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Effectiveness of Problem-Based Learning Module as An Instructional Tool in Improving Scientific Argumentation Skill

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Abstract

Scientific argumentation skill required to be mastered in this era. Unfortunately many students still have strunggle improving their scientific argumentation skills. This study was aimed at describing the effectiveness of ecosystem module grounded in Problem-Based Learning in improving scientific argumentation skills. This research was part of the field testing of R&D, a research and development previously conducted. Research participants included tenth grade senior high school students. Two classes were selected as a control and experiment class. The control class (existing) did not use the module but the experiment class use the module (module class) grounded in Problem Based Learning implemented. Data were collected from written tests and observations. Data analysis used the scoring rubric of scientific argumentation skill aspect which their results were tested with Gain test and independent T-test. The findings showed an increase in scores of the four aspects of scientific argumentation skills from the module class. The highest percentage of aspect was rebuttal aspect (27.27%) followed by evidence 26,06% and reasoning 23.94%, while the aspect of claim increased by 20.61%. The independent t-test results showed that there was a significant difference between pre-test and post-test results of the module class. It can be concluded that the ecosystem module with problem-based learning material was effective to improve students' scientific argumentation skills. The product of this reasearch can be use as a tools to improve students' scientific argumentation skills.

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INTRODUCTION

This ever-changing era require the improvement of human quality to further improve themselves. Learning should pay attention to the needs of learners to face of the digital age. Various skills such as science literacy, thinking skills, communication skills, problem-solving and reasoning skills need to be mastered as the main capital to be competive in the national and international arena. These skills can be mastered by improving scientific argumentation skills.

In fact, students' scientific argumentation skills in Indonesia are still low. The results of a survey conducted by the OECD in 2015 showed that 20% of PISA participating countries including Indonesia were still below the average regarding science literacy. One indicator of mastery of science literacy has been the capacity to make arguments and evaluate arguments based on evidence and apply the conclusions of the correct argument (NCREL, 2003). This proves that students' scientific argumentation skills in Indonesia are still low.

Scientific argumentation skill is a skill of providing statements accompanied by evidence and reason (McNeill & Krajcik, 2006). Arguing is also a process of linking ideas with the right reasons based on available data (Erduran, 2004). General argumentation skills according to Toulmin (2002) have six components, namely: claim, data, warrant, backing, rebuttal, and qualifier. The six components of the general argumentative skill by McNeill and Krajcik (2006) are then simplified into the sciencetific argumentation skill which includes the four components of claim, evidence, reasoning, and rebuttal. The claim is a statement or conclusion that answers the problem, the evidence is scientific data, backing or warrant that supports the claim, reasoning is a justification that connects the evidence in the claim using the principles of science, and rebuttal is the alternative answer given to refuse the claim. Mastery of these four aspects can determine the level of students' scientific argumentation skills. (Lee, *et al.*, 2013).

Improving the quality of 21st-century skills cannot be separated from the contextual and student-centered paradigm of learning (Muhfahroyin & Agung, 2017). Argumentation skills can also be constructed through argumentative contextual learning by creating conditions in which students have the opportunity to express their arguments (Lazarou, *et al.*, 2017). One example of activities that can be used to improve argumentation is that of discussions aimed at enhancing collaborative reasoning (Mayweg-pope & Kuhn, 2015). The process of discussion of cognitive conflict will arise and stimulate the occurrence of arguments, either corroborating, evaluating, questioning or opposing statements made previously (Schleigh, *et al.*, 2011).

Discovery or inquiry based learning can help students improve their arguing skills. Students construct explanations that support arguments through investigation of phenomena or problems (Bell & Linn, 2007). The Problem-Based Learning model according to Tan (2003) connects inquiry, self-learning, information gathering, and problem-solving in an integrated way. One contextual learning model that can improve scientific argumentation skill is Problem-Based Learning Model (PBL) (Gorghiu, *et al.*, 2015; Tan, 2004).

The steps of problem-based learning will stimulate students to find solutions by developing argumentary skills in group discussions. Components of claim will be obtained by students after they are faced with a problem or conflict. Evidence component will be obtained by students from observation or experiment. While the components of reasoning and rebuttal can be improved through the analysis results of observation or experiment and discussion. Evaluation issues can also affect improving argumentation skills. According to Berland and Lemma (2012), an argument begins with a question. Questions that can trigger an argument are questions that are interrogative.

Learning activities and evaluation questions can be integrated in the form of teaching materials as module. A module is a teaching material that has a systematic arrangement including materials, methods, and evaluations that are made to be an independent materials to achieve certainly expected competencies (Enke, *et al.*, 2015). Modules have advantages over other teaching materials. The advantages of the module, among others are independent, the purpose of achievement is clear, and it has the material and evaluation questions that can be made by the competence to be achieved (Dumitrescu, *et al.*, 2014). Students can practice making scientific arguments through the process of analyzing the problems presented in the module activities so that their scientific argumentative skills can be trained during the learning process with the PBL model.

Learning with the PBL-based module is contextual, and it presents an ill structure problems. Contextual learning connects real life with students' knowledge (Ridlo & Alimah, 2013). The ecosystem is one of high school Biology

material that is contextual. Problems related to the ecosystem material are found in the students' environment. The presentation of the ecosystem problem in an ill-structure is attached to the life of the students, and it can lead to argumentation.

The research that has been done so far has not yet integrated the PBL model into the module as a teaching material to train students' scientific argumentation skills. The PBL model is implemented directly in the classroom but still uses the teaching materials commonly used in schools and has not been specifically developed to improve scientific argumentation skills. Assessment of scientific argumentation skills is also largely limited to claims, evidence, and reasoning aspects whereas the rebuttal aspect is an important aspect of scientific argumentative skills because the better the students' rebuttal aspect, the higher the level of their scientific argumentation skills (Lee *et al.*, 2013; Osborne, *et al.*, 2004). This is the basis of research conducted by researchers.

This study was aimed at testing and analyzing whether the module of the ecosystem with problem-based learning would be effective in improving students' scientific argumentation skills. This study was also aimed at analyzing the mastery of aspects of students' scientific argumentation skills after treatment with the use of PBL modules of ecosystem materials already created.

METHODS

The research was conducted at one of the Senior High School (SMA) in Pacitan, East Java. The research was conducted from February 2017 to July 2107. This research was the part of R & D research using development stages by Borg & Gall 1983. The research was started with initial profile data as the basis of research followed by module development, module feasibility test, and module effectiveness test. Participants of this study were class X students in the even semester of the academic year 2016/2017. Test of the effectiveness of PBL module, this study used one class as an experimental class and the other as module class and control class. The sampled class has satisfied the homogeneity and normality test.

The PBL module used for this study has passed through the initial test phase. Initial trials undertaken involved validation of material experts, learning tool specialists, and module development experts to obtain a qualitative assessment of the draft modules that have been made. Material expert validation included material completeness, material accuracy, material upgrades, scientific systems, basic material concepts, sub-subject concepts, drawing concepts, material delivery techniques, improved argumentation skills with material, and relevance to everyday life. Validation of material includes the fulfillment of module characteristics combined with Problem-Based Learning model and module appearance. Validation of research instruments included learning tools, observation sheets, training questions on modules, pre-test and post-test questions.

Problem was used to measure aspects of students' scientific argumentation skills in writing while the observation instrument was used to see the implementation of Problem-Based Learning syntax. The question used for pretest was a question adapted from the question of measuring scientific argumentation skills in the general biological material (Sampson & Schleigh, 2016) while the posttest problem is a matter developed based on ecosystem material that has been adapted to measure students' scientific argumentation skills. Problems used had been tested to see validity and reliability by involving 20 students. The item validity test was done in two stages. Reliability test is performed using Cronbach's alpha coefficient. Reliability test result question was 0.78 which indicates that the problem will be used as a reliable measuring tool.

Data analysis technique used was descriptive quantitative. Scoring the aspect of scientific argument skills was adapted from the scoring rubric of scientific skill assessment aspect by Katherine L. McNeill (2011). The lowest score was 0, and the highest score was 3. The score of each student in the control class and the experimental class is then analyzed to know the effectiveness of the Problem-Based Learning module in improving the aspect of scientific argument skill. The effectiveness of the module was seen from the gain scores according to Hake (2008) as follows:

$$g = \frac{S\ posttest - S\ pretest}{100\% - S\ pretest}$$

Notes:
S post-test: mean score of post-test (%)
S pre-test : mean score pre-test (%)
G : gain factor

Gain factor from experimental class or module and control class or existing class. It was then further tested by using independent t-test by firstly testing the homogeneity and normality of data. The modules with Problem-Based Learning were considered effective for improving students' scientific argumentation skills if the significance level was less than 0.5.

RESULTS AND DISCUSSION

The result of the research showed that there was an increase of students' scientific skill score based on the difference between pre-test and post-test values of the module class and existing class. The increase of the second-grade score can be seen in Figure 1.

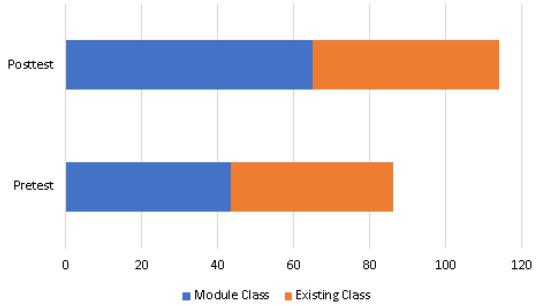

Figure 1. The Score Improvement of Students' Scientific Argumentative Skills on the existing class and module classes

Improvements to the module class were larger than the existing class. The difference in the module class was 21.6 points. In the existing class that used the instructional material in the form of a package book, the difference of score increase was only 6.2 points. This proves that the use of Problem-Based Learning module is effective enough to improve students' scientific argumentation skill.

The same results can be seen in the comparison of scores on the aspect of scientific skill which consists of claim, evidence, reasoning, and rebuttal. The results of the scores of these four aspects can be seen in Figure 2 below.

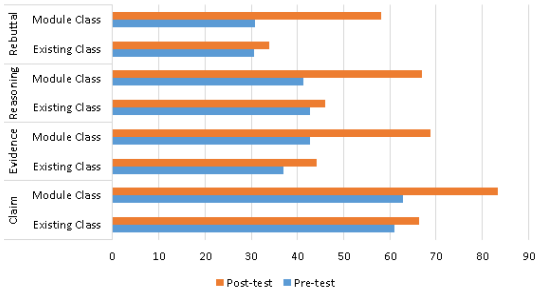

Figure 2. Comparison of scores of scientific skill aspects between pre-test and post-test of control and experimental classes

Based on Figure 2. it can be seen that the percentage of the post-test value of each aspect of students' scientific skill from both control and experimental class was increased. Percentage increase in module or experiment class was greater than control class. Of the four aspects of scientific argument skill studied in the module class, the percentage increase in the biggest rebuttal aspect was 27.27% and then followed by the evidence of 26.06%, the reasoning aspect 23.94%, and the claim aspect which increased by 20.61%.

The rebuttal aspect had the highest increase if compared to other aspects; this may be due to the initial score or the pretest score which is very low. Most students did not provide a rebuttal or student disclaimer at the time of pretest. Low student knowledge of the quality of rebuttal may be the cause of low pretest scores (Muratsu, *et al.*, 2015). The rebuttal score increased 27.27% after learning using PBL-based ecosystem module. Activity on the module stimulated students to form a qualified rebuttal.

In this research, the evidence aspect was increased by 26.06%. Students collected evidence at the Discovery and Reporting stage or Discovery and reporting of module activities. Students were already able to gather evidence and excuses, but some students still havd difficulty in selecting and using data as evidence to support their claims. Students found difficulties to distinguish between evidence and theory so that students tend to use their thinking to draw conclusions (Mcneill, *et al.*, 2006; Pritasari, *et al.*, 2015). Students' understanding of the content they encounter also affected their ability to present evidence. Students who have understood the content would more easily show evidence as a supporter of claims effectively (Foong & Daniel, 2010; Mcneill *et al.*, 2006).

Aspects of reasoning was increased by 23.94%. Some students gave their reasoning at a medium level with a maximum score of 2. Students had been able to give reasons or propose reasoning based on scientific principles and theories but not yet strong enough to link claims and evidence (Mcneill *et al.*, 2006). This was due to the limited knowledge of students on the material content faced. Students' ability to provide scientific explanations requires intense training. Students need to learn about reasoning or scientific explanation clearly and detail (Mcneill *et al.*, 2006; Osborne *et al.*, 2004).

Aspect claim had the lowest percentage increase compared to other aspects. This was because the student's claim score at the time of pretest is good. Most of the students have been able to get score 2 and 3. In posttest result after learning using PBL-based ecosystem module, most of the students can get maximum score. Students can make a claim well because students find it easier to focus on making claims or answers (Rich, *et*

al., 2010).

The result of pre-test, post-test and an average gain of module class and control class based on the overall score of scientific argue skill shows the following results:

Table 1. Results of Pre-test and Post-test Class of Module and Control Class

Category	Module Class		Control Class	
	Pre-test	Post-test	Pre-test	Post-test
Average Score	43.27	64.90	42.72	48.95
Highest Score	47	78	33	53
Lowest Score	7	62	20	20
Deviation Standard	12	7.18	5	8.71
Average Gain	0.53		0.29	

The average pre-test score of the module class was not that much different from the control class. This suggests that students' early scientific argumentative skills in both classes were equal to or on an equal level. The experimental class experienced an increased in the average score of scientific argumentation skills after experiencing treatment with learning using PBL-based modules. This was evident from the post-test average score in the module class or experimental which was much higher than the control class.

The gain scores held by the experimental class were included in the moderate category and higher than the control class which only has a low category. Gain scores of both classes did not reach the high category because most of the students have not been able to obtain the maximum score. Students in the control class were largely unemployed while in the experimental class the skill aspect score of students between pre-test and post-test increased although most of them recently achieved score 2.

The result of the average gain of the control class and the experiment was then tested further by first performing the normality test and homogeneity test as a parametric prerequisite test. The results of normality test with Kolmogorov-Smirnov pre-test and post-test score in both classes were normally distributed with a significance value of 0.200 and 0.463. The result of homogeneity test with Levine Statistic also showed homogenous population data. Pre-test and post-test data of both classes are normally and homogeneously distributed so that it could be further tested by parametric statistic test with the t-test.

T-test showed significant difference between the value of pre-test and post-test with sig. 0.00 thats mean Ho is accepted. Based on these results, it can be seen that the Problem-Based Learning ecosystem module can improve students' scientific argumentation skills. Students construct explanations that support arguments through investigation of phenomena or problems (Bell & Linn, 2007). Problem-Based Learning model according to Tan (2004) connects between inquiry, independent learning, information gathering, and problem-solving in an integrated way. The five syntaxes of Problem-Based Learning model that has been integrated into the module contain the investigation activity of the problem then with the discussion process. These learning steps can help students to shape their arguments.

The result of direct observation showed the improvement of the aspect of students' argumentation skill through Problem-Based Learning (PBL) model which could be known through the learning steps. Each of the PBL stages haad the potential to develop different aspects of argumentation skills according to the type of activities undertaken. At the stage of meeting the problem, students was faced with the ill-structure problems that still require completion. This triggers students to make ideas and ideas as the solution to the problem. The idea or idea was a temporary claim that can be used for the preparation of problem formulas and hypotheses. This was in accordance with the opinion of Tan (2003) which states that students could find ideas related to the problems based on the results of their thoughts at the stage of meeting the problem. In the stage of problem analysis and learning issues, students make the formulation of the problem based on their initial claim. At this stage, students practice thinking of evidence and reason as hypotheses or temporary answers to answer the formulation of problems they have raised.

Students can obtain evidence and reasons or reasoning at the discovery and reporting stage. Students work in groups to investigate problems. Ecosystem modules have been made in accordance with the PBL model syntax. Students learn to make claims based on evidence and reasons collected from the results of direct experiments and literature studies. Experimental or direct discovery activities can help students construct their knowledge and improve negotiation among group members (Widodo, *et al.*, 2017). The evidence and reasons for the findings and negotiations will

be used to support the claim and make rebuttal (Berland & Mcneill, 2009; Foong & Daniel, 2010; Muratsu *et al.*, 2015).

Module activities at the solution, presentation and reflection stage, bring up the rebuttal aspect. Each group reports and presents the results of its group discussion to other groups in a classical way so that there is a discussion between groups. This activity can raise aspects of rebuttal because at this stage students experience cognitive conflict from the discussion process (Sampson & Schleigh, 2016). The assignment of the students demands them to reach the consensus that guides them in making rebuttal (Eemeren, *et al.*, 2013). Rebuttal represents an understanding of the limitations of claims, the higher the value of rebuttal can be an indication that students learn to see problems from different sides (Widodo, *et al.*, 2016). During the discussion process, students are exposed to a variety of claims different from their claims. Students are required to bring evidence and alternative reasons to deny any other claims or alternative claims posed by other groups. At the last stage of interrogation, overview and evaluation, the students bring back the claim, but at this stage, the claim appears in the form of conclusions or decisions. The claim is an actual claim because it has been supported by the appropriate evidence, reasoning, and rebuttal to solve the problem.

This Ecosystem-PBL based modules can be use as a tools to improve students' scientific argumentation skills. The product of this reasearch also can be use as learning materials for ecosystem subject for tenth graders of Senior High School. The result of this reasearch will help other researchers who want to develope PBL-based modules to enhance students' scientific argumentation skills.

CONCLUSION

The improvement of students' argumentation skills scores from pre-test and post-test in the module class was higher than that of existing class. There were also and increase in the four aspects of scientific argumentation skills in the module class after using Ecosystem PBL based module. The highest percentage of aspect which increase is rebuttal aspect followed by evidence, reasoning and claim. The T-test results prove that there is a significant difference between the pre-test and post-test results of the module class. This showed that the Problem-Based Learning module of ecosystem material can improve students' scientific argumentation skills.

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