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Development of project-based student worksheets on renewable energy by utilizing rubber fruit shell waste to increase motivation

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ABSTRACT
The learning activities are impacted by the switch from the 2013 curriculum to the Emancipated Curriculum. Students become the focal points of learning and outcome-based learning in an autonomous curriculum. Additionally, the students had the chance to work on the project in person. The purpose of this project is to use rubber shell waste to create PjBL-based student worksheets for high school students that are relevant and useful on issues related to renewable energy. The Borg and Gall development model, which has seven stages, was used in this investigation. Grade 10 students were the subjects of this research. Results of validation from a variety of factors, including technical requirements of 83.3% with extremely valid category and component features of student worksheet 90% with very valid category, 86.7% of the construction conditions have very valid categories, 71.7% of the didactic requirements have valid categories, and 86.7% of the very valid categories have student worksheet compatibility with PjBL syntax. In the field test, the extremely practical score was 90.67 percent, while in the limited test, the practicality result was 88.2 percent for the practical category. So valid and practical student worksheets are obtained to increase student motivation in learning physics on the topic of renewable energy.

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Introduction

Physics is defined as an important part of science studied by students where learning physics can make humans think logically, theoretically, rationally, and confidently make a means to overcome the problems of everyday life, to compete in the demands of the current and future e of globalization and is a subject with a discussion of abstract concepts (Sasikumar et al., 2022; Verdian et al., 2021). In learning physics, students will find many numbers and equations that are not only memorized but must also understand the concept so that it can be easy to learn (Puspitasari et al., 2021; Redish, 2024). Therefore, interesting and practical teaching materials are needed.

Teaching materials that teachers can apply to learning activities are student worksheets (Hartina M Nur et al., 2023; Murni & Yasin, 2021). Student worksheet is a sheet that contains material, practice questions and tasks both individually and in groups (Janah et al., 2024; Sundari & Nugraha, 2020; Syamsuddin et al., 2023). The use of student worksheets in this learning has the aim of designing student thinking to be systematic (Nainggolan et al., 2024). This statement is in line with the statement (Septiaahmad et al., 2020) which says that student worksheets provide direction for students in solving physics problems by applying problem solving steps. And students are given the

opportunity to learn and work together with their friends to improve understanding of concepts (Kariasa, 2020; Le et al., 2018; Purwati, 2019).

Student worksheets have an important role in learning (Buniel & Monding, 2021; Indriyani & Firdaus, 2021). The role of student worksheets in learning is that it can help teachers in delivering material and help students to understand the material more easily (Kreps et al., 2024; Pawestri & Zulfiati, 2020; Ulya et al., 2023). In Physics learning, Student worksheets provide benefits to participants so that students can actively participate and think critically in solving problems (Gjerde et al., 2022; Nita, 2022).

The change from the 2013 curriculum to the Emancipated Curriculum has an influence on learning activities. In the Merdeka curriculum, students become the center of learning. The learning process is mostly done with project work and students are given the opportunity to work on their projects directly actively, explore and describe issues in the surrounding environment (Sari et al., 2023). The essence of this independent learning is to create an exciting learning environment and not be burdened with achieving certain grades (Sudaryanto et al., 2020).

The appropriate learning approach to be used in the Emancipated Curriculum is the project-based learning (PjBL) approach. This is because in project-based learning, students can directly reconstruct their intellectual knowledge (Pazmino et al., 2023; Yu, 2024). PjBL-based learning is a learning approach by focusing students on producing products and inviting students directly in their learning activities (Guo et al., 2020; Saimon et al., 2023; Santoso et al., 2023).

Renewable energy is physics material taught in 10th senior high school (Tatsar et al., 2022). In today's modern era, renewable energy is a very important issue (Baskutis et al., 2021; Gielen et al., 2019; Noor et al., 2023; Pani et al., 2022; Vakulchuk et al., 2020). Where energy demand continues to increase along with population increase and technological development (Ahmed et al., 2023; Jin et al., 2018; Setiawan & Aisyah, 2024; Wang et al., 2023). Excessive use of fossil fuels can cause environmental pollution and cause scarcity of fossil fuels (Reza & ., 2023). The role of renewable energy is as a solution to face energy challenges in the future (Effendi, 2023). In addition, shifting energy use from fossil fuels to renewable energy can reduce environmental damage and become sustainable energy (Rohma, 2024).

In Prabumulih city there are many rubber plantations. This rubber plant consists of stems, leaves, sap, seeds and shells. The main purpose in rubber plantations is to take the sap or called latex. However, the shell has not been optimally utilized. Therefore, efforts are needed to utilize rubber fruit shell waste into goods that have economic value. The way that can be applied is to process rubber shells into briquettes.

After one of the physics teachers of class X MAN 1 Prabumulih was interviewed about learning activities, it was found that the package book was the teaching material used when studying at MAN 1 Prabumulih City. There are no teaching materials other than books used in the learning process because the independent curriculum has only been implemented in 10th senior high school and teachers are still adjusting to the

application of the independent curriculum in the learning process at MAN 1 Prabumulih. In physics learning, teachers apply lecture, discussion and question and answer learning methods.

In addition, from the questionnaire distributed by the researcher, the details of the answers were obtained where in learning physics the teacher had never applied student worksheets in making projects. Where, in the independent curriculum students are required to actively participate in learning, one of which can be done by applying PjBL-based student worksheet. Then, the teacher has also never linked the learning material with the potential waste in Prabumulih city. Students want to try new things in physics learning by doing projects by utilizing rubber shell waste in Prabumulih city so that physics learning is not monotonous and makes students' attention focused on learning. To overcome this, PjBL-based student worksheets is needed that can process waste in the city of Prabumulih, one of which is rubber fruit shells as biomass which is included in the topic of renewable energy.

Then, based on research entitled "Development of Project-Based Worksheets on the Utilization of Fermented Date Seed Waste as Raw Material for Date Coffee Drinks" shows that the LKPD developed with the Design Based Research method, with three stages namely analysis, design, development is feasible and effective. Where the validation average r_{count} is 0.87 (Tazqiyah et al., 2021). This is in line with research entitled "Processing Organic Waste into Local Food Through Project-Based Biotechnology Lectures for Elementary School Teacher Education Students' Inquiry Literacy" shows that the student worksheets developed with an exploratory descriptive method analyzed by mix methods shows that through the syntax of organic waste problems in the surrounding environment can be resolved through project-based lectures, which can produce several aspects of inquiry literacy skills in lectures, as well as various local food products from processing organic waste (Tresnawati, 2022).

Based on previous studies on the development of project-based student worksheets that utilize waste, it appears that the development of student worksheet for renewable materials with a project-based model and utilizing rubber shell waste has not been studied. Then, based on the analysis by interviewing the physics teacher of class X MAN 1 Prabumulih City and the student response questionnaire, where in Physics learning they have not implemented project-based student worksheets and have never utilized the surrounding waste in Prabumulih City such as rubber shells. So, the researcher is very interested in conducting research on the development of Student Worksheets Based on PjBL on Renewable Energy Topics that utilize Rubber Shell Waste for Class X High School Students.

Method

Methods The research conducted by this researcher is a type of development research or Research and Development (R&D). R&D is a research method that can be applied when developing products that are applied in education. The development model applied is the Borg & Gall development model. The Borg & Gall development model

was changed in line with research needs so that it consisted of seven stages including (1) initial identification and information gathering, (2) planning, (3) developing the initial product form and first revision, (4) limited trial, (5) second product revision, (6) field trial, (7) final product revision (Bakker, 2018).

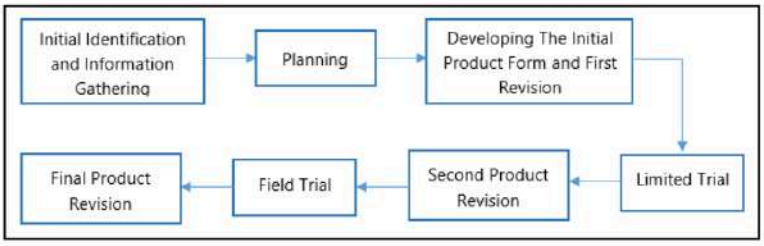

Figure 1. Research procedures

The data collection techniques applied by researchers in this study are walkthrough and questionnaire. Walkthrough is a validation technique used to test products at the initial product development stage. This is done by experts with the aim of getting a valid product. Suggestions obtained from validators are used to improve the products that have been developed. The learner worksheet validation grid is shown in Table 1.

Table 1. Student Worksheet validation grid

No.	Aspects Assessed	Statement Number
1	Components of worksheet	1, 2, 3, 4
2	Technical Requirements	5, 6, 7
3	Construction Requirements	8, 9
4	Didactical Requirements	10, 11
5	Suitability of student worksheets with PjBL Syntax	12, 13

The function of the questionnaire in this study is to test the product at the limited trial stage. The questionnaire was distributed to students as product users to test the practicality of using the developed product. Learners will answer the statements contained in the questionnaire and suggestions from students serve as a reference in the second revision stage of the product. The lattice of the questionnaire for students' responses to the worksheet is shown in Table 2.

Table 2. Questionnaire lattice for students' responses to student worksheets

No.	Indicator	Statement Number
1	Ease of use	11, 12, 13, 14, 15
2	Benefits obtained	2, 3, 4, 6,
3	Attractiveness	1, 5, 7, 8, 9, 10,

The data analysis technique is qualitative and quantitative data analysis. Qualitative data is obtained from suggestions or comments given by validators and responses from students who are respondents. While quantitative data analysis will describe the results of product development in the form of valid and practical.

Qualitatively analyzed walkthrough data obtained from suggestions or comments used to revise the product. Data from the initial product development stages that are analyzed quantitatively are intended to obtain a validity value expressed in percent and apply a Likert scale as a measurement scale. The expert validation sheet contains statements and is followed by five categories of choices in the form of a Likert scale as shown in Table 3.

Table 3. Product validity measurement scale

No.	Alternative Answer	Score
1	Very good	5
2	Good	4
3	Fair	3
4	Not Good	2
5	Not very good	1

The results of the validity test conducted by validators at the initial product development stage will be calculated mathematically which is written as follows.

$$Validation\ Percentage = \frac{Number\ of\ scores\ obtained}{Maximum\ number\ of\ scores} \times 100\ \% \quad (1)$$

After getting the validation value calculated using the equation above. Then classify the results with the product validity category shown in Table 4.

Table 4. Product validity categories

No.	Percentage	Category
1	≤ 20%	Very Invalid
2	21 % - 40 %	Not Valid
3	41 % - 60%	Moderately Valid
4	61 % - 80 %	Valid
5	81 % - 100%	Very Valid

Qualitatively analyzed questionnaire data obtained from suggestions or comments from students to make the second revision of the product. Questionnaire data analyzed quantitatively is intended to get a practical value expressed in percent and apply a Likert scale as a measurement. The students' questionnaire sheet contains statements and is followed by five categories of choices in the form of a Likert scale shown in Table 5.

Table 5. Practicality measurement scale

No.	Alternative Answer	Score
1	Strongly Agree	5
2	Agree	4
3	Moderately Agree	3
4	Disagree	2
5	Strongly Disagree	1

The results of the practicality test obtained from students at the limited trial stage will be calculated mathematically which is written as follows.

$$Percentage\ of\ Practicality = \frac{Number\ of\ scores\ obtained}{Maximum\ number\ of\ scores} \times 100\ \% \quad (2)$$

After getting the practicality value calculated using the equation above. Then classify the results with the product practicality category shown in Table 6.

Table 6. Product practicality categories

No.	Percentage	Category
1	≤ 20 %	Very Unpractical
2	21 % - 40 %	Not Practical
3	41 % - 60 %	Moderately Practical
4	61 % - 80 %	Practical
5	81 % - 100 %	Very Practical

Results and Discussion

This research product validation test involved 3 experts. The experts consisted of physics education lecturers at Sriwijaya University. The validity aspects assessed are in the form of worksheet components, technical requirements, construction requirements, didactic requirements and worksheet suitability with PjBL syntax. The validation data was collected using the walkthrough technique and then analyzed using a Likert scale. The validation results are shown in Table 7.

Table 7. Results of the validation of student worksheets

No.	Aspects being evaluated	Percentage	Category
1	Components of student worksheets	90 %	Very valid
2	Technical Requirements	83.3 %	Very valid
3	Construction	86.7 %	Very valid
4	Requirements Didactical Requirements	71.7 %	Valid
5	Conformity of student worksheets with PjBL Syntax	86.7 %	Very valid

Based on Table 7, the average validation assessment of the five aspects is 83.68%, which is categorized as very valid and continued to be tested at the next stage. After product 1 is tested for validity and improved according to the suggestions and comments given by the validator.

Furthermore, product 1 will be tested for practicality through a limited trial stage. Data collection at this stage was carried out by distributing questionnaires of students' responses to product 1. The results of the questionnaire assessment of students' responses are shown in Table 8.

Table 8. Results of students' responses at the limited trial stage

No.	Student	Percentage
1	KM	89.3 %
2	DH	92 %
3	NSF	89.3 %
4	PS	89.3 %
5	KML	89.3 %
6	RPH	86.7 %

No.	Student	Percentage
7	LPD	86.7 %
8	IF	82.7 %
Average		**88.2 %**
Category		**Very Practical**

From the table above, the average results of the practicality assessment of the limited trial stage of 88.2% are categorized as very practical. There are several points that were revised in the student worksheet based on comments given by students from the limited trial, namely the addition of materials to make them easier to understand and relate to the product to be made. And the cover of the student worksheet was made with a clearer picture.

After the limited trial, the product was revised according to the suggestions and comments from the students and then the field trial was conducted. Field trials were carried out by testing product 2 to all students of class X.2 MAN 1 Prabumulih City. The results of students' responses to product 2 are shown in Table 9.

Table 9. Results of Learner Responses at the Field Trial Stage

No.	Student	Percentage
1	MBD	89.3 %
2	MA	90.7 %
3	KML	94.7 %
4	NS	90.7 %
5	K	92 %
6	KM	92 %
7	MNU	93.3 %
8	IZ	94.7 %
9	LPP	90.7 %
10	PDA	90.7 %
11	NPRU	84 %
12	PSY	89.3 %
13	RAD	94.7 %
14	FC	94.7 %
15	FNS	84 %
16	IFH	89.3 %
17	RIM	96 %
18	AFAT	74.7 %
19	TR	96 %
20	BP	89.3 %
21	SPN	93.3 %
22	ANA	89.3 %
23	ZBK	94.7 %
24	RP	92 %
25	ZAM	89.3 %

No.	Student	Percentage
26	SAR	80 %
27	R	94.7 %
28	DPU	98.7 %
29	DLRP	94.7 %
30	RW	89.3 %
31	DKH	93.3 %
32	FGS	89.3 %
33	RRD	86.7 %
34	MFR	89.3 %
35	FNA	88 %
Average		**90.7 %**
Category		**Very Practical**

Table 10 results in an average practicality assessment from the field trial of 90.7% which is included in the very practical category.

The research conducted by researchers is a type of development research that results in a product. The product is a PjBL-based learner worksheet on the topic of renewable energy by utilizing rubber shell waste for class X high school students. This research uses the Borg and Gall development model with seven stages, namely initial identification and information gathering, planning, initial product development, limited trials, second revision, field trials and final revision.

The initial identification stage begins with a needs analysis; it is found that renewable energy material is difficult for students to understand because the teacher uses the lecture method in learning and the teacher has never applied PjBL-based student worksheets by utilizing rubber shell waste in the learning process. The reason students do not like physics is because the learning process is boring. Based on this, teaching materials are needed that can increase student motivation such as student worksheets. This is in line with (Wahyuni et al., 2021) argue that the use of student worksheets in learning can motivate students to learn. Furthermore, formulating learning objectives at the planning stage. Learning objectives are developed from learning outcomes in the independent curriculum.

The initial product development stage was carried out by preparing drafts of student worksheets, making student worksheet products and product validation by experts. Validation is carried out to assess the suitability of the product in several aspects. The results of expert assessment of several aspects of the student worksheet, namely the components of the student worksheet 90%, technical requirements of 83.3%, construction requirements 86.7%, didactic requirements of 71.7% and the suitability of the student worksheet with PjBL syntax of 86.7%. Then the suggestions obtained from the validator serve as a reference for revising the product. The product that has been validated and revised will proceed to limited trials. Limited trials were conducted to determine the practicality of the product (Yanti et al., 2023).

Figure 2. Development of student worksheets using the Borg and Gall model

The limited trial was conducted by eight different tenth-grade students at MAN 1 Kota Prabumulih and already represented students with both low and high ability levels. From the limited trial, an average practicality assessment score of 88.2% was obtained, categorized as very practical. Comments provided by students were used as a reference in the product revision. Then, a field trial was conducted by all students of class X.2 MAN 1 Kota Prabumulih. The field trial was conducted to determine the practicality level of the product on a large scale (Bombang et al., 2022). From the field trials, an average practicality rating of 90.7% was obtained, categorizing it as very practical. From the field trials, an average practicality assessment score of 90.7% was obtained, categorizing it as very practical. This means that the student worksheets are easy to use, attractive, and beneficial. Then, the suggestions provided by the students are used as a reference in the final product revision. Thus, a valid and practical student worksheet based on PjBL on the topic of renewable energy utilizing rubber shell waste for 10th-grade high school students was obtained.

As a biomass material for briquette production, rubber shells can be replaced with other biomass materials. Like briquettes made from corn husks (ZA et al., 2021), briquettes made from orange wood (Auliani et al., 2022), briquettes made from rice husks and coconut shells (Yirijor & Bere, 2024)(ZA et al., 2021), sawdust (Maharani et al., 2022), banana pseudo stems (Masthura, 2019), nutmeg seed shells (Kakerissa, 2021), tofu waste (Baihaqi & Masjud, 2024), and leaf litter and cow dung (Lestari, 2021).

Conclusion

Based on the results of research on the development of PjBL-based student worksheets on the topic of renewable energy by utilizing rubber shell waste for grade X high school students, it can be concluded that PjBL-based student worksheets on the topic of renewable energy by utilizing rubber shell waste for grade X high school students are

declared valid. This is based on five aspects of validity testing, namely aspects of the learner worksheet components of 90% categorized as very valid, technical requirements of 83.3% categorized as very valid, construction requirements of 86.7% categorized as very valid, didactic requirements of 71.7% categorized as valid and the suitability of the learner worksheet with PjBL syntax of 86.7% categorized as very valid. So that a student worksheet based on PjBL is obtained on the topic of renewable energy by utilizing rubber shell waste to increase the motivation of high school students in learning physics in grade X. However, this study has limitations, where the student's worksheet has not been tested for its effectiveness and the briquettes produced in the project have not been tested for their effectiveness. Therefore, I suggest that further research be conducted on the effectiveness of the worksheets and briquettes produced in the projects that have been carried out.

Conflict of Interest

No potential conflict of interest was reported by the author(s).

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