

# STUDENT'S CREATIVITY THROUGH PROJECT-ORIENTED PROBLEM BASED LEARNING (POPBL) WITH STEM INTEGRATION IN LEARNING SCIENCE

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**Abstract**— following current developments, educations as a place for students to get basic skills, must adjust the required competencies for 21st-century. One of important skill is the student creativity. This research attempts to investigate the effect of Project-Oriented Problem Based Learning (POPBL) with STEM integration on students' creativity in learning science. The descriptive method was adopted to investigate the data of students' creativity measured by the Creativity Product Analysis Matrix (CPAM), CPAM consists of three dimensions: novelty, resolution, and elaboration/synthesis. Twenty-seven students were involved in this research and the class was divided into five groups. Each group made a project adressing an environmental pollution problem around them. The overall students' creativity result showed 74% (Novelty), 85% (Resolution), and 81% (Elaboration/Synthesis). Firstly, group 3 got the highest score in terms of novelty dimension because they attended well to the product details, choosing of materials, and design. Secondly, while all groups made a valuable and useful product, most still needed to consider the environmental friendliness of their solution as related to the resolution dimension. Finally, the best products in terms of appearance was made by group 5, but they did not present the product clearly. The POPBL learning model integrates well with STEM as a learning approach to enhance students' creativity. This learning model can be used as one innovative learning model to increase other 21st-century skills in learning science.

**Keywords:** Students' Creativity, Project-Oriented Problem Based Learning, STEM, Learning Science

## I. INTRODUCTION

A nation wants their citizens to live prosperously and peacefully. There are many factors that influence the advancement of a country. One important factors is education because education can create students who are masters of the basic skills needed in the 21st century – the 12th century skill set. There are four life principles that underlie these skills, including learning to know, learning to do, learning to be, and learning to live together. Based on these four important life principles, the specific skills important for the 21st century include critical thinking, problem-solving, metacognition, communication and collaboration skills, creativity, innovation, information literacy, media, and technology (Zubaidah, 2017).

21st-century skills must continue to be developed through real activities in the teaching-learning process, especially in science learning. One skill that needs to be

developed is creativity. Creativity is an important skill in lifelong learning and is also needed in scientific problem-solving (Yasin, 2009). Creativity is influenced by social and environmental factors (Amabile, 1983: 358-376). The low ability of students in solving problems to master the science concept is in line with the low creativity possessed by these students. On the other hand, teachers feel that students' creativity is not adequate assessed with the usual high stakes testing and so they hesitate to foster the students' creativity (E. Mowrer-reynolds, 2005). This is evident in Indonesia where Indonesian students have been found to be less creative compared with students from other countries (Siswono, 2004). Therefore, at challenge for the Indonesian teacher is to find a feasible learning model that increases students' creativity.

Creativity competence is being developed in the reworking of the Indonesian curriculum which holds students as the center of learning. It is also reflected in the 2013 curriculum which states students can present creations or projects for all subject area. But the problem is what learning models are suitable for improving students' creativity in science learning. There are several mentioned in 2013 curriculum such as Problem Based Learning (PBL) (C.E.C.E.B. Hmelo-Silver, 2004), Project-based learning (PjBL) (S. Chandrasekaran, et al., 2013), and inquiry learning models (Edelson, 1996).

Development of the three models continues to be carried out by researchers across the country . The latest learning model is a combined learning model between PBL and PjBL, it is referred to as Project Oriented Problem Based Learning (POPBL) (W.N.F. Wan Husin et al., 2016). POPBL is an integration of project-based learning and problem-based learning that fosters students' ability to learn based on problems and solve problems through projects. This learning model has been applied in mastering engineering concepts (S. Mcloone, 2014) as well as computer programming (Ibrahim and Halim, 2013), however, there has been no research on the development of POPBL models to improve students' creativity. The results of the POPBL learning model are a project that is related to Science, Technology, Engineering and Mathematics (STEM). Therefore, the researchers tried to develop a POPBL learning model with STEM integration to improve students' creativity in learning science.

**II. METHOD**

The descriptive method was adopted to investigate the students' creativity through POPBL with STEM integration in learning science. Twenty-seven students divided into five groups were involved in this study. The study was conducted in the context of a science course on environmental pollution topics using a POPBL framework design implementation with STEM as the learning approach. This design consisted of three stages: 1) Onset stage: planning and preparing to learn about the topic and project related to environmental pollution problem 2) Execution stage: executing the project by discussion and sharing in the group, and redeveloping the project based on feedback from the teacher 3) Closure stage: evaluating students' projects to measure students' creativity.

This study used Creativity Product Analysis Matrix (CPAM) rubric which consists of three dimensions, novelty, resolution, and elaboration/synthesis (Besemer, 1998) to evaluate students' creative products systematically (K.C. Tsai, 2016). This rubric was validated by experts. Novelty assesses the originality of the product based on the concept and focuses on the original and germinal factor. Resolution measures the usefulness of the product, including functionality. It focuses on value, logic, and useful factors. Elaboration and synthesis refer to the aesthetic appeal of the product, including factors like elegance, complexity, understandability, and artistic factor.

**III. RESULTS AND DISCUSSION**

POPBL is one innovative learning model that can be used as an alternative teaching-learning strategy to enhance the curiosity of students and also their creativity. Creativity is the production of a novel and appropriate response, product, or solution in an open-ended assignment (Amabile, 2012). The end goal of the POPBL with STEM integration is for students to create group project related to a concept using STEM as a learning approach. The POPBL Framework design is divided into 3 stages: Onset Stage, Execution Phase, and Closure Stage (Ibrahim and Halim, 2013). After implementing the POPBL framework design implementation with STEM integration, students made a project titled "Simple Air Conditioner" in order to solve an environmental pollution case. The projects were analyzed with the CPAM rubric which assesses novelty, resolution, and elaboration/synthesis.

The results show that the percentage score for each dimension were 74%, 85%, and 78% for novelty, resolution, and elaboration/synthesis respectively (Table 1). Students' creativity in this POPBL with STEM integration example is good meanings that this learning model can affect the product creativity of students. POPBL is not only focused on solving the problem or issue but promote the creativity of students (Yasin, 2009). To understand the result in more detail, we investigated creativity measure for each student group in all three dimensions. Firstly novelty, group 1, 2, 4, and 5 had the same score of 67% while group 3

received a maximum score of 100%. For resolution, the scores were 89% (groups 2 and 5), 78% (group 1), 100% (group 3), and 67% (group 4). Finally, the result for elaboration and synthesis were 75% (groups 1, 2, and 4) and 83% (groups 3 and 5).

**Table 1.** Students' Creativity results using the CPAM Rubric

Dimensions	Group (%)					Average (%)
	1	2	3	4	5	
Novelty	67	67	100	67	67	74
Resolution	78	89	100	67	89	85
Elaboration and Synthesis	75	75	83	75	83	78
Total Average (%)	73.3	77	94.33	69.66	79.66	79

To confirm that POPBL with STEM integration affects student's creativity, the detailed description of students' creativity is needed (Table 2). Each group made a product related to an environmental pollution problem and the students gave a name to their product. The name of the products in student group order are Wahilen AC (Figure 1), Auto AC (Figure 2), Coll Filter Air (Figure 3), Cooling Air (Figure 4), and Pinky AC (Figure 5). The product creativity of the students was measured based on the CPAM rubric, separated for each dimension and indicator.

Novelty is defined as the originality of the created product. It is related to the newness of the product (Treffinger, 1981). This study included two of the four specific factors which are original and germinal. Resolution is measured by the extent to which the product matches or meets the needs of a problematic situation (Treffinger, 1981). For example, eco-friendly air conditioner as a product to solve an environmental pollution problem. There are 3 factors in the resolution dimension which are value, logic, and usefulness. Elaboration and synthesis assess the creativity of the product which is complexity, elegance, and artistic. Elaboration and synthesis extent to which the product combines different elements into a complete unit (Treffinger, 1981). The complexity factor measures the value and application of the products and consists of many elements at one or more levels, while elegant and artistic indicators measure the product physically.

Table 2. Description of Students' Creativity Product in Each Dimensions

Group	Picture	Novelty	Resolution	Elaboration and Synthesis
1	 <p>Figure 1. Wahilen AC</p>	<p>Design product has already based on problems but modification battery compartment comes from inspiration and uses large containers to maximize product work.</p>	<p>The product can complete the environmental objectives and under the concept. In addition, this product is useful as an alternative Air Conditioner because it can produce cooling air even though it is not a permanent solution.</p>	<p>The appearance of the product is good-looking. The product can be demonstrated and it has enough presentation because the production process clearly and it is effective for the result of the product. This product has a stable performance even though it still needs some reparation on the propeller part.</p>
2	 <p>Figure 2. Auto AC</p>	<p>Product design is based on problems and it also inspires other groups by modifies the place of the electrical circuit to make it easy to open the jar.</p>	<p>The product is succeeded in completing the objectives of this project and can be used in daily solutions because the performance of the product is stable, but it still needs development to make it perfect.</p>	<p>The product process follows all the steps orderly but it does not add the other materials as the way to develop the product. The product is explained with enough presentation because the cannot answer why they choose the big jar for this project.</p>
3	 <p>Figure 3. Cool Filter Air</p>	<p>Product design is really detail based on problem and own. Starting from the design of the project to choose the material for making the product. Design of product inspires the others to imitate it as an example.</p>	<p>The product can answer the environmental pollution problem, under the concept and clear procedure. In addition, this product can be implemented as the daily solution and also it has well functions and keep stable.</p>	<p>This group does not focus on elegant and artistic factor but focuses on how the product functions properly. They tried to make 3 propellers with different designs and materials. The propeller is examined to find the maximum wind production. This group also presents their projects clearly and can answer questions from other groups.</p>
4	 <p>Figure 4. Cooling Air</p>	<p>Product design is based on problem and modifies the example given by the teacher but still imitating, however the product use jars with longer shapes.</p>	<p>The product can solve the environmental problem but it had is not clearly procedure and cannot be implemented as a daily problem-solving.</p>	<p>This group considers an elegant indicator, so it results from an interesting product. However, this product does not function properly because the cable is not permanently installed.</p>

5	 <p data-bbox="408 459 598 481">Figure 5. Pinky AC</p>	<p data-bbox="646 159 853 369">The design of the product shows the modification by using cube-shape jars and also replace the content of the jars by using an ice cube and natural fragrance.</p>	<p data-bbox="885 159 1061 562">The product solves the problem of environmental pollution, and can be implemented but not applicable to daily solutions because the product the product use air fresheners to produce nice smell (unfriendly environmental solution).</p>	<p data-bbox="1093 159 1316 347">This product focuses on the good-looking aspect based on the elegant indicator, but it does not use the eco-friendly material and it can be presented clearly.</p>
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The description of the students' products above can show how students produce a product creatively through POPBL with STEM edintegration. POPBL is not only concerned with solutions to social problems but also stimulates students' creativity. The projects made by the students required the integration of science, technology, engineering, and mathematics to solve a problem. On the other hand, making product gave the students knowledge, and contributes to their long-life learning. POPBL is a more student-centered learning model that does not require students to just memorize science concepts (Yasin, 2009) but requires them to think creatively to solve the kinds problems they will find in daily life.

#### IV. CONCLUSION

Based on this study, it is concluded that POPBL with STEM integration can affect students' creativity in learning science. The overall students' creativity result showed 74% (Novelty), 85% (Resolution), and 81% (Elaboration/Synthesis). Firstly, group 3 got the highest score in terms of novelty dimension because they attended well to the product details, choosing of materials, and design. Secondly, while all groups made a valuable and useful product, most still needed to consider the environmental friendliness of their solution as related to the resolution dimension. Finally, the best products in terms of appearance was made by group 5, but they did not present the product clearly. The POPBL learning model integrates well with STEM as a learning approach to enhance students' creativity. This learning model can be used as one innovative learning model to increase other 21st-century skills in learning science.

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