows an increase in the average score of student’s critical thinking skills. In the pretest, the average score is 29.57. While in the posttest, the average score is 70.35. This result shows that problem-based learning approach effective to develop student’s critical thinking skills.

3.4. Result of N-Gain analysis of student’s critical thinking skills

The result of N-Gain score are presented in Table 4.

| Aspect of critical thinking skill | Average score of pretest | Average score of posttest | N-gain | Criteria |
|----------------------------------|--------------------------|---------------------------|--------|----------|
| Analyzing                        | 29.33                    | 78.96                     | 0.70   | High     |
| Interpreting                     | 30.37                    | 46.87                     | 0.23   | Low      |
| Concluding                       | 31.25                    | 91.4                      | 0.85   | High     |
| Evaluating                       | 25.78                    | 97.91                     | 0.95   | High     |
| All aspects                      | 29.27                    | 78.79                     | 0.69   | Moderate |
Each aspect of critical thinking skills has different gain score. Overall, the N-Gain score of each aspect of critical thinking skills is increasing with a moderate category. Although, the aspect of interpreting has a minimum improvement. This is because there are not many cases of the immune system that can display research data that suitable for high school students.

3.5. Result of Paired Sample T-test
The pretest and posttest data were analyzed using paired data tests with data normality tested first, as a prerequisite for further testing carried out parametric or nonparametric [19].

| Table 5. Result of Normality Test data value of critical thinking test |
|------------------|------------------|------------------|
|                   | Kolmogorov-Smirnov* | Shapiro-Wilk     |
| Pretest-posttest  | Statistic         | df               | Sig.   | Statistic | df | Sig. |
|                   | .067              | 64               | .200*  | .985      | 64 | .649 |

The results of testing the normality of scores for the results of learning critical thinking get the results of Sig > 0.05 which mean that the data is normally distributed. Result of Paired Sample T-test of student critical thinking skills are presented in Table 6.

| Table 6. Result of Paired Sample T-test of student critical thinking skills |
|------------------|------------------|------------------|------------------|
| Variable         | Average score of pretest | Average score of posttest | Sig.          |
| pretest-posttest score | 29.5703          | 70.3542          | 0.000          |

Parametric test results for paired data show Sig. 0.000. The criteria for drawing conclusions are if the significance level is (Sig.) <0.05. Paired Sample T-test results show that learning devices based on problem-based learning are effective to improve student’s critical thinking skills.

3.6. Result of observation sheet
Improvement of each critical thinking skills aspect are presented in Figure 5.

![Figure 5. Improvement of each critical thinking skills aspect](image-url)
analyzing obtained through identification of problems so that they obtain concepts and descriptions and submit opinions through their learning experience [20]. The aspect of interpreting defined as the activity of classifying, understanding, and expressing meaning. This is indicated by the ability of students to summarize the description of the patterns of interrelationship between information. Students are able to analyze tables and explain them well. Active discussion can improve critical thinking skills such as problem identification, categorization, classification, and interpretation [21].

Critical thinking skills in evaluation aspect is defined as an activity to assess the credibility of a statement by describing one’s perception. The ability to evaluate were developed through discussion activities. Students can respond to each other’s statements, provide alternative answers, and evaluate information sources during discussions. This stage provides many opportunities for students to express their opinions and process the feedback regarding answers to questions. The response from the presentation results enables students to develop critical thinking skills in the evaluation aspect [22]. Inference aspects can be interpreted as activities to identify and select elements needed to form conclusions [22]. Facione states that student’s interpretation skills can arise if they are challenged to work with data and faced with problems, so they will work by interpreting data and problems first, before finding concepts.

4. Conclusion
Based on the result of this research, problem based learning approach is effective in developing student’s critical thinking skills on immune system. This is evidenced by the increase in score of the N-Gain, value of significance on T-test, and the increase in percentage of student’s critical thinking skills.

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