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Effectiveness of PjBL-JAS-based Student Worksheets on Environmental Change Materials to Improve Students' Problem-Solving Ability and Creativity

Eryka Oktaviana, Sigit Saptono[1]✉, Aditya Marianti[2]✉, Sri Ngabekti[3]✉

[1]Master of Science Education, FMIPA, Universitas Negeri Semarang, Indonesia
[2]Biology Education, FMIPA, Universitas Negeri Semarang, Indonesia
[3]Environmental Science, FMIPA, Universitas Negeri Semarang, Indonesia

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Abstract

The change in curriculum to the Merdeka Curriculum provides a lot of changes in learning strategies, approaches, methods and models. Students need learning methods that can bring them to have the ability to be responsive to local, national and global issues and play an active role in providing problem-solving solutions. The purpose of this study was to test PjBL and JAS-based learning using student worksheets as learning tools. Students are asked to actively discuss, observe, explore and create a product. The N-Gain test results show that student worksheets are effective for improving students' problem solving skills and creativity. Problem solving ability and creativity of experimental class students are better when compared to control class students. The Mann-Whitney Test results show that there is a significant difference in value between the control class and the experimental class. Classical learning completeness of experimental class students was better than control class students. Therefore, student worksheets are very effective as a learning tool and as a tool to help improve students' problem-solving skills and creativity.

✉ Correspondence Address:
D6 Building 1st Floor Jl Raya Sekaran Gunungpati Semarang
E-mail: eryka.oktaviana@students.unnes.ac.id

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INTRODUCTION

Indonesia has experienced significant changes and improvements to its learning system in the last two years (Pamungkas & Sukarman, 2020). These changes include the implementation of a new curriculum, the use of technology in the classroom and inclusive education (Ndari *et al*., 2023; Putri *et al*., 2022; Wulandari *et al*., 2020). The curriculum change to the Merdeka Curriculum is one of the important changes in the learning system in Indonesia (Ferdaus & Novita, 2023). The implementation of Merdeka Curriculum in schools has been in effect since early 2020 and has faced several obstacles, but this curriculum is still seen as an appropriate and feasible approach to education in Indonesia today (Agustin & Sugiyono, 2019; Aji, 2023; Lembong *et al*., 2023).

Based on Keputusan Kepala Badan Standar, Kurikulum, Dan Asesmen Pendidikan Kemendikbud Ristek Nomor 033/H/KR/2022 (2022), at the end of phase E of grade X (ten), students are expected to have the ability to local, national and global issues and play an active role in providing problem-solving solutions. One of the materials that must be studied by grade X students is Environmental Change material. The purpose of students learning this material is so that students can know the reciprocal relationship between humans and the environment and how a balanced environment is important for human survival (Gede, 2023). Environmental change material is very complex and very broadly abstract, which is why this material is difficult for students to understand (Ural & Dadli, 2020). The difficulty in understanding the problem coupled with the unsupported learning media, learning models and appropriate teaching tools will affect student learning outcomes and abilities.

Studying biology in high school is important as it provides a basic understanding of the life sciences, where this knowledge can be directly applied to real-world issues, such as environmental problems, and allows students to develop problem-solving skills (Fauzi & Mitalistiani, 2018; Kurniati & Ahda, 2019). According to Holstermann *et al*., (2010), Ideal biology learning focuses on developing problem-solving skills and creativity, which can be achieved through a combination of hands-on experimental activities, critical and creative thinking exercises and collaborative group projects. The demands of the 21st century require students to develop critical thinking, communication, collaboration and creativity skills (Juanda *et al*., 2021; Mulyana & Sumarmin, 2019). With this demand, teachers must provide a pleasant learning atmosphere and experience so that it can support the improvement of students' problem solving skills and creativity.

In an independent curriculum, a teaching tool is needed that can implement the dimensions located in the curriculum itself and the teaching material is expected to support students in learning activities and achieving the objectives of learning activities. According to Depdiknas (2006) in Jowita, (2017), Student Worksheets are sheets containing tasks that must be done by students which contain work instructions, steps to complete a task and the task itself. Student worksheets serve to help students become more independent to understand the material and practice to develop their skills (Pratiwi & Indrayani, 2023). Biology learning, especially on environmental change material, requires direct learning resources so that students can gain new experiences and can learn independently to solve problems and increase their creativity. Therefore, the Project-based Learning (PjBL) model and the Jelajah Alam Sekitar (JAS) approach are a suitable combination to help improve students' problem-solving skills and creativity.

The PjBL model is a learning model that makes students the subject or center of learning, emphasizing the learning process that has the final result in the form of a product in other words students are given the freedom to determine their own learning activities, work on learning projects collaboratively until the results are obtained in the form of a product (Jowita, 2017). The JAS approach is defined as a learning approach that utilizes the natural environment around students' lives (real world environment) as a biology learning object and its phenomena are studied through scientific work that allows them to explore, identify problems, and propose useful solutions to improve students' problem solving skills (Alimah & Marianti, 2016; Nurhafifah *et al*., 2021; Sulistiyo *et al*., 2021).

Based on the results of interviews and observations that have been made, biology learning that takes place at SMA Negeri 1 Ungaran still dominantly uses the lecture method, the use of textbooks and

working on questions in the textbook. The level of students' problem-solving ability and creativity is currently quite good but still needs to be improved. In addition, students mentioned that they like learning outside the classroom and in the form of discussions. They feel that it is more memorable, less boring and they will get a more meaningful experience. One way to effectively improve students' problem-solving ability and creativity is to provide open-ended projects and activities in real-life scenarios that require students to think critically and come up with innovative solutions (Artika *et al*., 2023; Erawati & Permana, 2020; Middleton, 2009). Based on the background of the above problems, it is necessary to test the effectiveness of PjBL and JAS-based student worksheets on environmental change material with the aim of improving problem solving skills and creativity.

RESEARCH METHOD

The research was conducted at SMA Negeri 1 Ungaran from April to May 2025 in the second semester of the 2024/2025 academic year. The population of this study were all students of class X SMA Negeri 1 Ungaran consisting of 4 classes, namely class X-12 as the control class and classes X-9, X-10 and X-11 as the experimental class with consideration of the number of students as more than 100 students and teachers who teach in the same class. This study used a pre-experimental design with a one-group pre-test-post-test design as follows.

Figure 1. Research design

Description:

O_1 : Initial test before treatment

X : Giving treatment to the experimental group, namely by applying project-based learning with the help of PjBL-JAS-based Environmental Change worksheets.

O_2 : Final test after treatment

If the post-test value increases significantly compared to the pre-test value, then the PjBL-JAS-based student worksheet is effective for improving students' problem-solving skills and creativity. Data collection techniques used PjBL-JAS-based student worksheets on Environmental Change material, product and video assessment sheets, as well as pre-test and post-test questions. The questions used were in the form of multiple choice as many as 15 questions and descriptions as many as 10 questions. Test questions and student worksheets are used to measure the level of problem-solving ability and student creativity. The data obtained was then analyzed using a formula based on the standard Criteria for Achievement of Learning Objectives (KKTP). The KKTP value threshold used in SMA Negeri 1 Ungaran for biology subjects is 75. Data analysis that will be used includes Normalized gain (N-Gain) test, descriptive analysis of students' problem-solving ability and creativity, prerequisite tests which include normality test and homogeneity test and Mann-Whitney test.

RESULT AND DISCUSSION

This study aims to analyze the effectiveness of PjBL-JAS-based student worksheets on environmental change material on problem solving skills and student creativity. The effectiveness of a student worksheet product can be known based on the analysis of Pre-test and Post-test results using the N-Gain formula and the analysis of project task assessment. The pre-test, post-test and project task scores were obtained from the class used as the experimental class at the implementation stage. The experimental

classes used amounted to three classes with a total of 108 students and one control class with 36 students.

Normalized Gain Test

The Normalized gain test or N-gain score aims to determine the effectiveness of the use of a particular method or treatment in research by calculating the difference between the pre-test value and the post-test value (Anonim, 2021; Widayanti *et al.*, 2016). The N-Gain test is used to measure the effectiveness of students' problem-solving skills and creativity through pre-test and post-test scores. The N-Gain Test formula used is as follows.

$$\langle g \rangle = \frac{\langle S_{post} \rangle - \langle S_{pre} \rangle}{maximum\ score - \langle S_{pre} \rangle}$$

Description:
<g> : normalized gain score
S_{pre} : pre-test mean score
S_{post} : post-test mean score

The interpretation of the magnitude of the g factor score is categorized in Table 1.

Table 1. N-Gain Factor Score Interpretation

Factor <g>	Criteria
0,70 ≤ g ≤ 1,00	High
0,30 ≤ g ≤ 0,69	Medium
0,00 ≤ g ≤ 0,29	Low

The results of the N - Gain test are presented in Table 2 as follows.

Tabel 2. N - Gain Test Results

Class	Average Score					Category
	Pre-test	Post-test	Post-test – Pre-test	Ideal – Pre-test	N-Gain	
Control	43	64	21	57	0,37	Medium
Experiment	46	85	39	54	0,73	High

The average pre-test scores of control class and experimental class students did not show significant differences, which were 43 for the control class and 46 for the experimental class (Table 2). This shows that students from both classes have a relatively similar level of understanding of environmental change material at the beginning of learning. The relationship between the results of the Pre-test score and the initial condition of students' understanding of a subject matter can be caused by several factors, such as the lack of students' prior knowledge or their lack of knowledge about environmental change material, the material in the Pre-test questions that are too difficult and complex for students to understand, and the lack of preparation of students to work on pres-test questions (Adri, 2020; Anonim, 2016; Berry, 2008).

In contrast, the average Post-test score between control and experimental class students showed a significant difference, namely 64 for the control class and 85 for the experimental class. This shows that control class students did not experience a significant increase in understanding. In contrast to experimental class students who have increased understanding after intervention or treatment. The interventions or treatments provided include the use of a project-based learning model integrated with a nature exploration approach and the use of PjBL-JAS-based Student Worksheets on environmental change material.

The N-Gain test results of the control class and experimental class (Table 2) show that the N-Gain score of the control class is 0.37 with a medium category and the N-Gain score of the experimental class is 0.73 with a high category. The difference in the N-Gain scores of the two classes indicates that there is a significant difference in students' understanding of environmental change material. This difference shows that the addition of treatment in the experimental class has a significant good impact. The control class used conventional learning methods or lectures and problem solving, while in the experimental class there

was additional treatment. The experimental class received intervention or treatment using a project-based learning model and a nature exploration approach and the provision of PjBL-JAS-based Student Worksheets that encourage students to learn directly in the environment around Semarang Regency as their learning resource. In other words, the use of PjBL-JAS-based Student Worksheets is effective for improving students' problem-solving skills and creativity.

Problem Solving Ability and Student Creativity Assessment

Assessment of students' creativity problem-solving ability is measured through students' post-test scores. This assessment was conducted in the control class and experimental class to observe students' problem solving ability and creativity after learning activities. The results of the assessment of students' problem-solving ability and creativity between the Control class and the Experimental class are presented in Table 3. as follows.

Table 3. Results of Problem-Solving Ability and Student Creativity Assessment

Aspects	Pre-test		Post-test	
	Control	Experiment	Control	Experiment
Problem Solving	44	44	65	76
Creativity	45	45	69	84

The analysis was also conducted to determine whether or not there was an increase in students' problem-solving ability and creativity in the control class and experimental class. Comparison of the results of the assessment of students' problem-solving ability and creativity (Table 3) shows that the initial ability of students from both groups is the same. This is evidenced by the results of the pre-test conducted by showing the value of students' problem-solving ability of 44 (quite good) and the value of students' creativity of 45 (quite good). Students are considered to have the same knowledge about environmental change material and the ability to analyze problem solving and creativity that has not been maximized.

The results of the assessment of students' problem-solving ability and creativity at the end of learning did not experience a significant increase in the control class. The score obtained was 65% (good) for problem solving ability and 69% (good) for student creativity. This shows that students experience insignificant improvement because the learning used is still conventional and students' knowledge is only limited to what is conveyed by the teacher so that the learning atmosphere becomes monotonous and boring.

In contrast to the experimental class which experienced a significant increase in value. The value obtained was 76% (good) for problem solving skills and 84% (very good) for student creativity. This shows that the effect of giving treatment in the form of using PjBL-JAS-based Student Worksheets is very effective for improving students' problem-solving skills and creativity. Learning is not only done in one direction, but two directions, namely students learn independently and directly in the environment around them. They are taught to get to know their environment, then analyze the environmental problems that occur there and after that students are asked to create a creative product as a solution to overcome the environmental problems they find.

Students' problem-solving skills can grow and continue to improve if supported by the right environment and learning. Students are also trained to solve problems through activities and problems in the student worksheet. Various forms of questions in the evaluation questions such as narrative, pictures, tables and graphs are presented to train students' problem-solving skills. The increase in student creativity is seen from how they produce and produce a video and creative products and how they answer the questions presented in the evaluation questions. Making a video requires a great level of creativity and imagination to produce an interesting video. A good video has a composition between audio and visual that is harmonious and can convey information to the audience. The selection and creation of creative products also requires high creative thinking skills. This ability is needed so that the products made can be

useful, have aesthetic value, functional value and economic value so that they can support sustainable life goals.

The analysis of students' problem-solving ability and creativity was carried out by descriptive analysis using students' post-test scores. The post-test questions used contained all aspects or indicators of students' problem-solving ability and creativity, except for the aspect of high curiosity in the creativity assessment. Based on the graph of the level of problem-solving ability of control class and experimental class students (Figure 2), the aspect of understanding the problem and the aspect of planning a solution in experimental class students have higher abilities (score 84, very good category) when compared to the control class (score 24, poor category). Students in the experimental class were better able to understand and analyze problems quickly and were able to plan solutions in the most effective and innovative way. While students in the control class have not been able to understand and analyze a problem quickly, at least students need more than 60 minutes to understand and analyze the problem and plan for solving the problem.

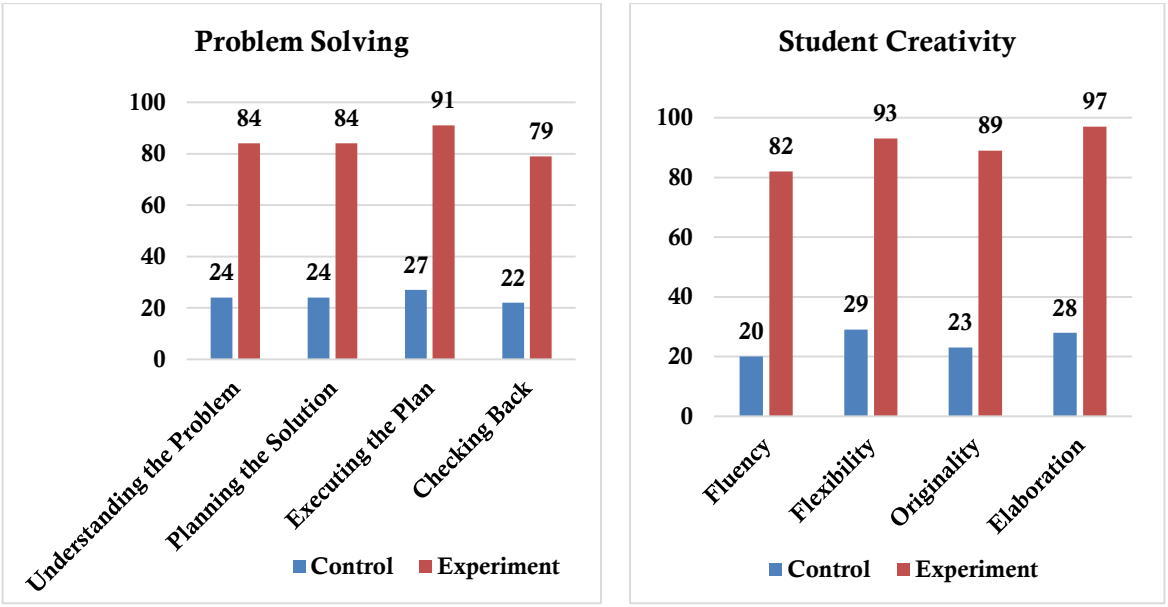

Figure 2. Comparison Chart of Levels of Problem-Solving Ability and Creativity in Control Class Students and Experimental Class Students

In the aspect of implementing the plan, experimental class students also had a higher ability (score 91, very good category) when compared to the control class (score 27, poor category). Experimental class students were able to carry out plans such as using the steps of making products and applying a relevant concept or theory, while control class students were only able to write down the steps and theories used (not applying them). In the aspect of checking back, control class students scored 22 (poor category) and the experimental class scored 79 (good category). Most of the experimental class students re-examined the work that had been done, whether it was as expected (plan) or not. In contrast to the control class students who only did and did not check back their work, so many results were not in accordance with the plans and theories that had been written before.

Based on the graph of the creativity level of control and experimental class students (Figure 2), experimental class students with a score of 82 (very good category) in the aspect of fluency thinking are able to generate many ideas or solutions and alternative answers more when compared to the control class with a score of 20 (not good category). This means that control class students were unable to provide many ideas/solutions and alternative answers to the problems presented so that the answers given were general answers. In the aspect of flexible thinking (flexibility), experimental class students scored 93 (excellent

category) and control class students scored 29 (unfavorable category). This explains that control class students have a deficiency in seeing a problem from various points of view and choosing an appropriate solution strategy even with different situations, while experimental class students have the ability to see problems from various points of view and determine excellent problem-solving strategies.

Table 4. Results of Normality Test and Homogeneity Test

Score	Class	df	Normality Test		Homogeneity Test	
			Sig.	Category	Sig.	Category
Pre-test	Control	36	.064	Normal	.000	Not homogeneous
	Experiment	108	.071	Normal		
Post-test	Control	36	.000	Not normal	.000	Not homogeneous
	Experiment	108	.002	Not normal		
Creative Products	Experiment	108	.000	Not normal	.198	Homogeneous
Video Assignments	Experiment	108	.000	Not normal	.283	Homogeneous
Problem Solving	Experiment	108	.000	Not normal	.012	Not homogeneous
Student Creativity	Experiment	108	.032	Not normal	.095	Homogeneous

In the originality aspect, experimental class students with a score of 89 (very good category) were able to generate more unique (unusual) and innovative ideas as a solution to overcome the environmental problems presented, while control class students with a score of 23 (not good) were identified as not being able to generate unique and innovative ideas or tended to use existing ideas. In the elaboration aspect, experimental class students with a score of 97 (very good category) were able to develop ideas and refine concepts by adding relevant information from various sources. Unlike the control class students with a score of 28 (poor category) who have not been able to develop ideas and refine the concepts they make with relevant information because most of the information they use comes from one source only. This result shows that the PjBL-JAS-based Student Worksheet on environmental change material can facilitate students in finding and developing deeper, more unique and more innovative ideas. These results indicate that the use of PjBL-JAS-based Student Worksheets on environmental change materials is very influential in improving students' problem-solving skills and creativity.

Prerequisite Tests of Normality and Homogeneity

The normality test is one of the tests used to determine whether the data distribution is normally distributed or not (Sintia *et al*., 2022). The Kolmogorov-Smirnov Normality Test is used to test normality in a large number of samples (>100). The basis for decision making in the normality test is if the significance value (Sig)> 0.05 then the data distribution meets the assumption of normality, while if the significance value (Sig) <0.05 then the data distribution does not meet the assumption of normality. Most of the normality test results (Table 4) show a value of 0.000, so the data does not fulfill the assumption of normality.

The homogeneity test is a statistical test procedure that aims to show that two or more groups of data samples are taken from populations that have the same variance (Sianturi, 2022). The basis for decision making in the homogeneity test is if the significance value (Sig) > 0.05 then it is stated that the variance of the two or more population groups of data is the same (homogeneous), while if the significance value (Sig) < 0.05 then it is stated that the variance of the two or more population groups of data is not the same (not homogeneous).

Based on the results of the homogeneity test of experimental class student data (Table 4) shows that the value of creative products with a value of Sig. 0.198 > 0.05 and the value of the video assignment with a value of Sig. 0.283 > 0.05 so that the homogeneity assumption is met. The value of student problem solving with Sig. 0.012 < 0.05 so that the assumption of homogeneity is not met, while for the value of student creativity with a Sig value. 0.095 > 0.05 so that the assumption of homogeneity is not met. Based

on the results of the homogeneity test for the value of creative products, video assignments, problem solving skills and student creativity (Table 4), the data does not meet the assumption of homogeneity. Thus, based on the results that have been obtained, all data are declared not to meet the assumption of data homogeneity.

Mann-Whitney Test Results

The Mann-Whitney test is a non-parametric statistical test that serves as an alternative to the T test when the assumption of normality is not met (Segura-Robles & Parra-González, 2019). The basis for decision making in this Mann-Whitney test is seen from the results of Asym. Sig. (2-tailed) with the interpretation if the Asym. Sig. <0.05, it is stated that there is a significant difference between the two paired sample groups, while if the Asym. Sig. > 0.05 then it is stated that there is no significant difference between the two paired sample groups. The Mann-Whitney test results show that the Asymp. Sig. (2-tailed) with a value of 0.000 <0.05 so that it can be said that there is a significant difference in problem solving ability and student creativity between control class students and experimental class students. The existence of this significant difference indicates that there is an effect of using PjBL-JAS-based Student Worksheets on Environmental Change Material on students' problem-solving ability and creativity.

Classical Learning Completeness

Classical learning completeness is used to know the overall learning completeness. The data collection technique used PjBL-JAS-based Environmental Change LKPD and evaluation questions (Pre-test and Post-test). The data used are post-test scores (40% weight), task 1 scores (30% weight) and task 2 (30% weight) for the control class. For the experimental class using post-test scores (40% weight), video task scores (30% weight) and product tasks (30% weight).

CONCLUSION

Based on the results of the product effectiveness test PjBL-JAS-based student worksheets are declared effective in improving students' problem solving skills and creativity based on the N-Gain test. The results of the Mann-Whitney test analysis show that there are significant differences in problem solving ability and student creativity between control class students and experimental class students. PjBL-JAS-based student worksheets on environmental change material are very effective to use as learning tools as evidenced by the number of students who have scores above the KKTP limit.

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