



Development of Student Worksheets based on Project-Based Learning on Renewable Energy to Improve Students' Concept Mastery and Creative Thinking Skills in Senior High School

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Abstract

The student worksheets development activity was carried out because its use in learning was still relatively simple, thus influencing students' enthusiasm for mastering concepts and developing creative thinking skills. This is due to limited teacher innovation in developing teaching materials that suit student needs. This research aims to determine the feasibility of project-based student worksheets learning and its influence on mastery and creative thinking skills. The feasibility of Project-based Learning (PjBL)-based worksheets learning was measured using the validation results of media experts, teaching module experts, and field practice experts, with scores of 78.45%, 86.11%, and 92.70%, respectively. Mastery of concepts and creative thinking abilities were measured using the Independent Sample T-test based on pretest and post-test data. The implementation results show an increase in mastery of concepts and creative thinking skills in classes that implement PjBL-based worksheets compared to classes that do not implement PjBL-based worksheets. The values are 0.003 and 0.032, respectively (significance level <0.05)

Keywords: concept mastery; creative thinking skills; pjbl-based worksheets; renewable energy

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INTRODUCTION

The independent learning curriculum is a student-centred curriculum with learning methods that promote critical thinking, such as exploring, creating works, and solving problems by generating innovative ideas so that the learning process becomes more active and productive (Andriani et al., 2023; Dwikoranto et al., 2023; Yaelasari & Yuni, 2022). The independent curriculum also allows teachers to freely

innovate to make the learning process more interesting and effective. (Hendriani et al., 2022; Yaelasari & Yuni, 2022). Many learning innovations have been conducted by teachers, such as the development of learning media in the form of teaching modules, books, and worksheets adapted to the needs of students. Students' worksheets are one of the teaching materials that support the learning process by requiring students to carry out activities in accordance with the

required learning process (Barlenti et al., 2017; Eambaipreuk et al., 2021; Lubis et al., 2021). Student worksheets in the form of exercise question sheets are still commonly used in the learning process. However, they are not designed attractively to pique students' interest in learning, which has resulted in a lack of learning motivation. As a result, students may not understand the material completely, leading to a decrease in their comprehension of the concepts presented (Barlenti et al., 2017; Fajriah & Suryaningsih, 2020).

The interview results indicate a lack of understanding of the students' concepts due to limited teacher innovation in developing teaching materials according to the curriculum and student needs. This is also exacerbated by limited internet access to learning media, so teachers tend to use printed books as the only teaching materials used in the teaching and learning process. In physics education, understanding concepts is the most fundamental aspect that every student must possess because concept mastery is related to the material obtained through the teacher and the ability to apply the concept in real-life situations (Laelandi et al., 2022; Reza et al., 2018). The implementation of physics learning has not yet involved students in finding their own experiences through a problem-solving-based learning process, resulting in a low understanding of material concepts among students (Sandopa et al., 2022). Concept mastery is only achieved when students are enthusiastic about the learning process. Therefore, by mastering the concepts, students can achieve learning success (Ictiari et al., 2022). Enhancing students' comprehension of concepts can be investigated by measuring their mastery of physics concepts through teaching materials and engaging them in problem-solving to identify appropriate solutions for real-life situations (Habibi et al., 2020). In the learning process, the

teacher is the main factor in improving learning outcomes by mastering concepts and utilizing teaching materials such as worksheets (Briones, 2018; Li & Singh, 2017). worksheets has several advantages. It can be used collaboratively during the learning process, encourages students to learn according to their abilities, and can help analyze problems in their surroundings. Students can also use their thinking competencies to solve existing problems (Fajriah & Suryaningsih, 2020). It is necessary to apply project-based learning to PjBL-based worksheets so that students can learn collaboratively according to their abilities and be able to analyze existing problems.

The PjBL model is a problem-solving approach that integrates knowledge and thinking skills to address issues in the surrounding environment through PjBL (Ling et al., 2024; Pradita et al., 2020; Ratnasari et al., 2017; Widyasmah et al., 2020). The implementation of PjBL-based worksheets involves students participating in solving all challenges in the process of solving real-life problems through the developed project. Project development encourages all students to share their abilities through collaborative activities, share ideas, and generate new ideas to solve the problems at hand (Baluarte-Araya, 2020; Munawarah et al., 2023; Sormunen et al., 2023). The characteristics of the PjBL model have the potential to encourage students to develop and train their thinking skills by utilizing objects in the surrounding environment to create a real product. This approach fosters a scientific mindset in students (Goldstein, 2016; Serevina et al., 2022).

Creative thinking skills are high-level thinking skills that involve using new and unique ideas to solve problems through concrete actions to produce useful innovations for the surrounding environment (Susatyo & Nurhayati, 2017). Based on the results of interviews,

one factor contributing to the low level of creative thinking among students is the lack of teacher habituation in teaching problem-solving methods, which would help students become accustomed to thinking creatively when facing various problems. Currently, teachers remain the primary source of learning in the learning process despite their additional role in developing learning media, such as worksheets, tailored to students' needs (Suliyannah et al., 2020). PjBL-based worksheets are effective teaching materials for improving concept mastery by involving students in solving problems, so students can practice and develop their creativity.

PjBL-based worksheets have been developed by several previous researchers, such as (Chalsum et al., 2023; Fajriyanti et al., 2018; Lupi et al., 2021). They reported that the use of PjBL-based worksheets in the learning process is practical and can assist students in carrying out every learning activity in a monitored manner, from the stages of determining the problem based on previous information, formulating ideas for the problem, determining materials and tools, making a schedule, and to the final stage of presenting the project developed. However, research on worksheets with renewable energy topics in senior high school is limited. In addition, the worksheets in that research were also designed in the form of paper or electronic sheets. Even though electronic worksheets are also quite effective teaching material for students, their implementation still has shortcomings, such as limited internet access in certain remote areas. As a result, schools in these areas must rely on available teaching materials. Therefore, this research aimed to develop specially designed PjBL-based worksheets in the form of attractive printed books, which will be a unique feature of this research in comparison to previous studies. Through PjBL-based worksheets,

students are expected to engage actively in learning. This will help them to improve their understanding of the concepts presented and develop their creative thinking skills.

Based on these considerations and previous research, it has been found that there are still very few studies that focus on the topic of renewable energy materials in high schools. Therefore, the researchers were interested in developing PjBL-based worksheets about renewable energy to improve concept understanding and the senior high school students' creative thinking skills. The aim is to assess the feasibility level of the PjBL-based worksheets on renewable energy, and how it affects the improvement of understanding of material concepts and creative thinking in students.

METHOD

This research used the ADDIE development model with a quasi-experimental pretest and post-test control group design (Campbell, 2002). The research utilized a sample from class X.1 as the experimental group, which received PjBL-based worksheets treatment, and class X.3 as the control group, which did not receive any treatment. The sample consisted of 36 students in the experimental group and 21 in the control group from a high school population. Prior to implementation, feasibility validity was conducted on the developed PjBL-based worksheets.

A validity test was conducted by media experts, teaching module experts, and field practitioner experts, based on the results of student response questionnaires to the worksheets. The validity criteria for the worksheets can be seen in Table 1.

Table 1 Validity criteria for PjBL-based worksheets

Validity criteria	Validity Level
85,01% - 100%	Excellent, so it can be used with minor revisions

Validity criteria	Validity Level
70,01% - 85,00%	Good, or can be used with minor revisions
50,01% - 70,00%	Poor, major revision is recommended before further use
01,00% - 50,00%	Bad, or should not be used

(Pratikno et al., 2020)

The perception and learning assessments were based on the students' reactions and responses to developed worksheets and the implementation of the learning process. The student response categories were calculated based on the following categories in Table 2.

Tabel 2 Student response category

Score	Category
91-100	Excellent
81-90	Good
71-80	Fair
60-70	Poor
< 60	Bad

(Sunarti, 2014)

The obtained data was analyzed using the independent sample t-test after conducting normality and homogeneity tests to determine if the data was normally distributed and homogeneous. The guidelines for making decisions on normality tests are based on the significance value of the obtained data. The data is considered normal if the significance value is greater than 0.05. Conversely, if the significance value is less than or equal to 0.05, the data is not normal. The guidelines for homogeneity test decision making if $F_{count} < F_{table}$ and vice versa. The research data, which comprised pretest and post-test scores from multiple choice and essay questions, were analyzed using Independent Sample T-test analysis to find out the differences between the experimental class that used PjBL-based worksheets and the control class that did

not. The guideline for deciding independent sample t-tests.

RESULT AND DISCUSSION

Analyze Stage

The process of identifying gaps was carried out by observation activities, namely interviews with physics teachers and the results of a questionnaire analyzing the needs of class X students regarding worksheets. Based on the results of teacher observations and interviews, it is known that in terms of the learning methods used, students still have difficulty understanding physics due to the lack of innovation by teachers when providing the material taught. The learning process carried out by teachers still uses the lecture method, so getting students to think at a higher level is difficult. The learning taught is still not in the form of problem-solving or project creation, especially the application of the project-based learning model, which is known to still be in the category of rarely used by teachers due to a limited understanding of learning approaches, tools and materials that can be used, as well as a lack of motivation from teachers. Student analysis was carried out by giving questions about concept mastery and creative thinking to 36 students at SMA Negeri 3 Pasarwajo. Based on the preliminary test results, it was found that the average concept mastery score was still in the low category, namely at 32.5, and the average score for creative thinking skills was categorized as very low, namely at a score of 29.5.

The learning model researchers chose to apply the material is the PjBL learning model. The project based learning stages are included in the following activities: (1) determining the project to be created, the teacher and students determine the theme of the project to be developed; (2) preparing plans and stages of project completion through experimentation, the teacher facilitates students to design what

stages will be carried out in making the project; (3) When preparing a project implementation schedule, the teacher provides assistance to students to prepare a schedule during project creation; (4) Carry out monitoring with teachers regarding the projects carried out. Teachers provide facilities and monitoring for students to improve projects that have been created; (5) Presenting projects carried out by students. The teacher gives space for students to dare to show the projects they have created; (6) project evaluation, teachers and students together reflect on the material obtained with the results of the project that has been carried out.

Design Stage

This stage begins with preparing open modules according to the independent learning curriculum syllabus, along with open module validation sheets. Next, design worksheets based on PjBL. The PjBL-based worksheets are designed using the Canva application, using A4 size according to the desired printed book format. The worksheets contains a cover, foreword, table of contents, learning outcomes, learning instructions, learning objectives, group division and group assignments. The worksheets also consist of activity 1, activity 2, and activity 3. The theme used on the worksheet cover is related to renewable energy material, which includes the title, class, phase, and project being developed. There is a page number on each worksheet sheet.

After designing the PjBL-based worksheets, then design questions on concept mastery and creative thinking skills as well as scoring guidelines and validation sheets, design evaluation instruments in the form of student response questionnaires regarding the readability of the PjBL-based worksheets, and response questionnaires for teacher responses to the validity of the PjBL-based worksheets. The assessment strategy is carried out with several

product validations which will be applied to the validity of teaching modules, worksheets validation by media experts, and field practitioners.

Development Stage

In this PjBL-based worksheets development stage, researchers developed the content of each activity 1, 2, and 3. Activity 1 is a stage that is carried out to strengthen student understanding containing a short narrative and several questions related to renewable energy before performing activity 2 and 3, namely the PjBL stage. The purpose of providing an understanding of the concept at the beginning of activity 1 is to assist students in identifying fundamental questions and resolving problems. Activity 1 can be seen in Figure 1.



Figure 1 Activity 1 Developing students' concept mastery about forms of energy, energy transformation, and proposed life problems in the form of articles about the increasing need for kerosene in Buton for students to solve

Activity 2 and Activity 3 were the application of the steps of the PjBL model referring to the Ministry of Education and Culture in 2013 and are adapted from (Merdekawati et al., 2022)

as follows: (1) determining the essential question. Before asking questions, the students were provided with statistical data on the level of demand for kerosene as a cooking fuel in several regions in Southeast Sulawesi province. From the data, they explained what problems would arise and how to solve those problems; (2) designing the project to be made, The students collected information related to the questions formulated. They searched for information via YouTube and other social media and linked it with information they had previously (understanding the concept of worksheets activities); (3) creating a schedule. The teacher provided a column for preparing a project schedule from the design stage to project evaluation; (4) monitoring the students' activeness and the project's development. The teacher monitored and guided the project development process either directly or via WhatsApp; (5) assessed the project result. The teacher assessed the project result and requested that the students present it as work and video tutorials on creating solar powered stoves. These tutorials were then uploaded to each group's YouTube channel; (6) Evaluating the learning experience. The teacher instructed the students to describe their learning experience during the project-making process. Figure 2 presents activities 2 and 3.

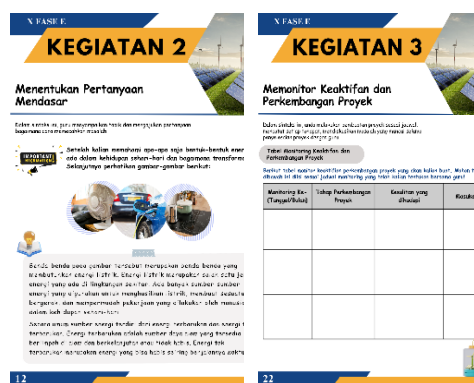


Figure 2 The PjBL syntax used in activities 2 and 3

Results of validity conducted by the media experts obtained a mean score of 78.45%, meaning that PjBL-based worksheets had a fairly valid validation level, but required some revisions. The validation results of the teaching modules showed a mean score of 86.11%, meaning that the teaching modules prepared by the researchers were highly valid but required minor revision.

The student worksheet's suitability for student-centered learning was evaluated, and the mean score for the item was 87.5%, indicating high validity. According to Oktaviani et al. (2017), the learning process using worksheets can encourage students to build their own knowledge, so they will focus on finding their own knowledge and understanding existing material with the surrounding problems (Li & Singh, 2017; Setiawan et al., 2021). Based on the indicator of the way the PjBL-based worksheets were presented, the mean score was 75%, meaning that it was fairly valid. According to Sujana (2023) and Yulkifli et al. (2019), student worksheets equipped with learning instructions will help students learn in a structured manner. In addition, incorporating visual aids such as pictures, animations, diagrams, and words into student worksheets can facilitate their understanding of learning concepts (Abdurrahman et al., 2019). Based on the indicators of language suitability and correct language rules, the PjBL-based worksheets were categorized as valid with a score of 87.5%. According to Fitriani et al. (2017) and Nurhaisa et al. (2023) student worksheets are considered appropriate if they meet several requirements, one of which is the use of language.

Formative Evaluation Stage

Based on the results of the data analysis that has been carried out, the PjBL-based worksheets on display suitability items obtained a percentage of 97.50% higher

than other items such as suitability of content achieving presentation of 95%, suitability of presentation language of 95%, content suitability of 94%, and efficient worksheets reached 90%. The total item presentation was 94%.

Practicality test questionnaires were distributed to 10 SMA Negeri 3 Pasarwajo students who had taken renewable energy material. Each questionnaire has a score range of 1-5. First, the one-to-one-trial test was carried out by selecting 3 students who had taken the renewable energy material. The results of the practicality analysis of the one-to-one trial stage showed that the worksheets that had been made showed an average of 88.2%, which was categorized as very practical and usable. Second, the small group trial test was carried out by distributing questionnaires to 10 students who had taken renewable energy material. Based on the results of the practicality test analysis at the small group trial stage, it can be seen that the worksheets developed by researchers showed an average of 88.13% which was categorized as very practical and usable.

And thirdly, field trials are carried out by distributing students in the same class who have taken renewable energy materials. At this stage, 36 students selected as respondents were class X MIPA 1 students. Based on the results of the analysis, the developed worksheets obtained an average of 93% for part I items, namely the contents of the worksheets, 94% for part II items, namely teachers, and 90% for part III items, namely student participation. The overall average of items is 92.70%. According to Fakhruddin et al., (2017), practical worksheets allow students to understand the material, practice independence, solve various life problems, increase knowledge, and improve their thinking abilities.

Implementation Stage

The implementation phase was carried out in 2 classes, namely class and class X.3 as a control class with implementation without PjBL-based worksheets. Before the learning process takes place, students are first given concept mastery pretest questions and creative thinking pretest questions in both classes. After the pretest questions were completed by the students, the researcher then carried out the learning process based on the activities that had been prepared in the teaching module and the worksheets that had been given to the students. After all the learning process activities were carried out, the researcher finally gave post-test questions on concept mastery and creative thinking to see the extent to which students understood the concepts and were able to think creatively.

Data on students' understanding of concepts was obtained from pretest and post-test scores totalling 30 points. The pretest and post-test results show that students' concept mastery increased in the experimental class after treatment, with a mean score of 80% compared to the control group. Figure 3 presents the results of the concept understanding score.

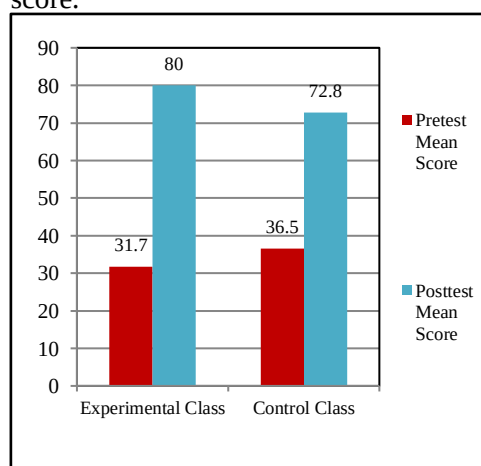


Figure 3 Graph of the pretest and post-test mean scores for concept understanding

Additionally, statistical tests were conducted, specifically the normality and homogeneity tests, to assess the ability to comprehend concepts. The results indicated that both the experimental and control groups were normally distributed, with a significance value of $0.0200 > 0.05$. The homogeneity test also showed that the conceptual abilities of students in both groups were equal or homogeneous, with a significance value of $0.259 > 0.05$. The independent sample T-test revealed a significance value of less than 0.05, specifically 0.003, indicating a significant difference in concept understanding ability between students in the treated (experimental) and those in the untreated (control) class.

Concept mastery was carried out at the beginning of worksheets learning in the form of questions about renewable energy. According to the research (Sulman et al., 2023), before advancing to higher levels, students need to have a clear understanding of the concept of observing the provided material. After mastering a concept at the beginning of learning, it is necessary to engage in activities that will enhance the concept's mastery.

According to Guo et al. (2020), students feel that PjBL learning helps them refine their understanding of concepts. However, students reported that the time required to solve problems was a challenge. According to Barniol & Zavala (2016) and Wiedstra et al. (2020), students achieve conceptual understanding by using worksheets containing questions that will guide students to develop an understanding of the received material concepts. According to Oktaviani et al. (2017), Physics teaching materials have a significant influence, namely that they can help students comprehend the concepts by measuring aspects of the cognitive domain presented by Anderson & Krathwol (2010) in the form of a multiple choice test.

Students' creative thinking ability was measured through an essay test consisting of five main topics on renewable energy. The pretest and post-test results showed that the students' creative thinking ability increased, with an average score of 84.6% in the experimental class. Figure 4 shows the test results of the creative thinking ability of both the experimental and control classes.

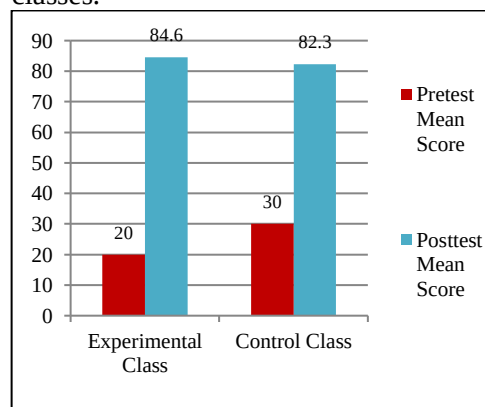


Figure 4 Graph of the pretest and post-test mean scores for creative thinking skills in the experimental and control class

The study analyzed creative thinking ability using normality and homogeneity tests. The data was found to be normally distributed, with a significance value of $0.112 > 0.05$ and $0.200 > 0.05$ for the normality test. The homogeneity test showed a sig value of $0.364 > 0.05$, indicating that the creative thinking ability in both classes was homogeneous. Additionally, an independent sample t-test was conducted, revealing a sig value of $0.032 < 0.05$. It was concluded that there was a significant difference in creative thinking between the class students who were treated using PjBL-based worksheets and the control class students who were not treated.

Fluency of thinking can be seen when students describe the solar cooker scheme from the ideas they have and focus on the answer sheet as a form of flexible thinking (flexibility) by

interpreting a problem in the form of a picture (Syafrial et al., 2021; Widyasmah et al., 2020). The picture includes the exact steps for the project to be created. Providing steps in making the project illustrates that students have fulfilled their original skills. The original aspect is the ability to generate ideas in an original way, meaning that students can design works according to ideas that arise from their own thoughts (Athifah & Syafriani, 2019; Sinuraya et al., 2020, Somwaeng, 2021).

Improving creative thinking skills requires learning media that can integrate a process of thinking through imagination, fluency, flexibility, scientific knowledge, surrounding phenomena, and scientific problems faced (Bayley, 2024; Fakaruddin et al., 2024; Wulansari et al., 2019). It is reported that the PjBL-based worksheets can improve creative thinking, and teachers are encouraged to implement learning strategies that prioritize more complex activities by focusing on questions or problems, encouraging students to face and solve problems through realistic projects. In line with research conducted by Agustini et al., (2022), student creativity can be expressed through project-based or real-world learning activities that differ from traditional methods.

CONCLUSION

After analysis and discussion, it can be concluded that the validation and practicality of the PjBL-based worksheets which media experts have carried out got a score of 78.45%, teaching module experts got a score of 86.11%, field practitioner experts with a score of 94%, and student responses got a score of 92.70%. Which is categorized as valid and very good. Meanwhile, based on the effectiveness of the worksheets, each obtained a value of 0.003 and 0.032 ($\text{sign} < 0.05$), which showed that PjBL-based worksheets on

renewable energy could improve concept mastery and creative thinking skills in high school students.

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