Implementation of problem-based learning to improve students’ critical thinking skills

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Abstract. This study aimed to determine the effect of the implementation of problem-based learning on learning outcomes and student critical thinking skills in the course of Invertebrate Zoology. This study used experimental method with one group pre-test-post-test control design. The population were all students (n=80 students) of the fifth semester of the Biology Education Study Program, Faculty of Teacher Training and Education, Seramb Mekkah University, Banda Aceh, 2018/2019 academic year. The data of student learning outcomes and student critical thinking skills were analysed by t-test (Independent Sample t-test) and by percentage respectively. The results showed that the mean of N-gain of Problem Based Learning (PBL) class and control class were 72.5 (moderate) and 56.05 (moderate) respectively. This result indicated that there was an increase in student learning outcomes by implementation of the model of teaching. In addition, the values of t-test showed that $t_{\text{count}} > t_{\text{table}}$ (3.75> 1.95), so that the implementation of the model of teaching has significantly affected the student learning outcomes. The student critical thinking skills has categorised into very good (95%). Therefore, it can be concluded that implementation of problem-based learning has improved learning outcomes and critical thinking skills on students in invertebrate zoology course.

1. Introduction

Teaching and learning process is crucial to implement the curriculum in educational institutions to gain the desired goals. The purpose of education is to change student’s behavior regarding to intellectual, moral, and socio-cultural. Learning is the activity of the teacher/lecturer to design active learning which emphasizes the provision of learning resources [1]. Teaching and learning process is the most basic activities of the entire learning process, so that the success or failure of the process depends on the process. The main principle in biology learning at this time is to improve and prepare learning activities utilizing students which is aimed to change the paradigm from "teaching biology" to "learning biology" [2]. This study focused on the implementation of problem-based learning in the course of invertebrate zoology in the Biology Education department (3 credits). This course provides basic knowledge and general concept of phylum of invertebrate. The phylum consists of Protozoa, Porifera, Coelenterata, Platyhelminthes, Nemathelminthes, Mollusc, and Echinodermata. The course is aimed to improve the students ability to understand broadly about the phyla and differences between classes in each phylum. Inverbrate zoology is one of core subjects in dBiology Education department.
Teacher Training and Education Faculty, Serambi Mekkah University, Banda Aceh [4]. Previously, lecturers has used lecturing and group discussion as the method of teaching for the course. However, the student learning outcomes and student critical thinking skills was still poor. Moreover, student was less enthusiastic on the course.

In group discussion, only some students have participated well and have tended to dominate the class. Those students with the ability below the average tended to be inactive. In addition, student’s understanding the application of the course in day life was still inadequate. This was due to they were not trained to think critically and to solve complex problems. It can be seen from the averages of final exam of the course were 74.50 (academic year of 2015/2016) and 75.18 (academic year of 2016/2017). Based on the facts, appropriate learning strategy must be obtained to deal with the problem. Problem-based learning has been known as a model of teaching to explore and drill students analytical and thinking skills. In the national curriculum, it focuses on student independence regarding to solve complex problem using the right strategies and approaches [2]. The notion of problem-based learning is used as an approach to confront students directly with the problems during learning. This model has been considered as innovative strategy to improve student’s knowledge and life skills. Problem based learning is run systematically in solving life problems, especially interaction with the environment [3]. Moreover, the model provides group work interaction, two-way communication, and information processing. Problem solving skills is critical to draw conclusion. During implementation the model, it begins with providing problems linked to contextual one. Through the problems, students work in team and find solution to solve them by implementing their knowledge and finding information relevant to the problems. Therefore, teachers serve as a facilitator guiding and assisting students in finding the solution [4].

2. Method
The research has been conducted in Biology Education Department Teacher Training and Education Faculty of Serambi Mekkah University (USM), Aceh Province, Indonesia. The In order to measure student abilities of thinking and of developing cognitive learning and critical thinking skill, we used test (pre-test and post-test) and questionnaires respectively. The research used experimental method with the experimental design was one group pre-test – post-test. The population was students at academic year 2018/2019 taking invertebrate zoology course accounting for 80 students (the fifth semester). Those were divided into experimental class (40 students) and control class (40 students). Data of student learning outcomes was analysed by t-test whereas category of student critical thinking skill was analysed by score percentage [5].

3. Results and Discussion

3.1. Cognitive learning outcomes
This study used quantitative approach with a cross-section model [11]. Data was collected after two weeks training. Cognitive learning outcomes were determined by scores of pre-test and post-test. From the scores, significant difference of N-Gain score has been determined between the pre-test and post-test, as shown in Table 1 and Figure 1.

| Table 1. Pre-test and post-test scores |
|-------------------------------|-----------------|-----------------|
|                               | Control class   | Experiment class |
| Pre-test                      | 62.50           | 78.6            |
| Post-test                     | 50.20           | 53.35           |
| Gain                          | 24.30           | 17.75           |
| N-Gaint                       | 55.10           | 68.30           |
Table 1 shows that the post-test scores of the experimental class were higher than that of control class which were 78.60 and 62.50 respectively. The means N-Gain score were 68.30 (experiment class) and 55.10 (control class). This indicates that there were increases in cognitive learning outcomes. It is assumed that the model of teaching in control class has insignificantly influenced the student achievement [6].

There were differences in the cognitive learning outcomes between both classes since the implemented models varied. In the experimental class, problem-based learning has been used to give the students opportunity to analyse the material and to fully participate in discussion the problems given by the teacher. The student activities were assessed by observing learning activities considering to critical thinking both in asking or expressing opinions[7]. However, in the control class, interaction between the lecturer and students and among the students were still poor. It is assumed that teaching learning environment in control class has insignificant effect on student achievement.

3.2. Critical thinking skills

In this study, there were 257 teachers have participated who participants in the first cohort of 2019 professional development belonging to mathematics, science and social science teachers. It took three months for the participants to complete the online professional development.

Biology lectures should immediately confront students with problem-solving learning [8]. This triggers initiatives to ask questions and answer questions independently, and students can find material concepts through further investigation and study activities, so they can create meaningful learning and improve students critical thinking skills. Critical thinking skill is essential to develop and improve student understanding in concepts of the course and to solve complex problems [9]. Improvement of critical thinking skills can be seen in Table 2.

Table 2. Student Critical Thinking Skills Based on Indicators

| Sub Indicators            | Meeting 1 (%) | Meeting 2 (%) | Meeting 3 (%) | Mean (%) | Criteria   |
|--------------------------|---------------|---------------|---------------|----------|------------|
| Identifying of problem   | 78.7          | Good          | 83.1          | 87.4     | Very good  |
| Raising question         | 67.5          | Good          | 85            | 87.3     | Very good  |
| Problem                  |               |               |               |          |            |
| Giving Simple explanation| 69.9          | Good          | 73.7          | 84.3     | Very good  |

Figure 1. N-gain scores of pre-test and post-test
Table 2 indicates that the percentage and criteria (category) of indicators of student critical thinking skills each meeting. The data shows that there were increases in the percentage of indicators as the number of meeting increased. Consequently, the criteria have changed from good to very good category except for sub indicator producing examples. According to the mean, the highest percentage of essential indicators was 83.9% (reporting the results with criteria very good) followed by identifying problem (83.1% with criteria very good). However, category of good has been showed for the other indicators (raising question, giving simple explanation, raising conclusion, and producing example). The increases in critical thinking skills is shown more clearly seen in Figure 2.

According to Figure 2, there were increases of all indicators of critical thinking skills as the number of meeting increases. This can been seen through the rises in percentage of each parameter from the first and the last meetings. Every student can explain all the issues raised and actively report the results of observations in their zoology courses all of which have a medium and high level of critical thinking criteria especially designing problems, explaining problems, or other ideas. The students have been encouraged to train themselves in expressing ideas, solving the problems, and concluding the problems by ethical and aesthetic values, scientific and honest incompetence. The students have awareness in the issues outlined and in the answers. Moreover, they focused on producing proper examples. In critical thinking skill improvement, other aspects namely having mental strength and taking quick response to the problems are crucial during the process of teaching and learning.

Implementation of problem-based learning gave the students chances to analyse the problems and were expected to fulfill whole indicators, so that they produced correct and proper conclusion in accordance with academic values. The correlation between critical thinking skills and learning
outcomes is required to determine [13]. Learning outcomes (N-Gain) is the independent variables (X), and critical thinking skills scores are the dependent variable (Y). The student who has a good strategy, a course, student will get maximum learning outcomes. Table 3 shows the correlation between the two variables.

| Group | Critical thinking skills | Learning outcomes | Correlation (r) | Determinant coefficient ($R^2$) |
|-------|--------------------------|-------------------|-----------------|--------------------------------|
| Values| 5035                     | 3560              | 0.64            | 0.39                           |

Implementation of problem-based learning has contributed significantly to student learning outcomes, and also improved critical thinking skills students. Critical thinking skills are essential for student to improve their ability to deal with the problem by using knowledge, facts, and data. Problem based learning combined with critical thinking skills will give the students chance to share thoughts and opinion, and making good decision and judgement during teaching learning process [14].

4. Conclusion
Implementation of problem-based learning in invertebrate zoology course has improved the ability there is a great relationship between designing problems, giving explanations or giving examples to make it easy for students to understand critically according to the stages of learning. Critical thinking skills for students always have a comprehensive relationship in the right decision-making process by analyzing and interpreting in sequence. Students usually provide the right arguments with accurate data and are easily understood by other members.

5. References
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