Universitas Muhammadiyah Malang, East Java, Indonesia

JPBI (Jurnal Pendidikan Biologi Indonesia)

p-ISSN 2442-3750, e-ISSN 2537-6204 // Vol. 6 No. 2 July 2020, pp. 225-232

Research Article

Implementing project-based learning to enhance creative thinking skills on water pollution topic

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ARTICLE INFO

Article history
Received May 14, 2020
Revised June 05, 2020
Accepted June 15, 2020
Published July 21, 2020

Keywords
Cretive thinking skills
Environmental problem
Project based learning

ABSTRACT

The implementation of Project-based learning (PjBL) has been recognized as a recommended alternative learning to habituate students to solve their daily problems. This study aimed to describe students' creative thinking skills (CTS) in water pollution topic using PjBL. The descriptive method was used in this study. The sample in this study were junior high school students in the Bandung City, Indonesia. The instruments used in this study were CTS test, peer assessment, and product creativity assessment rubric. The data gained were analysed using descriptive statistics analysis in terms of mean and percentage. The results showed that the mean test score of students' CTS was 89% (excellent category). The achievement of peer assessment indicators was 87%, while the performance of product creativity indicators was 88%. This study concluded that the implementation of PjBL in science learning could improve the CTS of junior high school students.

How to cite: Yamin, Y., Permanasari, A., Redjeki, S., & Sopandi, W. (2020). Implementing project-based learning to enhance creative thinking skills on water pollution topic. *JPBI (Jurnal Pendidikan Biologi Indonesia), 6*(2), 225-232. doi: https://doi.org/10.22219/jpbi.v6i2.12202

INTRODUCTION

In the 21st Century Education with the demands of Sustainable Development Goals (SDGs), integrated science and biology learning is aimed at preparing students to solve various daily life problems (Burbules, Fan, & Repp, 2020; Laal & Salamati, 2012). One of the daily problems associated with SDG's and requiring 21st Century skills is environmental issues (Dell'Angelo, D'Odorico, & Rulli, 2017; Husamah, 2015; Rafaj et al., 2018). It is undeniable, in the current era, environmental problems are still the main problem faced by humans (Alam, 2014; Jianping et al., 2014). Various pollution occurs everywhere, one of which is in water environment (Khatun, 2017; Spanton & Saputra, 2017). Water pollution categorized as serious environmental problem because it can reduce the availability of clean water and trigger various diseases for local residents (Narendran, 2015). Therefore, integrated science implementation in schools is expected to be one way to increase the students' awareness regarding the problem of water pollution.

Integrated science learning has been applied in several countries. Several studies conducted to see the effectiveness of the application of integrated science learning. (Idowu, 2011) discussed some of the fundamental problems to develop integrated science curriculum in Nigeria. Other studies investigate the perception of students and teachers of the difficult topics integrated science learning in America (Ogunkola & Samuel, 2011), Ghana (Ameyaw, 2011), and Nigeria (Edokpayi & Suleiman, 2011). In the implementation of integrated science learning it needs to be supported by professional teachers who can apply integrated science learning in the classroom well (Hafizan, Halim, & Meerah, 2012). In addition, it needs to be supported by appropriate learning activities that can stimulate students to be more active in the learning process.

In connection with the integrated science and biology learning role, teachers must be able to empower various thinking skills of their students (Scott, 2015). One of the thinking skills needed by students to solve water pollution problems is creative thinking skills (Birgili, 2015). By having good creative thinking skills, students can trigger students to understand a problem more deeply (Mumford & McIntosh, 2017; Vidal, 2010). Their criticality in examining problems has also increased (Hidayati, Zubaidah, Suarsini, & Praherdhiono, 2019). In addition, they are also able to think flexibly and better determine solutions to problems (King, Goodson, & Faranak, 2011). In order for these thinking skills to be optimally empowered, learning designs must implement appropriate learning innovations.

One of the learning innovations that has the potential to empower students' thinking skills is Project-based Learning (PjBL) (Bell, 2010; Jensen, 2015; Rambely et al., 2013). PjBL implementation can stimulate students to be actively involved in the learning process (Movahedzadeh, Patwell, Rieker, & Gonzalez, 2012). PjBL also have an enormous potential to make learning experiences more interesting and meaningful for students (Jensen, 2015). PjBL is also considered to be one of the most promising models for empowering creative thinking skills (Isabekov & Sadyrova, 2018; Rambely et al., 2013).

The various benefits of PjBL have been further strengthened by the emergence of various studies examining PjBL (Chiang & Lee, 2016; Wekesa & Ongunya, 2016). Suryandari, Fatimah, Sajidan, Rahardjo, and Prasetyo (2018) investigated the effectiveness of project-based science learning to enhance pre-service teachers literacy skills and learning creativity in wave and optical materials. Memişoğlu (2011) focused to improve students' success and memorization using PjBL in teaching the "population in our country" unit in the social sciences class. Other studies analyzed the effect of PjBL on student motivation (Chiang & Lee, 2016); students' engagement (Viswambaran & Shafeek, 2019), metacognition (Pavkov-Hrvojevic, Obadovic, Cvjeticanin, & Bogdanovic, 2016), and science process skills (Hernawati, Amin, Irawati, Indriwati, & Aziz, 2018).

Based on the information conveyed in previous paragraph, research on PjBL is increasingly develop. However, the implementation of PjBL in several countries, such as in Indonesia still not satisfying because this learning is often difficult to implement in the classroom due to several obstacles. The obstacles that can be faced by teacher including time, curriculum, availability of tools/materials and teacher's understanding about PjBL (Kubiatko & Vaculová, 2011). In addition, those studies also rarely relate the problem of environmental pollution as the basis for student project preparation. Therefore, increasing the frequency of research examining the implementation of PjBL in Indonesia with environmental problems that occur in Indonesia needs to be increased. Therefore, the purpose of this study was to examine the empowerment of students' creative thinking skills through the application of PjBL on the topic of water pollution. This research will provide many benefits such as providing information related to the effectiveness of this learning in empowering the 21st Century skills of Indonesian students. Apart from that, this study can also provide an overview of the obstacles faced when implementing PjBL in Indonesia. In addition, with this research, PjBL dissemination in schools in Indonesia can be increased.

METHOD

This descriptive research examined the implementation of PjBL in the topic of water pollution. This study begins with need assessment from curriculum expectation. Curriculum was reviewed to determine the aim and competence of learning materials that will be developed, as well as identify the main material that needs to be taught. The next step was the study of literature; carried out by collecting and selecting relevant materials, putting it back together systematically, so that eventually it is acquired the design of learning and research instruments.

The stages of PjBL that implement in this study are shown in Table 1. PjBL implementation was conducted for three face to face meetings. In the first meeting, the stage 1 and 2 were carried out. In the second meeting, the stage 3 and 4 were conducted. In the third meeting, the stage 5 and 5 were finished.

The research was conducted in 2018. The sample of this study was c 113 seventh grade students who studying in one of junior high schools in. The sample was divided into 4 classes, each class totaling of 28-29 students. To determine student creative thinking skills, creative thinking skills test, peer assessment and product creativity assessment rubrics were chosen as data collection instrument. The test of creative thinking skills consisted from 40 item with two-tier test which consists of the first tier as a multiple choice and the second tier as the reason from the first-tier option. The test of creative thinking skills in this study used indicators of creative thinking skills proposed by Torance, including fluency, flexibility, originality and elaboration (Torrance, 1988), which described in Munandar into several sub-aspects (Munandar, 2004).

Table 1. PjBL implementation in this study

Learning Stages	Activity
Stage 1: Start with the essential question	In the early stages of PjBL, the students actively answered questions.
Stage 2: Design a plan for the project	In designing project planning, each group member gave each other ideas, but students appeared to be a little confused in designing project planning.
Stage 3: Create a schedule	At the stage of arranging schedules, students appeared active and shared their own ideas well. The project was completed on time according to a predetermined plan.
Stage 4: Monitor the students and the progress of the project	Monitoring the students and the progress of the project was not only carried out during learning but also carried out through media communication tools such as mobile phones.
Stage 5: Assess the outcome	The results testing stage was done through product presentations and tests in front of other students.
Stage 6: Evaluate the experience	The stage of evaluating the experience was done by asking questions and sharing experiences during the project creation process.

Peer assessment contains Yes/No question for each creative thinking skills indicators. The assessment of creativity product consisted of eight indicators including new products, new procedures, products resulted from individual/group interactions with their environment, originality, significance, the accuracy of the application of the science concept in doing projects, relevancy of application of science concept in project creation, and suitability of products made with learning objectives (achievement of basic competencies) (Eragamreddy, 2013). Finally, the data were analyzed by descriptive analysis through the calculation of the percentage of the results of student achievement.

RESULTS AND DISCUSSION

Meaningful science learning was expected to improve students' creative thinking skills. Students were directed to find solutions to problems faced in everyday life. The theme raised in this study was water pollution. With integrated science learning on the theme of water pollution, students were directed to think creatively to find solutions in an effort to overcome water pollution. The results of the students' creative thinking skills test are presented in Table 2.

Table 2. Creative thinking skills test and peer assessment recapitulation

Indicators		Test	Peer assessment
Ability to think smoothly		87%	89%
Ability to think flexibly		89%	85%
Ability to think originally		92%	88%
Ability to specify		84%	91%
Ability to assess (sensitivity)		85%	81%
Curiosity		91%	86%
Imaginative nature		91%	76%
Responsibility for pluralism		90%	83%
Courage to take risks		89%	92%
Appreciation	toward ideas and opinion	96%	95%
	toward the products		97%
Average		**89%**	**87%**

Based on the percentage of student achievement presented in Table 2, the lowest aspect of creative thinking skills was “ability to specify” indicator, while the highest was “appreciation” indicator. However, even though the "ability to specify" indicator was the lowest, the percentage of student achievement in this aspect

had reached 84%. Thus, based on the test results, the creative thinking skills of students who have taken PjBL were already in a good category. These results were also in line with the level of students' creative thinking skills when measured using peer-assessment. Furthermore, the percentage range of student achievement in each aspect of creative thinking skills was from 81 to 97%. There were two aspects whose percentage was not optimal, i.e. "new products" and "new procedures" aspect (Table 3). However, the average of indicator achievement based on students' product was reached 88% (excellent category).

The high level of creative thinking skills of students after participating in PjBL is in line with several previous studies that have also implemented this learning. Some of these studies examine the increase of students' creativity in various countries (Isabekov & Sadyrova, 2018; Rambely et al., 2013). Several studies in Indonesia also reported similar results (Antika & Nawawi, 2017; Ummah, Inam, & Azmi, 2019). The increase in students' creative thinking skills after participating in PjBL further emphasizes the role of this learning in empowering thinking skills and various other 21st Century competencies (Bell, 2010; Kokotsaki, Menzies, & Wiggins, 2016; Takeda, 2016). As has been reported in various previous studies, PjBL is included in innovative learning that can empower critical thinking skills (Sasson, Yehuda, & Malkinson, 2018), science process skills (Hernawati et al., 2018), problem-solving ability (Chiang & Lee, 2016), and metacognition (Pavkov-Hrvojevic et al., 2016).

Table 3. Recapitulation of product creativity achievement

Indicators	Indicators Achievement
New products	67%
New procedures	67%
Products resulted from individual/group interactions with their environment	93%
Originality	100%
Significance	87%
The accuracy of the application of the science concept in doing projects	93%
Relevancy of application of science concept in project creation	93%
Suitability of products made with learning objectives (achievement of basic competencies)	100%
Average	**88%**

The effectiveness of empowering creative thinking skills through PjBL is caused by the characteristics and variety of learning activities in this learning. By implementing PjBL in integrated science learning, students will be immediately facilitated in dealing with contextual problems (Chen & Yang, 2019; Musa, Mufti, Latiff, & Amin, 2011) and trained creatively to solve these problems (Isabekov & Sadyrova, 2018; Sumarni, 2013). In this study, water pollution was raised as the main problem that had to be solved by students. Products designed by students were the solution to the problems faced, which was water filters. Students were divided into four groups. Each group was given the freedom to determine the materials and methods used to make water filters according to their creativity. After that they explained and tested the products they had made. Documentation of product presentation and trial can be illustrated in Figure 1. Figure 1 showed that students designed water filtration from (a) mesocarp and charcoal; (b) gravel and charcoal; (c) sand, mesocarp and gravel; (d) sand and mesocarp. Each group used different materials for water filter but visually the water produced by all groups looks clear. Mesocarp, charcoal, and gravel removed suspended solid particles and water permeates through a bed of granular media.

Project activity provided an real environment condition for students to develop their creative thinking skills. Students will try to find solutions for the problems they face in any way and from their own will. Moreover, this approach supports students in acquiring manual skills and by performing authentic activities. The creative process can be undertaken for any project or task in which we are challenged to come up with a unique product or result to solve a problem or reach a goal (Eragamreddy, 2013) The problem of water pollution challenged the students to engage actively design a product to solve problem. In such challenging situations, students are fostered to use their creativity during designing the product. Through PjBL, students not only identify problems and find solutions to problems faced, but students also required combining knowledge and creative thinking skills to solve the problems (Isabekov & Sadyrova, 2018; Sumarni, 2013). PjBL has also facilitated students to develop themselves both academically and practically to find solutions in daily life (Husamah, 2015; Kubiatko & Vaculová, 2011).

Figure 1. Documentation of product presentation and trial in (a) group A, (b) group B, (c) group C, and group D

Based on the findings of this study, PjBL provides optimal benefits for developing student creativity. Creativity as an indicator of high creative thinking skills is a competency that must be optimally empowered in the current era (Guo, 2016; Lee & Carpenter, 2015). Together with critical thinking, communication and collaborative skills, creative thinking skills are classified as 4C competencies (Guo, 2016) which are seen as one of the main competency groups in the 21st century (Lee & Carpenter, 2015). Given the high implementation of conventional learning in various schools in Indonesia, socialization and innovative learning training such as PjBL is necessary carried out continuously.

CONCLUSION

This study conclude that PjBL implementation would help students develop creative thinking skills. Student could improve their creative thinking skills through product design activities as their effort to solve the problem they face. The empowerment of students 'creative thinking skills is evidenced by the high percentage of achievement of students' creative thinking skills, both by means of measuring tests, peer assessments, and product assessments.

Given the high benefits of PjBL, the application of this learning should be more massive in Indonesia. The government and policy makers are expected to be able to hold various trainings and socializations related to the benefits and ways of teaching integrated science learning using PjBL. Various studies examining PjBL also need to be carried out continuously in order to provide more information regarding the benefits of this learning.

ACKNOWLEDGMENT

The authors gratefully acknowledge financial support from Pakuan University.

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