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DEVELOPMENT OF PROJECT-BASED LEARNER WORKSHEET FOR PINEAPPLE PEEL WASTE PROCESSING TO TRAIN CREATIVE THINKING SKILLS AND SELF-REGULATED LEARNING

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Abstract :
This study aims to develop a valid and practical project-based learner worksheet to train creative thinking skills and self-regulated learning on alternative energy material. This type of research is Design and Development Research (DDR) adapted from Richey & Klien (2007) using validity test consisting of empiric validation and expert validation, as well as practicality test consisting of readability test, teacher perception test, and learner response test, the effectiveness test consists of the results of the analysis of trained creative thinking skills and self-regulated learning in small groups. The results of the empiric validation test are seen based on the success of the biobattery product turning on the LED in a particular circuit. On the results of the expert validation test, obtained an average score from the three experts of 3.24, with the average score on the media and design aspects obtained at 3.32 with very valid category, and the material and construct aspects obtained at 3.15 with a valid category. The results of the practicality test obtained an average score for the readability test of 83.8% with a very practical category, the teacher perception test of 87.3% with a very good category, and the learner response test of 84.7% with a very good category, obtained an average practicality test score of 85.3% with a very practical category. The effectiveness test was seen based on the results of the analysis of trained creative thinking skills obtained the results of 81% and the analysis of trained self-regulated skills.

Keywords: Creative Thinking Skills, Learner Worksheet, Project Based Learning, Self-Regulated Learning

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INTRODUCTION

The development of the 21st century is characterized by the rapid development of globalization, which demands high quality human resources in all efforts and results (Mardhiyah et al., 2021; Amin et al., 2023; L. Hasibuan & Nugraha, 2023). Achieving these quality human resources requires improving the quality of education. One aspect of learning skills that students have in 21st century skills, namely creative thinking skills (Trilling & Fadel, 2009; Jr, 2024; Astalini et al., 2023). In addition to creative

thinking skills, self-regulated learning is important in a learning process because in its indicators it can shape the character of students (Luthfi et al., 2018; Sari et al., 2022; Yusipa, 2024). Efforts that can be made to train creative thinking skills and self-regulated learning are by training students to face real problems in the environment (Diawati et al., 2017; Oktavia et al., 2023).

One of the problems in Lampung Province is the increase in pineapple fruit production which causes the amount of pineapple peel waste to continue to increase. Currently, the utilization of pineapple peel waste is only used for animal feed and the rest is wasted so that it will cause environmental pollution (Syauqi & Inasari, 2020). The problem in other conditions is the increased use of electrical energy, so that new alternative energy sources are needed so that human electrical energy needs can be met. These real problems can be used as a physics learning project using a project-based learning model (PBP). PBP allows students to learn material in an integrated manner and use their knowledge to solve problems in the form of projects (Bilgin et al., 2015)

The implementation of PBP model learning that is carried out outside the classroom requires a learning media that can support learning, namely in the form of a learner worksheet guide. Learner worksheet that has been specifically designed and adapted to learning objectives, can make it easier for students to understand the material being taught (Yusuf & Widyaningsih, 2022; Ndatyapo et al., 2024; Nursakinah & Jauhar, 2023). In accordance with a copy of the decision of the head of the standard body, curriculum, and educational assessment number 033/H/KR/2022, it is stated that the learning outcomes for Physics phase E or class X subjects are that students can have the ability to be responsive to global issues and play a role in providing problem solving. Therefore, alternative energy material is an important material to be taught to students because it can equip students to understand the importance of using energy that is more environmentally friendly and sustainable in the future, so that environmental damage can be reduced (Sumarmi et al., 2021; Winda & Firmansyah, 2021).

Based on the preliminary research results that have been carried out, the achievement of learning objectives, especially on alternative energy material, can be created through project-based learning using learner worksheet related to environmental pollution issues. As previously described, environmental pollution issues related to increased production of pineapple peel waste and the use of electrical energy from batteries can be applied in learning as a project (Kurniawati et al., 2024; Rachmatika & Salighehdar, 2024). Both problems can be used as a solution as an alternative energy source, namely biobattery. It is said to be a biobattery because it uses fruit waste as an electrolyte in the form of a paste from natural and environmentally safe materials (Fitrya et al., 2021; Sunhaji, 2021; S. Hasibuan et al., 2024). Biobattery utilizes the electrical properties of fruit waste containing electrolytes to produce energy so that it can become alternative electricity, so that pineapple skin waste can be a substitute for chemicals in batteries (Abdullah & Masthura, 2021; Fauziyah et al., 2023; Subhan et al., 2024). In addition to achieving learning objectives, students can also play a role in overcoming the problem of environmental pollution.

From the description above, it is found that the utilization of pineapple skin waste is not optimal which will have an impact on environmental pollution and the problem of increasing use of electrical energy which will cause an energy crisis. In addition, the use of batteries as the main place to store electrical energy also has a negative impact on the environment. On the other hand, students' understanding of the theory and concepts in alternative energy materials related to global issues and their role in solving problems has not been achieved, supported by the results of a questionnaire filled out by several physics teachers and several students.

In several existing development studies, there has been no research that has developed learning media, namely learner worksheet based on pineapple peel waste processing projects. In line with other existing studies, it is said that the creation of learning media such as project-based learner worksheet is needed in school learning because students are active in the teaching and learning process so that students' understanding of the material being taught increases. So the novelty in this study focuses on research that develops learning media, namely learner worksheet based on pineapple peel waste processing projects. So the development of learner worksheet based on pineapple peel waste processing projects is important to do, especially to train creative thinking skills and self-regulated learning.

RESEARCH METHOD

Research Design

The type of research used is Research and Development (R&D) in education with a project-based learning model. The research method used is 4D, namely Define, Design, Development, and Dissemination.

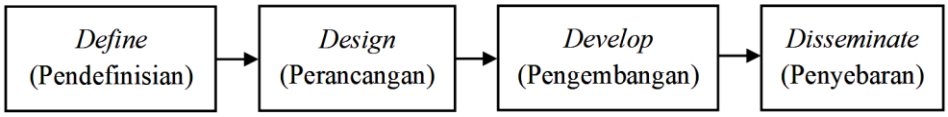

Figure 1. Steps of the 4D Model

The 4D model was chosen because it is considered easy to implement and has structured and clear stages to produce a product. The product to be developed is then tested for feasibility with validity and product trials. The product referred to in this development research is project-based learner worksheet to train students' creative thinking skills and self-regulated learning.

Research Procedure

In the define stage, the author determines and defines the requirements for developing project-based learning media, especially on alternative energy materials. At this stage, the researchers conducted three main stages of analysis, namely front-end analysis, concept analysis, and task analysis. Furthermore, at the design stage, the author designs the product to be developed, namely the preparation of learner worksheet construction, systematic design, and instrument design. At the develop stage, there are two activities, namely expert appraisal is an assessment of the feasibility of learner worksheet developed by experts and development testing is the implementation of learner worksheet design trials in small groups. Furthermore, at the disseminate stage, the author conducted a limited distribution of the developed learner worksheet and made an official publication of the research results.

Instruments, and Data Collection Techniques

The instruments used in this development research are instruments at the define and development stages. At the define stage, the instruments used are teacher response questionnaires and student response questionnaires. Both instruments are intended to obtain information related to the use of learning media, especially learner worksheet in the learning process, as well as knowing the level of understanding of students on learner worksheet that has been used during the learning process. The questionnaire contains 'yes' or 'no' questions by giving reasons for choosing the answer, as well as several questions by choosing several answer options. Questionnaires were distributed to six different schools in Lampung Province, in the form of Google Forms via WhatsApp chat application. At the development stage, the instrument used is an expert validation questionnaire to assess or measure the feasibility of the learner worksheet product developed, the product functioning test as proof of the success of the biobattery product developed. Furthermore, the practicality test questionnaire, including the readability test, teacher perception test, and student response questionnaire. The three questionnaires are intended to determine the extent of ease in using and understanding the developed learner worksheet.

At the develop stage, project-based learner worksheet development is carried out which will become the final product in this study, then learner worksheet product validation is carried out by experts, namely media and design aspects, as well as material and construct aspects of the learner worksheet developed. The validation process was carried out by showing the learner worksheet developed, then the expert was asked to fill out a validation questionnaire. In addition, researchers also developed a pineapple peel waste biobattery product that can turn on a wall clock as an empirical test, then filled out a product functioning test questionnaire to support the success of the product.

The practicality aspect of the developed learner worksheet was measured using a readability test questionnaire, a teacher perception test questionnaire, and student responses. At this stage, a limited trial of the product was carried out by asking for the responses of several teachers and students. Data collection was carried out by showing the developed learner worksheet, then the teacher was given a

teacher perception test questionnaire and students in a small group were given a readability test questionnaire, then students who had worked on the learner worksheet were given a learner response questionnaire to fill in.

The effectiveness aspect of the developed learner worksheet is reviewed based on the trained aspects of the creative thinking skills indicators of students which are assessed from the results of students' answers in the learner worksheet during the trial implementation with teacher guidance. The results of the answers were then analyzed to see the trained creative thinking skills of students. In addition, this study also looked at the self-regulated learning aspects of students who were assessed based on filling out a questionnaire by students who referred to self-regulated learning indicators after students worked on the developed learner worksheet.

Data analysis technique

1. Data Analysis Technique Validity

Analysis of validity data obtained from validation test questionnaires related to media and design, as well as material and construct aspects filled out by experts. The criteria for validity through the expert validity test, then the data obtained from the expert validity test results are analyzed using the formula:

$$p = \frac{Average\ obtained}{\sum Total}$$

The calculated results are then interpreted so as to get the quality of the product to be developed. The score interpretation is adapted from Ratumanan and Laurent (2011) as shown in Table 1.

Table 1. Conversion of Product Validity Assessment Score

Research Result Score Interval	Criteria
3,25< score <4,00	Very Valid
2,50< score <3,25	Valid
1,75< score <2,50	Less Valid
1,00< score <1,75	Not Valid

The researcher provides a limitation that the project-based LKPD product developed is categorized as valid for use if the product reaches the score determined by the researcher, namely a minimum percentage of 2.50 with valid criteria.

2. Practicality Data Analysis Technique

- Readability Test

Analysis of readability test data is intended to determine the practicality of the product obtained from students in small groups (quantitative data). The results of the answers in the questionnaire will be analyzed using percentage analysis based on the formula according to Sudjana (2005) as follows.

$$\%X = \frac{\sum score\ obtained}{\sum maximum} 100\%$$

The percentage data obtained was then analyzed and converted using percentage analysis according to Arikunto (2011) with the following criteria.

Table 2. Conversion of Practicality Assessment Score

Percentage	Criteria
80.1% - 100%	Very Practical
60.1% - 80%	Practical
40.1% - 60%	Practical Enough
20.1% - 40%	Less Practical
< 20%	Not Practical

Researchers limit the product being developed to be categorized as practical if it reaches the score determined by the researcher, namely a minimum of 40.1% with the criteria of being quite practical.

- Teacher Perception Test

Teacher perception data was obtained from filling out a perception test questionnaire filled out by teachers related to the use of the developed project-based learner worksheet (quantitative data). The data obtained was then analyzed by percentage based on the formula according to Sudjana (2005) as follows.

$$\%X = \frac{\sum score\ obtained}{\sum maximum} 100\%$$

The percentage results obtained are then converted to the criteria according to Arikunto (2011) as follows.

Table 3. Conversion Score of Perception Assessment of Products

Percentage	Criteria
80.1% - 100%	Very good
60.1% - 80%	Good
40.1% - 60%	Fairly Good
20.1% - 40%	Not Good
< 20%	Not Good

The researcher limits the LKPD product that is developed to be categorized as good for use in learning if it reaches the score determined by the researcher, namely a minimum of 40.1% with fairly good criteria.

- Learner Response

Data on students' responses were obtained from filling out a response questionnaire by students related to the use of the developed project-based learner worksheet (quantitative data). Then the response data was analyzed by percentage using the following formula according to Sudjana (2005).

$$\%X = \frac{\sum score\ obtained}{\sum maximum} 100\%$$

Furthermore, the percentage results obtained were also converted to the same criteria in the teacher perception test, which can be seen in Table 3. The limitation determined by the researcher is that the developed LKPD product is categorized as good for use in learning, also with a minimum score of 40.1% with fairly good criteria.

3. Effectiveness Data Analysis Technique

- Creative Thinking Skills Trained

Data analysis used to determine the training of creative thinking skills is obtained based on the results of the assessment analysis by looking at the aspects of the indicators contained in the answers of students in the learner worksheet developed. The results of the answers on the learner worksheet will be analyzed using percentage analysis based on the formula according to Trianto (2010) as follows.

$$NP = \frac{\sum NI}{SM} \times 100\%$$

Description:
NP = Value sought
∑NI = Number of indicators that appear
SM = Maximum score per indicator
The percentage results obtained are then converted to the creative thinking skills assessment category which refers to the score conversion as follows.

Table 4. Creative Thinking Skills Assessment Score Conversion

Percentage	Criteria

< 20%	Very Untrained
21% - 40%	Not Trained
41% - 60%	Moderately Trained
61% - 80%	Trained
81% - 100%	Highly Trained

The researcher limits the LKPD product that is developed to be categorized as being able to train students' creative thinking skills if it reaches the score determined by the researcher, namely a minimum of 41% with the criteria of being sufficiently trained.

- Practiced Aspects of Self-Regulated Learning

In accordance with the research of Luthfi et al. (2013), which says that in every assessment process, in addition to creative thinking skills, self-regulated learning is also needed to self-regulate each student. Therefore, this study also looked at the achievement of self-regulated learning aspects of students. Data analysis was obtained through filling out a questionnaire by students after using the developed learner worksheet. Based on the results of the data obtained from the questionnaire, the data will be analyzed using percentage analysis based on the formula according to Trianto (2010), which is as follows.

$$NP = \frac{\sum NI}{SM} \times 100\%$$

The percentage results obtained are then converted to the same assessment category on the creative thinking skills aspect, which can be seen in Table 4. The limitation determined by the researcher is that the LKPD product developed is categorized as being able to train students' self-regulated learning if it reaches the score determined by the researcher, namely a minimum of 41% with the criteria of being sufficiently trained.

RESULTS AND DISCUSSION

1. Expert Validation Test Results

The developed learner worksheet was then validated by physics learning experts using validation instruments with assessments according to the scoring rubric of the instrument which can then be stated as valid based on the validation interference presentation. The validation test involved three experts who are experts in their fields. Validation of learner worksheet products consists of two categories, the first is the media and design aspects, then the second is the material and construction aspects. The following are the assessment results obtained from the validation test results.

Table 5. Expert validation test results

Aspect		Validators			Average Score	Category
		Expert 1	Expert 2	Expert 3		
Media and Design Validation	Cover Section	3.67	2.44	3.56	3.22	Valid
	Contents Section	4.00	2.80	3.50	3.43	Very Valid
Validation of Materials and Constructs	Content Conformity Section	3.00	3.08	3.42	3.16	Valid
	Construction Section	3.43	3.14	2.87	3.15	Valid
Total Average		3.52	2.86	3.34		Valid
Overall Average					3.24	Valid

In Table 5, the average score of all validation aspects is 3.24 with a valid category. Based on the results of the validation test of the two aspects, it can be interpreted that the learner worksheet product

developed is valid and can be implemented in learning to train creative thinking skills. The validity of a developed learner worksheet can be said to be valid if two validity concepts, namely content aspects and construct validation, have been met. Also supported by the use of the Project-Based Learning model which allows students to think creatively and better understand learning content (Loka *et al.*, 2022; Hardi et al., 2023). This is because students must first identify a real problem in their environment and then students are asked to find a solution related to the problem.

2. Empirical Validity Test Results

The results of empirical validation in this development research are that the developed pineapple skin waste biobattery product can produce sufficient voltage to power the LED. The following data is obtained from testing the pineapple skin waste biobattery.

Table 6. Empirical test of parallel circuit biobatteries

Material	Results		
	Time (s)	Voltage (v)	Current (A)
Pineapple Peel Waste	60	1.24	4.23
	120	1.21	4.14
Without Additives	180	1.14	3.24

Table 7. Empirical test of series circuit biobatteries

Material	Results		
	Time (s)	Voltage (v)	Current (A)
Pineapple Peel Waste	60	2.04	1.29
	120	1.51	1.15
Without Additives	180	1.47	1.13

The data results in the tables above are the empirical data results of the pure pineapple skin waste biobattery experiment without additives with a fermentation period of 1 day. The test results obtained data that pineapple skin waste connected in series can produce a greater electrical voltage compared to parallel circuits. The addition of the number of cells connected in series can increase the electrical characteristics produced. Where the addition of the number of cells in a series circuit can increase the voltage value (Dalimunthe et al., 2024). This is because the voltage value is directly proportional to the addition of the number of cells. Later, the results of the successful biobattery product can be used in learning, especially in direct current electricity practicums. Where, the use of conventional batteries can be replaced with biobatteries that have been made so that students are able to make electrical circuits.

3. Practicality Test Results

The developed practicality consists of a readability test questionnaire, a teacher perception questionnaire, and a student response questionnaire. The following is a summary of the results of the readability test filled out by students who have worked on the developed learner worksheet. Overall, the results of the readability test obtained an average percentage of 83.8% with a very practical category. In addition, the project-based learner worksheet product developed is presented in a systematic/sequential arrangement and is equipped with images and discourses that can make it easier for students to understand learner worksheet in learning activities. The level of readability of a teaching material can be said to be high if the teaching material is easy to understand and apply in the learning process (Ardila et al, 2021).

In the teacher perception test, the average score obtained was 87.3% with a very good category. This shows that the learner worksheet developed is very good to be implemented in the learning process of Alternative Energy material and each activity in the project-based learner worksheet developed is able to train students' creative thinking skills so that students' self-regulated learning can also be trained. Teacher perceptions that are categorized as very good mean that the project-based learner worksheet developed is easy to use in the learning process (Yuzan & Jahro, 2022).

In the student response test, a very good response was obtained from students which was marked by an average score of 84.7% with a very good category. Thus, it can be interpreted that project-based learner worksheet developed to train creative thinking skills and self-regulated learning can be applied in

learning. Students will give a positive response if learning is fun, so that it will have an impact on increasing their interest and learning outcomes (Ramadhanti et al., 2024).

4. Effectiveness Test Results

Students' creative thinking skills are trained through the work of the developed learner worksheet, and students' self-regulated learning is seen based on the results of filling out the questionnaire. Before the developed project-based learner worksheet is implemented on a wider scale, the developed learner worksheet is first tested limited to the learning process in the classroom. The results of the work that has been done in the limited trial are then analyzed referring to the assessment of the achievement of creative thinking skills indicators.

Table 8. Indicators of creative thinking skills achievement

Indicator CTS	Assessment Aspects	Max Score	Total Score	Percen-tage	Average Percentage	Category
Fluency	P1	60	57	86.6%	85.5%	Highly Trained
	P2	60	57	85%		
	P3	60	55	85%		
Flexibility	P4	60	48	80%	82.5%	Highly Trained
	P5	60	51	85%		
Originality	P6	60	45	75%	78.9%	Trained
	P7	60	48	80%		
	P8	60	49	81.6%		
	P9	60	46	76.6%		
	P10	60	47	78.3%		
	P11	60	50	83.3%		
	P12	60	49	81.6%		
	P13	60	45	75%		
Elaboration	P14	60	47	78.3%	77.2%	Trained
	P15	60	48	80%		
	P16	60	44	73.3%		
Total Average Percentage					81%	Highly Trained

The results of the analysis of the achievement of creative thinking skills as a whole, obtained an average score seen from the results of the analysis of the indicators of fluency, flexibility, originality, and elaboration, which is 81% with a very trained category. Thus, it can be said that the project-based learner worksheet developed can train students' creative thinking skills, although there have been no maximum results. Of course, further research must be carried out so that the data or information obtained can strengthen further research in the future. Based on the results of the analysis, it is also known that the elaboration and originality indicators have high challenges to be improved. This proves that the majority of students still have difficulty in developing unique ideas that are different from ideas that are generally accepted by others, in addition to the ability of students to provide long and in-depth explanations so that the answers are not detailed (Irman et al., 2025).

The selection of learning models also influences training students' creative thinking skills. Learning activities that relate to life or the surrounding environment can strengthen students' creative thinking skills because they are required to solve problems in their environment. An environment that is in accordance with the content of the subject matter can expand and clarify the material, concepts, and principles of the subject matter. In addition, constructivist learning designs can hone creative thinking skills because this learning strategy makes students more active than teachers, such as doing practical activities, field studies, discussions, and others (Putriyana *et al.*, 2020). Therefore, the role of the teacher as a guide is very important in helping students to be able to understand the material through appropriate learning models and learning media (Rochman *et al.*, 2024).

In addition, project-based learning can not only train students' creative thinking skills in each assessment process, but self-regulated learning is also needed to regulate each student (Luthfi et al., 2019). So that the effectiveness in this study, researchers also see the achievement of self-regulated learning of students using a questionnaire that refers to self-regulated learning indicators as an assessment of the student process.

Table 9. Self-Regulated Learning Achievement Indicators

Indicator SRL	Rated aspect	Max Score	Total Score	Percen-tage	Average Percentage	Category
Metacognition	Planning a learning strategy	120	109	90.8%	86.1%	Highly Trained
	Setting goals in learning	120	99	82.5%		
	Self-monitoring in learning	180	145	80.5%		
	Evaluate yourself	120	109	90.8%		
Motivation	Interested in assignments and lessons	240	207	86.2%	84.4%	Highly Trained
	Confidence	180	149	82.7%		
Behavior	Choosing an environment that optimizes learning	120	94	78.3%	80.4%	Trained
	Creating an environment that optimizes learning	120	100	83.3%		
	Managing time in doing assignments	120	92	76.6%		
	Looking for learning resources	180	150	83.3%		
Total Average Percentage					83.6%	Highly Trained

According to Zimmerman, the division of achievement indicators for SRL is metacognition, motivation, and behavior. Based on these 3 indicators, the results of the analysis of achievement from filling out the questionnaire by students, there are very good aspects with a score of 86.1% which is categorized as very high. This is stated in the first aspect, namely metacognition, so it can be interpreted that students will try to regulate themselves in learning to achieve the goals expected by students. Students will regulate themselves to gain a broad conceptual understanding of a topic with the aim of getting satisfactory results. Students' metacognition can be seen through their conscious efforts to understand their own cognitive processes and the learning materials to be studied, to improve their learning process and memory so as to create learning independence (Yusri, 2020). Based on the results of the analysis of the achievement of self-regulated learning indicators as a whole, an average score of 83.6% was obtained with a very high category. So it can be interpreted that, in addition to creative thinking skills that are trained through activities in the project-based learner worksheet that are developed, students' self-regulated learning is also trained according to the activities carried out in learning.

Overall, the results of this study are that valid, practical, and effective project-based learner worksheet has been developed to train students' creative thinking skills and self-regulated learning. The weaknesses or limitations of this study are in the results of the effectiveness test which were only carried out in limited groups and used trial samples that were less appropriate for their validity. Where, the validity of the developed project-based learner worksheet is intended to train creative thinking skills and self-regulated learning of high school students. However, in the research that has been conducted, especially in testing the effectiveness of the developed learner worksheet, the researcher used a trial sample on new Physics Education students of the Class of 2024 whose validity was basically less appropriate. This was

done because of several obstacles experienced during the research. So that the results of this study cannot be drawn general conclusions, therefore further research is needed to obtain more concrete conclusions.

CONCLUSION

Based on the data obtained, it can be concluded that the developed project-based learner worksheet is valid, practical, and limitedly effective which is used as a learning medium for alternative energy material. The developed product certainly needs further research for further refinement and to determine the broad effectiveness of the developed learner worksheet.

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