JPII 6 (2) (2017) (221-228)

Jurnal Pendidikan IPA Indonesia

http://journal.unnes.ac.id/index.php/jpii

IMPLEMENTATION OF PROBLEM-BASED LEARNING WITH GREEN CHEMISTRY VISION TO IMPROVE CREATIVE THINKING SKILL AND STUDENTS' CREATIVE ACTIONS

M. Nuswowati*[1], E. Susilaningsih[1], Ramlawati[2], S. Kadarwati[3]

[1]Department of Chemistry Education, Universitas Negeri Semarang, Indonesia
[2]Department of Science Education, Universitas Negeri Makassar, Indonesia
[3]Department of Chemistry Engineering, Curtin University, Australia

DOI: 10.15294/jpii.v6i2.9467

Accepted: April 13th, 2017. Approved: June 30th, 2017. Published: October 17th, 2017.

ABSTRACT

The aims of the research are to increase creative thinking skills and creative action through the implementation of Problem-Based Learning (PBL) model with green chemistry insight. The research design of mixed method experimental models embedded with a pretest-posttest control group was applied to measure the effectiveness of the application of the of Problem-Based Learning (PBL) model with green chemistry insight at the end of the learning activities to increase creative thinking skills and creative action of students in solving various environmental problems. The results showed that creative thinking before and after implementation of the experimental class is 82.42 and N-Gain 0.73 (high category), while that in the control class is 69.85 and N-Gain 0.32 (medium category). The assessment of the creative action begins from investigating groups of problem-solving ideas written on the outcome of the discussion groups. The consultation with the lecturer is carried out for the implementation of tasks, exhibit, communication (presentation), and rewriting in the form of reports in more detail results/products of the creative activity that has been done and also the sustainability of the action. The application of the Problem-Based Learning (PBL) model with green chemistry insight is able to increase creative thinking skills and creative action of the students.

Keywords: Problem-Based Learning (PBL); green chemistry; creative thinking skills; creative actions

INTRODUCTION

There are still many learners in Indonesia who have not been able to relate the scientific knowledge he studied with the phenomena that occur in his environment. This can happen because learners do not have the experience to link it during the learning process/lectures. At present, environmental issues are still an actual problem and a global issue (Tan, 2007). Environmental problems have an essential potential to be raised in chemistry learning. The benefits that can be felt directly would be very interesting and meaningful for learners. Lessons devoted to solving actual problems need to be designed through an appropriate model and instructional medium to facilitate student activity linking concepts and the real world (Taufiq et al., 2016).

The weaknesses of environmental chemistry lectures during this time are revealed from student questionnaires. The explanation of lecturers is too dense with the material (topics) and field trips which objectives are less clear (Nuswowati, 2011). The impact is that students are less motivated to ask questions or improve their knowledge, and show they are not ready to make field trips. The impact of attitudes and behavior, when invited to field studies or out of lectures, has not been reliable as an example or paragon. The problem-based environmental chemistry lecturing model has been shown to increase students' character scores in solving environmental

***Address Correspondence:**
E-mail: mnuswowati@mail.unnes.ac.id

problems and can improve the mastery of environmental chemicals, but there is no significant relevance between improving mastery of material and improving character scores (Nuswowati & Taufiq, 2015).

The thinking ability of learners can also be developed by applying the Problem-Based Learning (PBL) model. Learners will be faced with a variety of contextual problems that require the ability to think and solve problems (Alejandro & Juan, 2010). Furthermore, according to Fatimah & Widiyatmoko (2014), the implementation of the model shows the learning achievement of learners increased and the ability to think learners also experienced a significant improvement. Construction of knowledge through learning, one indicator of success is the ability of identification and reasoning that serves as a problem solver (Özgelen, 2012). Scientific reasoning is developed through arguments arising from classroom communication (Acar et al., 2015).

Based on the description from previous experts and researchers, it can be said that Problem Based Learning (PBL) is a learning model that can apply the concepts and principles of science including chemistry of the environment, which is also more suitable to be studied through score appreciation (Yoonet al., 2014; Hicks & Bevsek, 2012). As we all know, the main cause of environmen- tal pollution is the application of science. Science applications can have both positive and negative impacts on two sides of the coin. To deal with both impacts, learners need to be equipped with prevailing scores, so that the results of chemical technology directed only to improve the welfare of human life.

PBL is a model that prioritizes the suitability of learning with the things that are found in the daily lives of learners. This model conforms to CTL principles, namely inquiry, constructivism, and emphasis on higher-order thinking. Applica- tion of the PBL model can produce many desi- rable abilities in higher education (Sahin, 2010; Juntunen, 2013). Several relevant studies have been con- ducted about learning chemistry, environment, environmental learning, green chemistry, Prob- lem-Based Learning approach, interrelated thin- king skills (Nuswowati & Taufiq, 2015; Dhage, 2013; Nuswowati, 2011).

Green chemistry is a philosophy that encourages the design of a product or process that reduces the use and production of toxic and or harmful substances (Wardencki et al., 2005). The concept of green chemistry deals with Organic Chemistry, Inorganic Chemistry, Biochemistry, and Analytical Chemistry. This concept tends to lead to applications in the industrial sector, but also has links to environmental chemistry. Green chemistry focuses more on efforts to minimize the income of harmful substances and maximize the efficiency of the use of chemical substances. Meanwhile, environmental chemistry emphasizes more on environmental phenomena that have been contaminated by chemical substances (Ravichandran, 2011).

The growth of the environmentally friendly chemical industry is increasingly needed. The trend is known as green chemistry or sustainable technology. Green chemistry arises from a shift in the traditional concept paradigm of concept efficiency that focuses primarily on the outcomes of chemical reactions, which can economically eli- minate waste and avoid the use of toxic and ha- zardous materials (Zejnilagic-Hajric et al., 2015). Green chemistry activities are formulated as an efficient use of basic (especially renewable) materials, waste removal and avoi- dance of toxic and toxic reagents and solvents in industrial and chemical product applications (Jonassen & Hung, 2015).

Green chemistry movement has begun to be encouraged in Indonesia especially after seeing the impact caused by the chemical results that make scientists aware of the importance of green chemistry movement. This green chemistry also addresses issues of energy shortages, diminishing natural resources, current pollution problems, and many other key issues. Given the importance of green chemistry that has the potential to preserve the environment, this movement needs to be supported by all parties, especially the industry and government. Green chemistry is not going to solve all the pollution, energy, and food problems but its role can make an enormous and fundamental contribution to the preservation of life on planet earth. Based on the background encountered, the researchers apply Problem-Based Learning (PBL) model of green chemistry vision to impro- ve creative thinking skills and creative actions of students. This study aims to improve the creative thinking skills and creative actions of students through the implementation of Problem-Based Learning (PBL) model vision of green chemistry.

Learning model that has the vision of green chemistry expected learners to build the concept into a science that enters long term memory so that learning result increases. Additionally, with the application of learning models that have the vision of green chemistry, it is expected to facilitate the balance of hand on and minds on skills which is expected to improve students' learning outcomes as well as creative thinking skills and creative actions.

METHODS

The method of this research is mixed method design with experimental models embedded through pre-test post-test control group to measure the effect of applying Problem-Based Learning Model (PBL) with the vision of green chemistry at the end of learning activity toward the improvement of creative thinking skill and creative action of the student in solving various environmental problems.

The populations of this study are students of Chemistry education of the fifth semester year 2016. Samples of the research are 38 students as the control class and 36 students as experimental class.The samples are taken randomly, after knowing that all classes are homogenous. Creative thinking skills are measured by a description test that modifies the indicator of creative thinking skills from Guilford (1977) for the reasons that best fit the stages of PBL. Initially, the drafting of the creative thinking skill test consisting of six questions of each environmental chemistry and the Hintz were created. The test of creative thinking skill comprised four subjects/topics carried out in this study. As a whole, there were 24 questions. After being tested regarding the validity, reliability, and creative thinking skills, there are 20 questions that meet the criteria to measure the creative thinking skills of students before and after the implementation of the problem-based and environmental chemistry-based teaching model with green chemistry vision.

To measure creative attitudes by using the adaptation of 32 point statements developed by Munandar (2009), it has been believed to reveal the general creative attitude. Of the 32 statements in the observation sheet of a marker of creative attitudes, there are positive statements and negative statements. In positive statement, answer "yes" got score 1, answer "no" got score = 0. In the negative statement, answer "no" got score 1 and answer "yes" got score 0.

The assessment of creative action begins with the investigation of a group of problem-solving ideas written from the results of group discussions. Utilization of consultation time with lecturer for task implementation, exhibiting, communicating (presentation), and rewriting in the form of a report in more detail result/product of creative action has been done together with sustainability action.

According to Buntat & Nasir (2011), creativity is the ability to create something. Creativity is divided into a variety of types. It is not only seen from a product that one produces but also it can be seen through the performance of a person at the time of the task. The creative actions in this study were seen from student performance in group investigations focused on exhibiting (presentation) creative actions. Assessment of creative action involves seven aspects: (1) clarification of group investigation identification; (2) explanation of the source of the problem; (3) skill to predict the impact if not immediately addressed; (4) Smoothly answering or responding to questions from other groups; (5) working together in groups.

RESULTS AND DISCUSSION

The effectiveness of the problem-based lecture model can be measured by measuring the difference between the students in the experimental class and the control class. Both groups are supported by the same lecturer. Before and after the lecture, pretest and postest were done.

At the beginning of the lecture, both experimental class or the control class were given an agreement (lecture contract) stating that there is a different treatment. Control classes with lecture contracts are like those of past years, while the experimental class needs emphasis, especially on problem-based lecture synthesis and assessment techniques. Some environmental chemistry lecture deals for an even semester focus to support competence demands are as follows: (1) Be able to detect, recognize, and understand and respond to problems; (2) Able to predict pollutant sources and their impacts if not promptly addressed; (3) Be able to consider solutions or approaches to existing air pollution problems; (4) Be able to spark ideas in genuine and green chemistry ways to solve pollution problems; (5) Be able to detail action steps undertaken in solving the problem of pollution in which there are tables, graphics, pictures, models and or words.

The success of implementing PBL with green chemistry vison can be analyzed from several aspects. In this study, the focuses of analyis are thinking skill aspects and creative actions, as well as the students' response within the lecturing process.

Creative Thinking Skill

Before and after the lecture, both control class and the experimental class were given a description test with the same problem. The results showed that creative thinking skills of experimental class before and after application were

82,42 and N-Gain 0,73 (high category), while control class 69,85 and N-Gain 0,32 (medium ca- tegory). This increase is included in the medium category. The results of pre test, post test, and N- Gain of creative thinking skill are presented on the Table 1.

Table 1. The Scores of Creative Thinking Skill

Class	Pre-Test	Post-Test	N-Gain
Experimental	35.82	82.42	0.73
Control	55.94	69.85	0.32

The creative thinking skill test in the form of a test description that follows the steps or syntax of problem-based learning (PBL) vision of green chemistry was applied. The steps are different from those applied to control class that does not use the PBL steps with the task group presentation of the problem-solving action. The process of control class lecture is also a group task to create a paper presentation. The students made any paper about any theme on environmental chemistry. Titles are made mostly like the title of instructional material. All of the groups consisting of nine groups of control classes made titles that address the solution of air, soil or water pollution problems. In experimental classes, titles are created mostly like article titles. Six student groups (out of a total of 36 students) made titles that address the solution of air, soil or water pollution problems.

Creative thinking skills of each indicator with different subjects (air, soil and water chemistry) have been analyzed regarding scores on each aspect of assessment in each competency of the first year trial. The results of these trials analyzed the results of each indicator as a consideration in developing the assessment instrument. There are five predetermined indicators for creating creative thinking skills: (1) Able to detect, recognize, understand and solve environ- mental problems; (2) Able to predict environmental pollution sources and their impacts if it is not addressed immediately; (3) Able to consider solutions or approaches to solving existing environmental pollution problems; (4) Be able to spark ideas in original and Green Chemistry ways to solve environmental pollution problems; Indicator 5: Be able to detail and design action steps undertaken in solving the problem of environmental pollution in which there are tables, graphics, pictures, models and or words. Differences in the score of the five indi- cators can be seen in each subject can be seen in Figure 1, Figure 2, and Figure 3.

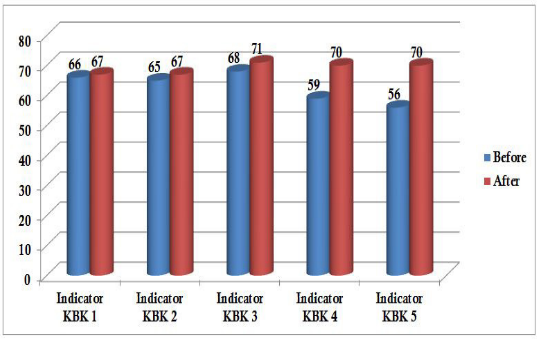

Figure 1. The Scores of Each Indicator of Creative Thinking Skill in The Subject of 'Air' in the Control Class

In the materials of 'air', the highest average score of the control class before treatment is at the third indicator of creative thinking skill with score 68. The lowest average score is at the fifth indicator with score 56. Then, the highest average score after treatment is at the third indicator with score 71, and the lowest score is at the first and second indicator with score 67.

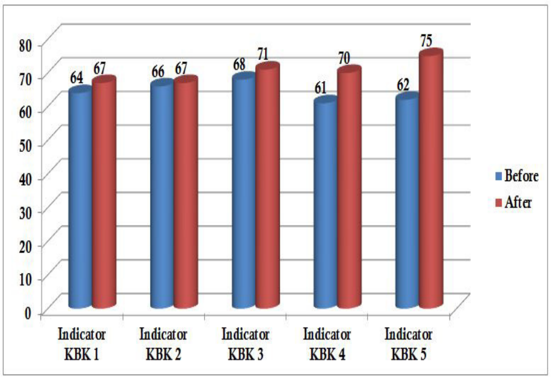

Figure 2. Scores of each Indicator of Creative Thinking Skill on the Subject of 'Soil' in the Control Class

For the materials of soil, the highest average score of creative thinking skill in the control class before treatment is at the third indicator with score 68. The lowest average score is at thr foourth indicator withs core 61. The highest average score after treatment is at the fifth indicator with score 75 and the lowest average score is at the first and second indicator with score 67.

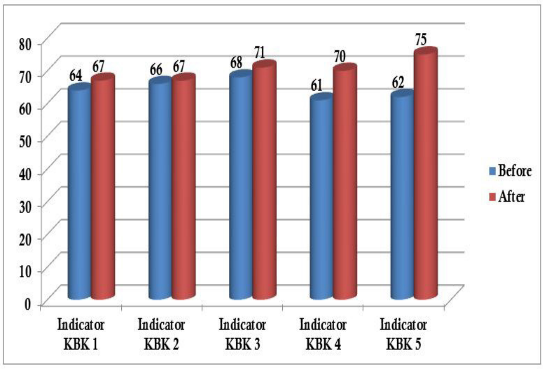

Figure 3. The Score of Each Indicator of Crea tive Thinking Skill in The subject of Water in the Control Class

In the materials of water, the highest average score of creative thinking skill of control class before treatment is at the fourth indicator with score 68. The lowest average score is at the fourth indicator with score 61. While after treatment, the highest everage score is at the fifth indicator with score 75. The lowest averagescore is at indicator 1 and 2 with score 67.

The lowest score of indicator before the learning process for control class is indicator 4 (triggering idea), the average scores of air, soil and water are 59.61 and 61 respectively. The lowest score also occurs in Indicator 5, the average score of air, soil and water are 56.62 and 62 respectively, while the highest score is indicator 3 (i.e., 68, 68 and 68). The draft action was performed. After the learning process, the lowest scores are indicator 1 (detect) and 2 (predict), while the highest scores are indicator 3 and 5. The score of all indicator of creative thinking skill after learning has increased although it is small. The highest scores in the control class are indicators 3 and 5.

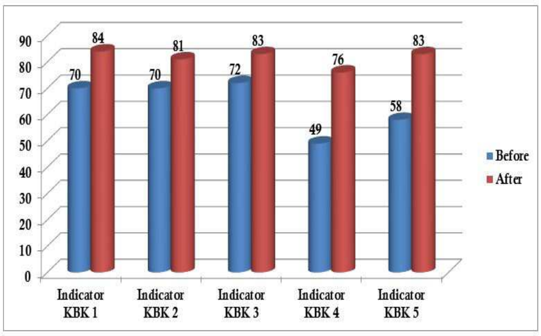

Figure 4. The Score of Each Indicator of Creative Thinking Skill of Air Subject in Experimental Class

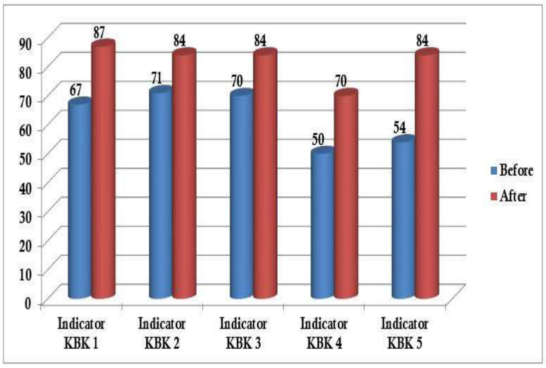

Figure 5. The Score of Each Indicator of Creative Thinking Skill of the Land Subject in the-ExperimentalClass

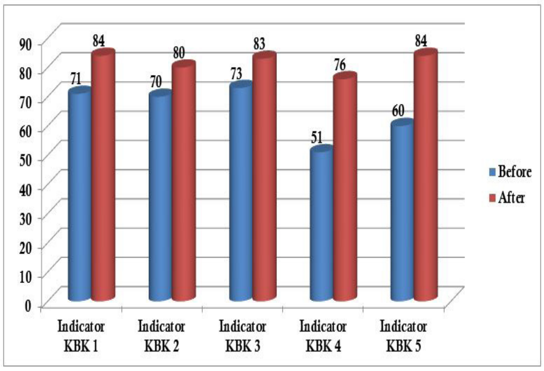

Figure 6. The Score of Each Indicator of Creative Thinking Skill The subject of Water in the Experimental Class

The scores of creative thinking skills in the experimental class, before learning, on indicator 4, for subject air, soil and water are 50.51 and 49 respectively. The highest score of creative thinking skills for air, soil and water matter is in indicators 1 (87, 84, and 84) and indicator 5 (84, 84, and 83). The results of the assessment of creative thinking skills can be seen in Figure 4, Figure 5 and Figure 6.

The indicators of creative thinking skills are applied in the learning process, and their assessment also refers to the PBL steps and the subject matter. It is very helpful in achieving the learning objectives, as Nuswowati & Taufiq (2015) mentions, that there are two fundamental processes, which occur during the process of creative thinking, i.e., cognitive (what we know), and non-cognitive (what we feel). The cognitive process is what the students know, not yet what is perceived, and bringing up the idea of problem solving. Non-cognitive processes such as the attitude of students to the problems around them have not been trained in the current lecture process. This is particularly relevant to the research by Hajiet et al. (2015) and Rosita et al. (2014) that the application of learning tools based on green chemistry learning can improve mastery of soft skills and make learners motivated to be involved in problem-based learning with green chemistry orientation.

Improved creative thinking skills are also followed by improvements in other learning outcomes. It is increasingly asserted that the model of Problem-Based Learning with green chemistry is appropriate to apply to the environmental chemistry learning process since this learning model involves the learner's activities in the cognitive, psychomotor and affective aspects.This is by research by Tosun & Taskesenligil (2011) revealing that the Problem-Based Learning model can improve students' motivation and learning strategies. The students' cognitive learning outcomes are increased due to motivation and appropriate learning strategy.

Creative Actions

The creative action data were obtained from the assessment of the prospective teacher presentation while displaying the report of the results of the group investigation. In the assessment sheet of group presentations, there are seven aspects that are assessed. The assessment results are shown in Figure 7.

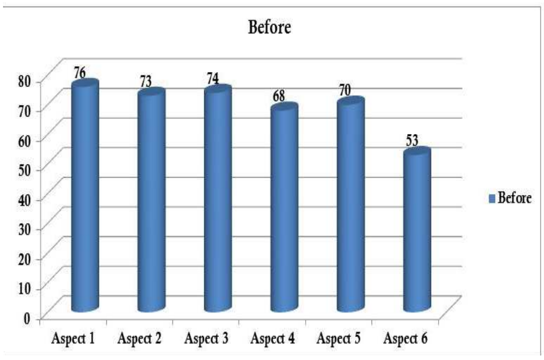

Figure 7. An assessment of Creative Action through the Presentation of the Experimental Class Group

Information

Aspect 1 :	Explain the identification of group problem
Aspect 2 :	Communicate the source of the problem and predict the impact if it is not addressed immediately
Aspect 3 :	Be able to consider solutions or approaches to existing air pollution problems
Aspect 4 :	Skillfully show off ideas
Aspect 5 :	Detail and design action steps to undertake.
Aspect 6 :	Fluently answer/respond to questions/ objections/opinions of friends of other groups
Aspect 7 :	Work together in groups

The results of the assessment of creative actions indicate that the indicator 1 is the explanation of the identification of group problems and indicator seven that are working together in the group is the highest. Average assessment of problem identification is 76 and work together is 90. Indicators 2, 3, 4, and 5 are good too, with successive grades of 73, 74, 68 and 70, this is possible because, in lectures, it has been given clear guidance on the implementation of the presentation. Specifically, in the 6th creative action indicator that fluently answers/respond to questions/arguments/opinions of friends from other groups, the score is 53 which belongs to the category of very low. It is possible because if questions of friends are too broad, students are less able to answer and respond the suggestions from his friends. Based on these data, it is shown that this green chemistry is very good, in line with the research of Sudarmin (2013) which develops organic chemistry labs based on green chemistry.

The application of Problem-Based Learning (PBL) model is to attract and motivate students to follow environmental chemistry. This suggests that learners are more likely to follow the learning process by applying the Problem-Based Learning (PBL) model with green chemistry vision. It is proven by the questionnaire results of the responses of learners who partially agree.

The percentage of average students who gave opinion agree is as much as 89%. These results are in line with the results of the Tandogan & Orhan (2007) study, giving the result that the implementation of the Problem-Based Learning (PBL) model can motivate, enhance cooperation, and develop stu- dents' science process skills.

CONCLUSION

The results showed that creative thinking skills before and after application in the experimental class were 82.42 and N-Gain 0.73 (high category), while control class 69.85 and N-Gain 0.32 (medium category). The assessment of creative action started from the investigation of the group of problem-solving ideas written from the results of the group discussion. Consultation time with the lecturers was conducted for the execution of tasks, exhibits, communication (presentation), and rewriting in the form of reports in more detailed results/products of creative actions that have been done and been measured its sustainability. Application of Problem-Based Learning (PBL) model with green vision can improve creative thinking skill and creative actions of students.

The improvement of creative thinking skill is also followed by the improvement of cognitive learning outcomes with score 0.74 (high category). Some things become obstacles in this research and become suggestions for improvement for the next researcher. In the moment of group presentation in the classroom, the questions and responses must be by the issues raised by the presenting group. Assessing tools of creative thinking skills and creative actions need to be more developed so that it can measure the real performance of the individual. It is also suggested that the designated observer should know the importance of the evaluation tool. Researchers also recommend developing further research related to the assessment of creative attitudes with various other instruments, such as observation and portfolio.

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