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Project Based Learning Assisted by E-Worksheet Effect on Creative Thinking Ability on Renewable Energy Topic

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Abstract. The study aims to determine the effect of physics learning using the Project Based Learning (PjBL) model assisted by E-LKPD based on Live Worksheet on the creative thinking ability of grade X students and how much influence physics learning with project-based learning model assisted by E-LKPD based on live worksheet on the creative thinking ability of grade X students. The research was conducted with a quasi-experiment design involving experimental and control classes. The results showed the average posttest of the experimental class of 66 was higher than the control class of 64.85. The Independent Sample t-Test test resulted in a t value of 4.745 and Sig. (2-tailed) < 0.001, indicating a significant difference in science understanding. Students' creative thinking skills also improved significantly with a t value of 4.745 and Sig. (2-tailed) < 0.001. The result of the effect size is 1.05, which shows that there is a significant increase in the creative thinking skills of students who use the PjBL model assisted by E-LKPD based on Live Worksheet, with the average posttest value of the experimental class higher than the control class. The application of the PjBL model involving E-LKPD based on live worksheets is proven to be effective in increasing student creativity.

Keywords: project based learning, E-LKPD, creative thinking, live worksheet

1. Introduction

The changes and developments of the 21st century help improve the quality of education in the digital era. One of the challenges of 21st century education is preparing students to compete with the creative thinking world of work. The abilities needed by 21st century students are 4C (Critical Thinking, Creativity, Collaboration, Communication) [1]. Physics is based on hypotheses, research, experiments, and the development of thinking for the development of creativity. Creativity is demanding a person's ability to give birth to new things, both in the form of ideas and works, all of which are different from before. For this reason, learning carried out on physics material should be to improve students' creative thinking skills. Because creative thinking can make it possible to study problems systematically, formulate innovative questions, and design a variety of original solutions. In line with this, physics is one of the important subjects at various levels of education, so it is natural that physics subjects are developed and considered by all educational actors [2].

Creative thinking skills have become one of the main goals of education and teachers are striving to achieve it through various teaching methods. Lack of practice in creative thinking can result in limitations in the thinking process and poor problem-solving skills. Students tend to rely on memorization in solving problems showing their poor creative thinking skills. Improving creative thinking skills is important in helping students generate ideas from various perspectives that can be developed as problem-solving solutions. Students with creative thinking skills will find it easier to find solutions by connecting the concepts they have mastered. In the context of physics learning, many students face significant difficulties that often lead to low creative thinking skills [3]. physics learning by utilizing technology such as live worksheets can help make it easier for teachers to guide students, and also save paper because it can be filled directly on the live worksheet. E-LKPD based on live worksheet is used in physics learning so that it can help improve students' creative thinking skills [4]. Creative thinking is one of the stages of higher order thinking needed in learning because in today's

curriculum students are always faced with problems so that creativity is needed to solve these problems [5]. Some indicators of student difficulties are prior knowledge, material profile, misconceptions, and problem solving. The initial knowledge of each student must be found in a different way, which is called differentiated learning. Differentiated learning is one of the learning strategies in the Merdeka curriculum because the principle that liberates students is the learning process [6].

Live worksheet is a website platform that allows teachers to utilize the E-LKPD that has been provided or create their own interactive E-LKPD online. Live Worksheets is a unique platform that can be used like a website to create interactive worksheets online. The use of live worksheets in making LKPD is also very beneficial because the LKPD that is prepared is very interactive and easy to use by students [7]. Live worksheet-based LKPD can make the subject matter more interesting and concrete. The usefulness of the LKPD can be equipped with pictures and learning videos in addition to the description of learning media. Interactive learning has a positive impact on student learning outcomes. Live worksheet-based interactive LKPD is more effective because it is equipped with interactive features that can make students' interest in learning increase [8]. E-LKPD based on live worksheet is a new electronic learning system in the learning process that is supported through the web. Students can access it at home and can study anywhere, all activities are carried out online and class implementation is not carried out directly. Pjbl-Based Learning Provides the role of the teacher as a facilitator can help students in developing abilities and utilizing various technological advances in education. Project-based learning activities assisted by live worksheet-based E-LKPD can help students create their own problems and find their own solutions. Students are expected to investigate, evaluate, analyze, and collect data.

The PjBL model is a learning model that uses projects as the core of learning. The PjBL model is an innovative learning model that involves project work, students work independently in developing and completing real product learning with demands for independence in student learning. Project-based learning is characterized by the process of designing to produce a product in the activity and students learn many skills from this project-based learning [9]. The PjBL model is an appropriate learning model for modern educational goals because it focuses on learner activities and makes students active, creative, and involved in the learning process [10]. The PjBL model is a teaching approach that encourages students to use their imagination, participate in presentations, and see student work firsthand [11]. Constructivistic theory underpins project-based learning, which gives students many opportunities to create an active learning environment. The PjBL model exposes the learning process through project activities and helps the cognitive memory retention process to be more permanent, if students are involved in problem-solving and decision-making activities. In project-based learning, students are asked to solve problems that are difficult to answer. The PjBL model focuses on problems that allow learners to connect concepts and involve learners to do problem solving with constructivist, realistic, and independent [12]. The PjBL model is a teaching and learning strategy that involves students to work on a project that is useful for solving community or environmental problems. The focus of project learning lies on the core concepts and principles of a discipline of study. Students conduct problem-solving investigations and meaningful task activities, autonomously construct their own knowledge, and culminate in producing real products [12]. The objectives of the PjBL model are: 1. New knowledge and skills in the learning process. 2. Improve students' ability to solve problems. 3. Increase student involvement in solving complex problems to produce real products. 4. Improve students' skills in identifying and managing problem sources, materials, tools needed to complete a project. 5. Improve student collaboration in groups [13].

Based on the results of interviews, teachers at SMAN 3 Bengkulu Tengah began implementing the Merdeka Curriculum in 2021. In the Merdeka Curriculum, class X physics material includes three learning chapters, namely chapter one the nature of physics, quantities, and measurements, chapter two energy sources and chapter three global warming symptoms. In this study examining chapter two, namely energy sources, the cp fragments used are Students are able to describe natural phenomena within the scope of creative thinking skills, students are able to optimize the potential of using tools to make observations, students are able to question and describe the results of observations, students

identify the background of the problem formulate goals and use references in designing investigations, students will prepare appropriate equipment in observations, students are able to use the results of data analysis to create solution ideas, students dare to ask questions and argue and students present the results of the assignments given. The objectives in learning activities are to identify types of energy and describe energy changes that occur in everyday life, analyze energy source problems and impacts in the lives of modern society, identify and describe alternative energy sources and analyze energy transformation in technological products. Furthermore, the indicators of its achievement are identifying the forms of energy involved in the application in everyday life, finding energy availability problems in the surrounding environment, finding potential energy sources in the surrounding environment, and designing simple energy-producing tools or prototypes as a solution to energy availability problems. The learning media that are often used by teachers at SMAN 3 Bengkulu Tengah are ICT learning media such as youtube, powerpoint, and learning videos developed by teachers. However, the Learner Worksheet (LKPD) used by students is LKPD obtained from publishers in printed form, LKPD developed by the teacher himself. The rapid development of technology makes the education process change so that teachers are required to be able to keep up with the development of learning technology. Learning with the hybrid learning method is one of the lessons applied to learning technology. in the LKPD which now still uses a lot of printed LKPDs, E-LKPD based on live worksheets will be applied to adapt to the times [14].

Based on the description above, the purpose of this study is to investigate: a. Knowing the effect of physics learning with project-based learning model assisted by E-LKPD based on live worksheet on the creative thinking ability of class X students, b. How big is the effect of physics learning with project-based learning model assisted by E-LKPD based on live worksheet on the creative thinking ability of class X students.

2. Methods

This study used a quantitative approach and used a Quasi research design This study used quantitative research methodology, and the type of research was quasi-experimental with a pretest-posttest non-equivalent control group design (Figure 1) because the experimental group and control group were not randomly determined.

Experiment	O_1	X	O_2
Control	O_3		O_4

Figure 1. Non-equivalent control group design [15]. X-Classes treated with PjBL model assisted by E-LKPD based on live worksheet. O_1 and O_3 are Pretest given to experimental and control classes. O_2 and O_4 are Posttest given to experimental and control classes.

The research was conducted at SMA Negeri 3 Bengkulu Tengah with the address of pasar pedati village, pondok kelapa sub-district, bengkulu tengah district, bengkulu province. The research took place from July to November 2024 of the 2024/2025 academic year. The study population was class X students totaling 336 students. According to Sugiyono [15] the research sample was determined by convenience sampling technique, so that the determination of the experimental and control groups as research subjects based on considerations (a) easy access to the school by the principal, and (b) the willingness of physics teachers and grade X students to participate in this study. In this study using students of class X_{10} as an experimental class with 30 students and class X_6 as a control class with 30 students.

Learning activities in the experimental and control groups applied project-based learning (PjBL) but students in the experimental group used live worksheet-based E-LKPD developed by the researcher while students in the control group used printed E-LKPD provided by the school. The research problem is whether physics learning with PjBL assisted by E-LKPD based on live worksheet affects the creative thinking ability of class X students. Thus, the independent variable (treatment variable) of the research is physics learning assisted by E-LKPD based on live worksheet, and the dependent variable is creative thinking ability. Thus, the research hypothesis H_0 tested in the study is H_0 = There is no statistically

significant difference between the average score of class X_{10} students who carry out PjBL model learning assisted by E-LKPD based on live worksheet with the average score of class X_6 students without the help of E-LKPD based on live worksheet.

Hypothesis testing was tested using an independent-t test because the data of the two groups were independent of each other to compare the means of the two groups [16]. Equation (1) and equation (2) are used to prove whether the null hypothesis is rejected or accepted.

$$d = \frac{\bar{X}_1 - \bar{X}_2}{S_{gab}} \tag{1}$$

and,

$$S_{gab} = \sqrt{\frac{(n_1-1)S_1^2+(n_2-1)S_2^2}{n_1+n_2-2}} \tag{2}$$

where d = Effect size value, S_{gab} = Standard deviation of the two groups, $\bar{X}_1$ = Skor rata-rata kelompok eksperimen, $\bar{X}_2$= Mean score of control group, n_1 = Number of samples of the experimental group, n_2 = Number of samples of the control group, S_1^2 = Experimental group variance, S_2^2 = control group variance.

T-test is a hypothesis test that aims to see the comparison of the two samples. The T test is used to analyze the data and find out whether the results are in accordance with the expected hypothesis. . The formula used to test hypotheses about differences in two or more populations where each sample group is independent of another sample group is shown in equation (3) and equation (4) [17].

$$t = \frac{\bar{x}_1 - \bar{x}_2}{S_{gab}\sqrt{\left(\frac{1}{n_1}+\frac{1}{n_2}\right)}} \tag{3}$$

and,

$$S_{gab} = \sqrt{\frac{(n_1-1)s_1^2+(n_1-1)S_2^2}{n_1+n_2+2}} \tag{4}$$

where t = Calculated t value, $\bar{x}_1$ = The calculated mean value of the experimental group data, $\bar{x}_2$ = Mean value of control group data, n_1 = Number of experimental group students, n_2 = Number of control group students, S_{gab} = Book deviations of the two groups, s_1^2 = Experimental group data variance, s_2^2 = Control group data variance.

The stages in the learning process with the PjBL model assisted by E-LKPD live worksheet is shown in Figure 2.

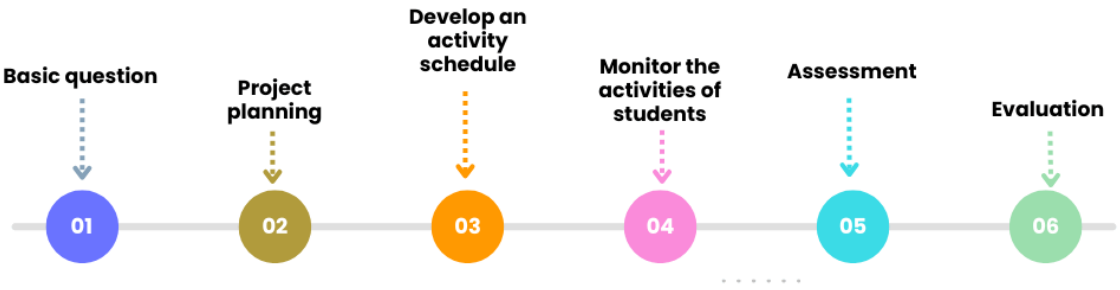

Figure 2. Implementation of learning with the PjBL model assisted by E-LKPD live worksheet.

Based on Figure 2, the implementation of learning with the PjBL model assisted by E-LKPD live worksheet is carried out in six stages as follows: (1) the first step is the basic question, at this stage the teacher delivers renewable energy material in accordance with the teaching module and PjBL syntax. In the first problem, a news video is shown about non-renewable energy in the future. where the questions

that arise in the video are what is an energy source? What is non-renewable energy? What if fossil energy runs out or is eliminated? Then students answer these questions with their respective opinions and arguments. Then the teacher presents renewable energy related material as an alternative energy source if fossil energy runs out in the future. (2) the second step is project planning, at this stage the teacher tells the students that they will make a project of a miniature renewable energy power plant. The teacher forms students into 4 groups, each group choosing what miniature renewable energy power plant project they want to make. (3) The third step is to develop an activity schedule, at this stage students and teachers discuss to create and organize a schedule of activities that will be carried out during the activity. (4) The fourth step is to monitor the activities of students, at this stage the teacher goes around to see the work of each group in making projects and if there are groups that have difficulties, the teacher and the group will solve problems together in the project work. (5) The fifth step is assessment, at this stage students will make presentations on the projects that their groups have made and the teacher assesses the results of the presentations and projects. (6) The last step is evaluation, at this stage the teacher again gives a brief explanation of renewable energy and gives students the opportunity to have an opinion about this learning process.

3. Results and Discussion

This study aims to determine the effect of physics learning with the PjBL model assisted by E-LKPD based on live worksheet on creative thinking skills on renewable energy material at SMAN 3 Bengkulu Tengah. Data collected in the form of per-test and post-test for creative thinking skills, this test is an essay question. After applying and seeing the results of the effect of physics learning with the PjBL model assisted by E-LKPD based on live worksheets on creative thinking skills, an analysis was carried out to prove the first hypothesis in this study. Learning outcomes and descriptive statistical analysis as in Table 1.

Table 1. Descriptive statistical analysis.

	N	Minimum	Maximum	Mean	Mean Difference	Std. Deviation
Post-Test Experimental	30	62	88	70.33	2.70	7.347
Post-Test control	30	55	78	67.63	2.70	6.424
Pre-Test Experimental	30	3	28	12.23	1.57	8.323
Pre-Test control	30	3	28	13.80	1.57	5.720
Listwise N	30					

Based on IBM SPSS Statistics 27 software for windows, there are descriptive statistical analysis results which include N or the amount of data, minimum value, maximum value, average value (mean), and standard deviation. From the above results, it shows that there is an effect of physics learning with the PjBL model assisted by E-LKPD based on live worksheet seen from the experimental class which has a significant increase in creative thinking skills compared to the control class. In the experimental class pretest, student scores were between 3 to 28 with an average of 12.23 and the standard deviation was 7.347, which shows that the initial ability of students can be said to be low before being given treatment. After being given the PJBL treatment assisted by live worksheet-based E-LKPD in the experimental class, the students' posttest scores increased to around 62 to 88 with an average of 70.33 and a standard deviation of 6.424.

In the control class pretest, the students' scores were between 3 and 28 with an average of 13.80 and the standard deviation was 8.323, which showed that the students' initial ability could be said to be low. After the learning was applied to the control class, the students' posttest scores increased to between 55 and 79 with an average of 67.63 and the standard deviation was 5.72. The average obtained in the control class is lower than the experimental class, this shows that the learning model and learning media are very important to have a positive influence.

The increase in the average score of the experimental class is greater than that of the control class. This indicates that providing more meaningful learning experiences through project-based learning assisted by E-LKPD (Electronic Student Worksheets) based on live worksheets can enhance students'

creative thinking skills more effectively. Observing the standard deviation, the post-test standard deviation of the control class is lower than that of the experimental class. After conducting descriptive statistical analysis, a normality test was performed to determine whether the data were taken from a normal population or followed a normal distribution, which is an absolute requirement before performing hypothesis testing [18]. The results of the normality test conducted on the pre-test and post-test data of the students are presented in Table 2.

Table 2. Normality test.

Groups (Class)	Test	Shopiro-Wilk	
		Statistic	Sig
Experimental	Pre-Test	0.932	0.055
(X_{10})	Post-Test	0.932	0.055
control	Pre-Test	0.916	0.021
(X_6)	Post-Test	0.987	0.962

Based on the output of the normality test above, it is known that the significance value (sig) for all data in the Shapiro-Wilk test is >0.05, Thus, it can be stated that all data meet the requirements, and it can be concluded that the research data are normally distributed. Next, a homogeneity test will be conducted to determine whether two or more sample data groups come from populations with the same variance and to assess whether the data are homogeneous (similar) or heterogeneous (different). This homogeneity test also aims to determine whether the post-test variances of the experimental class and control class are homogeneous. The results of the homogeneity test conducted on the students' pre-test and post-test data are presented in Table 3.

Table 3. Homogeneity Test

	Levene Statistic	df1	df2	Sig.
Based on Mean	0.44	1	58	0.51
Based on Median	0.30	1	58	0.58
Based on Median and With adjusted df	0.30	1	56.82	0.58
Based on trimmed mean	0.36	1	58	0.55

Based on the output of the homogeneity test using IBM SPSS Statistics 27 for Windows, the significance values obtained were as follows: based on mean is 0.51, based on median is 0.58, based on median and with adjusted df is 0.58, and based on trimmed mean is 0.55. Therefore, the result based on the mean is 0.51 > 0.05, which indicates that $F_{calculated} < F_{table}$, indicating that the data aligns with Sugiyono's [14] statement regarding the hypothesis in the homogeneity test. According to this statement, the null hypothesis (H_α) is compared with (H_0) ata with non-homogeneous variances The basis for decision-making is that if $F_{calculated} < F_{table}$ at a significance leve (a) of 5% thus H_0 is accepted and H_α is rejected. Following this, a T-test will be conducted to compare the two samples and analyze the data to determine whether the results align with the expected hypothesis [17]. The T-test performed on the post-test data of the experimental and control classes is presented in Table 4.

Table 4. Independent samples t-test.

	T	Df	Sig. (2-tailed)	Std. Error Difference	Lower	T table	Cohen's Effect size *
Equal variances assumed	4.745	66	< 0.001	1.57	0.07	3.3	1.05
Equal variances not assumed	4.745	64.85	< 0.001	1.57	0.07	3.24	1.05

Interpretation of Cohen's Effect Size: If 0.8 ≤ d ≥ 2.0, the effect is considered large; if 0.5 ≤ d < 0.8, the effect is moderate; and if 0.2 ≤ d < 0.5, the effect is small [18]. Based on the output of the T-test above, the obtained Sig. (2-tailed) value is < 0.001. This matches the criteria for the T-test, where if the

Sig. value is < 0.05, then H_0 is rejected, and H_1 is accepted. Thus, it can be concluded that there is a difference in the average learning outcomes related to creative thinking skills between the experimental class and the control class. The (df) value indicates that the average learning outcome of the experimental class (66) is higher than that of the control class (33). This difference is also reflected in the T-test results, where the experimental class scored higher than the control class. The lower bound of 0.07 shows that the difference in averages between the experimental and control classes is statistically significant. The data analysis results demonstrate a significant effect of implementing the project-based learning (PjBL) model assisted by E-LKPD based on live worksheets. Next, the effect size was calculated to determine the magnitude of this influence. Based on the table above, which shows the standard deviation for each class, Cohen's d value was found to be 1.05. According to Rivki et al. [19], this value falls into the category of a large effect in the interpretation of effect size. This means there is a significant impact of applying the PjBL model assisted by E-LKPD based on live worksheets on the creative thinking skills of Grade X students at SMAN 3 Bengkulu Tengah.

The research results indicate an improvement in students' creative thinking skills, as seen from the experimental class's average score, which increased from 12.23 on the pretest to 70.33 on the posttest. This demonstrates the effectiveness of the PjBL (Project-Based Learning) model, which focuses on students designing projects to enhance their creative thinking. This finding aligns with [1], who stated that addressing the low level of creative thinking skills can be achieved by implementing the PjBL model, thus improving students' creative thinking abilities in physics learning. It also supports [10], who found that the PjBL model can foster student creativity during the learning process. Similarly, [2] explained that the PjBL model significantly interacts with and positively influences students' creative thinking skills.

The results of the hypothesis test conducted using IBM SPSS Statistics 27 for Windows indicate an improvement after the treatment was applied using E-LKPD based on live worksheets. This confirms that the null hypothesis was rejected and the alternative hypothesis was accepted. These findings are consistent with[20], who stated that the use of E-LKPD based on live worksheets can serve as an alternative learning method to enhance students' thinking skills. Similarly, [7]supports this view, noting that E-LKPD based on live worksheets is effective for use in physics learning, making it more engaging and improving the quality of learning. Additionally, [21] asserted that the use of live worksheets in learning can enhance students' creative thinking skills.

4. Conclusion

Based on the effect size analysis, the magnitude of the impact of physics learning using the PjBL model assisted by E-LKPD based on Live Worksheets is 1.05, which falls into the large category. This indicates a significant effect on improving the creative thinking skills of Grade X students. The research results show that students who participated in learning with the PjBL model assisted by E-LKPD based on Live Worksheets achieved a higher average score improvement compared to those who learned without the support of this media. The PjBL model encourages students to learn more creatively, while the E-LKPD based on live worksheets supports the learning process through engaging and interactive features.

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