



# Analysis Development E-Worksheet Based PBL-STEM Approach with a Assisted by Nanofiber Membrane Media on Renewable Energy Materials to Improve Students' Creative Thinking Abilities

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Received: July 05, 2024

Revised: November 17, 2024

Accepted: February 25, 2025

Published: February 28, 2025

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DOI: [10.29303/jppipa.v11i2.8397](https://doi.org/10.29303/jppipa.v11i2.8397)

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**Abstract:** The increase in population and global economic growth means that energy demand continues to increase every year, so that limited energy resources such as fossil fuels are depleted more quickly. The purpose of this research is to determine the needs analysis for developing PBL-based e- LKPD with a STEM approach on renewable energy material to improve students' creative thinking abilities. This research is a qualitative descriptive study using a survey through a student needs questionnaire and interviews with physics teachers at Madrasah Aliyah Pondok Pesantren Ahlul Quran Palembang. The data obtained was then analyzed descriptively. The research results show that 80% of students find it difficult to learn renewable energy material. All students and teachers strongly agree if teaching materials are developed in the form of PBL-based e-Worksheetwith a STEM approach so that they can improve students' creative thinking abilities and can be used as teaching materials to support learning by students both at school and independently at home.

**Keywords:** Creative thinking; E-Worksheet; PBL; Renewable energy; STEM

## Introduction

The increase in population and global economic growth means that energy demand continues to increase every year, so that limited energy resources such as fossil fuels are being depleted more quickly (Liarakou et al., 2021). On the other hand, the use of fossil fuels also has negative impacts on the environment, such as air pollution and global warming (Hiğde, 2022). To overcome this, science and physics teachers have a very important role in explaining the concept of renewable energy to students and directly linking renewable energy source materials with the environment (Demirbağ & Yilmaz, 2020). Teachers can be role models for students to practice the use of renewable energy in class, so that students are interested in learning about

renewable energy and are able to increase students' scientific literacy (İzğionbaşı, 2020). Therefore, classroom learning must focus on renewable energy, so that students are motivated to learn the principles of renewable energy thoroughly and can apply them in everyday life (Hiğde, 2022; Husamah et al., 2022).

Several previous studies have discussed teachers' methods of explaining the concept of renewable energy in class, for example using videos, animations and PowerPoint slide presentations (Abdurrahman et al., 2023; Berber, 2021). However, the learning carried out is less interesting because students only learn the theory that is explained without being shown directly through demonstrations of renewable energy projects, so there is no visible increase in students' scientific literacy which is an indicator of 21st century skills (Wahyu et al., 2020).

### How to Cite:

Ardi, Sriyanti, I., & Marlina, L. (2025). Analysis Development E-Worksheet Based PBL-STEM Approach with a Assisted by Nanofiber Membrane Media on Renewable Energy Materials to Improve Students' Creative Thinking Abilities. *Jurnal Penelitian Pendidikan IPA*, 11(2), 466-473. <https://doi.org/10.29303/jppipa.v11i2.8397>

Therefore, students must be able to master 21st century skills such as critical thinking, creativity, collaboration, communication and mastering technology so that they can help students face various challenges in the future (Rizaldi et al., 2020). But in reality based on results research conducted by PISA (Program for International Students Assessment) in 2018 as reported by the OECD (Organization for Economic Cooperation and Development) that ability science participant students in Indonesia still classified low. Indonesia got a score of 396 in science ability and was in the bottom 10 of the 79 countries studied (Ananingtyas et al., 2022). Therefore, researchers and teachers continue to look for ways to improve students' scientific literacy.

PBL-STEM based e-Worksheet is a type of teaching material that provides many conveniences for teachers and students. PBL-STEM based e-Worksheet is a unit of electronic based e-learning in the use of data and communication technology, more precisely in electronic form (Febriani et al., 2017). The operation of PBL-STEM based E-Worksheet does not only use internet access, but can be accessed without an internet connection (offline) (Muskiti et al., 2020; Pasaribu et al., 2023). PBL-STEM based e-Worksheet which is made in electronics has the advantage of being able to save on stationery such as paper so that it indirectly helps in overcoming the problem of paper waste (Pasaribu et al., 2023). Thus, PBL-STEM based E-Worksheet could be an alternative teaching material that can improve students' creative thinking abilities. Meanwhile, Physics is a science that deals with natural conditions and their surroundings which can be observed through experiments, observations, or trials (Muskiti et al., 2020).

PBL-STEM based E-Worksheet aims to prepare students who are able to understand technology, can think systematically, be able to communicate well and be creative in solving problems (Büyükdede & Tanel, 2019). PBL-STEM based E-Worksheet not only knows the abbreviation for STEM but is also a branch of knowledge that can be implemented in the classroom and can support students' ability to have a career in the future (Sury et al., 2022). Students must be active in seeking information about technology that can be used in everyday life (Zahara et al., 2021). However, in reality there are still many teachers who have not implemented learning using PBL-STEM based e-Worksheet in the classroom, teachers only explain the material without linking the learning to the STEM approach. Therefore, PBL-STEM based E-Worksheet is the basis for increasing student creativity (Chercules et al., 2023; Kartikasari et al., 2023). The selected experiments in the development of E-Worksheet are based on PBL-STEM on renewable energy materials by making mini cars and lithium ion batteries from nanofiber membranes made from palm oil shell waste (CKS) (Marlina et al., 2022; Sriyanti et al.,

2020). The supercapacitor from the PAN/CKS nanofiber membrane has a storage cycle of 5000 times (Almafie et al., 2022). The nanofiber membrane will be used as an effective practical medium and can be used by teachers to practice alternative renewable energy materials in class. In addition, teachers and students can easily find coconut shells Palm oil, whose sources are very abundant, is spread throughout Indonesia (Sriyanti et al., 2018).

This research can provide a big role for society and teachers in Indonesia, especially in the Merdeka curriculum era which emphasizes creative thinking in the teaching and learning process. Overall, this research continues to develop and shows the great potential that PBL-STEM based E-Worksheet can improve students' learning outcomes and creative thinking abilities. However, research on the manufacture and implementation of PBL-STEM based e-Worksheet using nanofiber membranes has never been found. To overcome this problem, the development of E-Worksheet based on PBL-STEM on renewable energy materials uses nanofiber membranes as an energy storage system (supercapacitor). Nanofiber membranes are made from fine fibers which have a very small scale, namely nanometers (Jauhari et al., 2021; Sriyanti et al., 2021). Nanofiber membranes have conductive properties that can produce high electric currents, because they contain lignocellulose (carbon) elements (Almafie et al., 2022). Nanofiber membranes can be used as an energy source that can be demonstrated by teachers in class (Arianti et al., 2022).

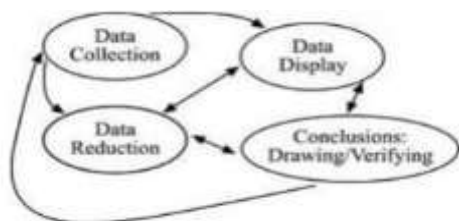
Currently, materials made in printed form tend to have a monotonous nature. This is due to students' lack of attention when using printed materials. A method that can overcome boredom in using printed materials is to use materials made electronically which can be used as educational media containing images, animation, audio or video (Sriyanti et al., 2017). Based on the explanation above, this research aims to analyze the need for developing PBL-based e-Worksheet with a STEM approach assisted by nanofiber membranes in renewable energy materials to improve creative thinking skills.

## Method

This research is a qualitative descriptive study. Where in this descriptive study, the researcher analyzes or describes the results of the data that has been collected regarding an object so that a conclusion is created. In this qualitative study, the research instrument is the researcher himself. The focus of this study is to analyze the need for teaching materials in the form of e-Worksheets based on PBL-STEM Assisted by nanofiber membranes in physics learning.

The time of the study was conducted in March 2023. The location of the study was carried out at MAS PP Ahlul Quran Palembang. The subjects of the study were 3 different sources of informants, namely students, teachers and policy makers. The first source of informants was 63 students obtained using the simple random sampling technique. The second source of informants was a physics teacher at MAS PP Ahlul Quran, totaling 2 people. The researcher chose these informants for the reason that there was the use of data validity techniques in the form of triangulation so that the researcher needed information from a third party to strengthen the data obtained by the researcher.

The data collection technique used questionnaires and interviews. The data collection technique in the form of a questionnaire filled out by students with the questionnaire used is a closed questionnaire and uses a Likert scale of 1-4. The indicators are as many as 5 indicators and 31 statement items that have been validated using Excel and SPSS software. Furthermore, the collection technique in the form of interviews was conducted with teachers using structured interview guidelines. Teacher interviews were conducted to obtain information about the learning process, teaching materials used by teachers, learning technology, student characteristics and what physics concepts were considered difficult. The data obtained from the three sources of informants were then validated by the researcher using triangulation. Where according to Nababan et al. (2022) explains that something that is produced from various points of view can be ascertained through a process called triangulation. This is in line with Augina et al. (2015) that the validity of data can be checked using a triangulation technique, which technique compares the main data with other data outside the main data. In the literature Yuliani (2018) it is explained that there are 3 types of triangulation, namely source triangulation, technique triangulation, and time triangulation.



**Figure 1.** Miles and Huberman's components of data analysis

In this study, source triangulation is a type of triangulation that researchers choose and use. The sources of informants that researchers use are students, teachers and curriculum representatives. Where the data obtained from various sources, the researcher then tests its credibility by checking the data, namely by triangulating sources (Nababan & Putri, 2022).

Furthermore, the researcher uses the interactive model from Miles and Huberman from references (Nababan & Putri, 2022) in analyzing research data because it is in accordance with the type of research conducted. The interactive model in question can be shown in figure 1.

Based on Figure 1, it is known that after the research data is collected, the analysis components provided according to Miles and Huberman are data reduction, data presentation, and conclusions: withdrawal or verification. The description can be explained as follows:

Data reduction: at this stage all data obtained from interviews and questionnaires are then re-selected. If there is data that is considered inappropriate or even not in line with the needs and is not valid, then the data can be discarded immediately. Data presentation (data display): at this stage the data that is appropriate and valid using SPSS will be displayed in the form of a table which is then described so that it can describe the E-Worksheet needed. Conclusion: withdrawal or verification (conclusion drawing/verification): at this last stage, conclusions are drawn based on the results of the data analysis so that the final results are obtained regarding what kind of E-LKPD needs students and teachers need when learning online.

## Result and Discussion

Product This research is preliminary research conducted to obtain an overview of the characteristics and needs of students and then used as a basis for consideration in developing teaching materials in the form of PBL-based e-Worksheet with a STEM approach. The needs analysis was obtained from interviews with teachers and distribution of student needs questionnaires. The results of the interviews obtained information as presented in table 1.

Based on the results of interviews with class X MIPA physics teachers, it can be analyzed that students' understanding of learning concepts is low. When learning, teachers only use worksheet books and teacher's manuals. This makes students feel bored and not directly involved in learning. Student learning results show that students experience difficulties and understand the learning material. The teacher explained that 20% of the students were assessed as having completed the questions on the renewable energy material. Based on the results of interviews, the teacher said that students' creative thinking abilities were still low.

The factor that causes students' low creative thinking abilities is because students are not used to working on questions with a high level of difficulty (Agussuryani et al., 2022). Material that contains student activities in the form of challenging questions that can improve students' creative thinking abilities (Sativa et

al., 2022). Good teaching materials are an important element for teachers to convey material to students in a more meaningful way (Sury et al., 2022). But in reality the teacher delivers the material still using the lecture

method, so that students do not understand the physics material presented in the form of words. Apart from that, table 2 explains the results of the analysis based on the student needs questionnaire.

**Table 1.** Results of Needs Analysis Based on Teacher Interviews

Question	Answer	Analyze the required product specifications
What is the general interest of students when learning physics, especially renewable energy material?	Based on learning outcomes and students' interest in learning physics is still low	Interesting teaching materials are needed and the application of learning models that focus on learning so that students are more motivated
What are the difficulties faced during the physics learning process, especially regarding renewable energy material?	There is a lack of learning resources and students do not have an interest in learning physics	Interesting teaching materials are needed and the application of learning models that focus on learning towards students so that they can attract students' interest.
What learning methods do you use in studying physics?	Lectures and textbooks	Teaching materials are needed that contain learning models to make them more interesting
Have you ever used teaching materials in studying physics, especially renewable energy? If so, what kind of teaching materials did you use?	Once, usually using LKS books, PPT and learning videos.	Teaching materials other than PPT and learning videos are needed
In your opinion, what are the students' creative thinking abilities in the teaching and learning process activities?	Still very low, because they only received the material that was explained. If they are given a question they have difficulty.	Teaching materials are needed that can improve students' creative thinking, and questions that can improve or train students' creative thinking.
What percentage of students complete the physics subject, especially renewable energy material?	20%	Teaching materials are needed that can be used by students to make it easier to understand physics lessons on renewable energy material

**Table 2.** Results of Needs Questionnaire Analysis

Category	N	Percentage
Lack of learning resources	20	85%
Learning tends to use conventional methods	19	72%
Material that is difficult to understand	20	95%
Students' knowledge about E-Worksheet	30	80%
Application of E-Worksheet to student learning	20	90%

Findings from respondents revealed that the material was understood and a lack of learning resources were the main causes of difficulties in understanding physics material. Table 2 shows responses to the obstacles faced while studying science in physics material. From Table 2 it can be seen that 85% of the obstacles experienced were a lack of learning resources. As many as 72% of learning tends to use conventional methods, 72% of the material is difficult for

students to understand, 95% of students' knowledge about E-LKPD, and 90% apply E-Worksheet to students' learning.

Based on this, teaching materials are needed that can help students learn independently. So students can learn anywhere and anytime. So something is also needed teaching materials in the form of electronics that students can access via smartphones owned by students (Marlina et al., 2022). This is because in E-Worksheet there are videos and animated images which can improve students' creative thinking abilities (Mierdel & Bogner, 2019; Syafrial et al., 2022). This is what further underlies the development of STEM-integrated PBL-based e-worksheet to improve students' creative thinking abilities which can be used independently by students or with teacher guidance. The results of the analysis of interview characteristics with students showed information in table 3.

**Table 3.** Results of Needs Questionnaire Analysis

Aspect	Class X MIPA Student Responses				
	SS	S	K.S	T.S	STS
I like studying physics, especially renewable energy material	0%	70%	13.3%	16.7%	0%
I sometimes have difficulty learning, especially renewable energy material	20%	60%	20%	0%	0%
I need learning media to study renewable energy material	70%	25.5%	14.5%	0%	0%
I will be more enthusiastic about studying physics, especially renewable energy material, if I use e-LKPD	20%	80%	0%	0%	0%
I agree if a PBL-STEM based e-Worksheet is developed so that they can master renewable energy materials	60%	36.7%	0%	3%	0%

From the results of the student questionnaire, it can be concluded that 80% of students have difficulty understanding renewable energy material. These student difficulties are caused by a lack of learning resources and the teaching materials used by teachers donot attract students' interest in learning, so that students are less interested in learning. This shows the need for teaching materials that can support and help students understand renewable energy material (Putri et al., 2019). The existence of teaching materials in the form of e-Worksheetcan encourage students to play an active role in the learning activities being taught. In line with the opinion Muskita (2020), choosing the right media can

make learning more meaningful. Apart from that, the factor that influences the success of students who plays the most important role is the educator, in this case the teacher (Hsiao et al., 2022). Where currently the Mardeka curriculum demands teachers as mediators and facilitators, teachers must be able to provide various learning facilities so that students can easily obtain information (Chercules et al., 2023). Next, the analysis of student characteristics was obtained from teacher interviews and distributing student needs questionnaires. The results of the interview obtained information as in table 4.

**Table 4.** Results of Analysis of Student Characteristics Based on Teacher Interviews

Question	Answer
Have you ever made teaching materials? If so, what kind of teaching materials have you developed?	Once GLB and GLBB materials used LKPD
What obstacles do you face when developing teaching materials?	When developing, you don't understand the application you are making
Have you ever done physics practicum, especially renewable energy material?	Never before in renewable energy materials, but in other materials
When carrying out practical activities, do students have enthusiasm?	The students were very enthusiastic
Have you ever made electronic teaching materials? If you have ever mentioned what kind of teaching materials?	PPT, never before for e-LKPD
Between e-Worksheetand print media, which is the most interesting to use as teaching material on renewable energy?	e-Worksheetis more interesting
In your opinion, what if we developed a PBL-based e-LKPD with a STEM approach assisted by nanofiber membrane media as a teaching material?	Very interesting
If a PBL-based e-Worksheetis developed with a STEM approach assisted by nanofiber membrane media, in your opinion, which content should be included in the e-LKPD?	Expand more interesting videos, animations, pictures and quizzes including crossword puzzles and questions that can improve creative thinking abilities.
a. picture	
b. videos	
c. Text	
d. Animation	
e. visual videos	

From table 4, it can be concluded that teachers have never developed e-Worksheetteaching materials, especially renewable energy materials. The development of teaching materials is only carried out on GLB and GLBB materials but there are still problems in making them. When learning about renewable energy, teachers have not yet carried out practical work, let alone connected it to nanofiber membrane media. However, the teacher also carried out practicums, namely on GLB and GLBB material, the students seemed very enthusiastic. Therefore, researchers are interested in developing PBL-based e-LKPD with a STEM approach assisted by nanofiber membrane media, which will later include project make electric cars powered by nanofiber

membranes from palm oil shells. Based on interviews conducted, students are very interested in developing a PBL-based e-Worksheetwith a STEM approach assisted by nanofiber membrane media on renewable energy materials to improve students' creative thinking abilities. In line with research conducted, the results of the development of PjBl-STEM based LKPD products are very effective in fostering students' creative thinking skills (Linda et al., 2023; Riyasni et al., 2023; Rizkika et al., 2022). In accordance with the learning outcomes (CP) of the Mardeka curriculum implemented at MA PP Ahlul Quran, the identification of learning outcomes (CP) for renewable energy material is as follows.

**Table 5.** Identification of Phase E Learning

Element	Competence	Material	Learning Outcomes
Understanding of Science	Apply	Alternative energy	Students understand measurement systems
Process Skills	Analyze	The relationship between alternative energy and its use	Scientific work, alternative energy and its use to overcome energy availability problems.

**Table 6.** Results of Educational Technology Analysis Based on Student Needs Questionnaire

Question	Class X MIPA Student Responses				
	SS	S	K.S	T.S	STS
I have a personal Android smartphone	53.3%	46.7%	13.3%	16.7%	0%
I often use an Android smartphone at home	20%	60%	14.5%	3.5%	0%
I have been using an Android smartphone for quite a long time at home	70%	30%	0%	0%	0%
Android smartphones are very often involved by teachers in learning	20%	50.5%	10.5%	10%	0%

The results of the educational technology analysis above are based on direct observations and interviews with teachers at MA PP Ahlul Quran Palembang. Facilities and infrastructure in madrasas as supporting facilities for teaching and learning activities are available and supportive, such as computers, projectors and wifi. Apart from the availability of ICT devices, all students have Android smartphones which they bring to the madrasah when carrying out practical assignments and exams. This is illustrated in the table of student technology analysis results above. From the potential of madrasas, it can be concluded that there are no obstacles in the learning process using ICT-based teaching materials. Therefore, this can support researchers to develop PBL-based e-Worksheet with a STEM approach assisted by nanofiber membrane media in renewable energy materials. Previous research Pasaribu et al. (2023) stated that the development of e-Worksheet based on PBL-STEM, one of which can improve students' creative thinking abilities, shows that the feasibility results of PjBL-STEM based LKPD learning media on renewable energy material have a practicality level of 93.3% in the very high category. This states that the LKPD developed is practical for use in learning. Apart from that, PjBL-STEM learning is able to guide students to produce simple projects. Students gain more meaningful learning, thereby triggering students' interest and motivation. This learning is appropriate if it is realized in the form of LKPD teaching materials. Research conducted Rizkika et al. (2022) on the development of STEM-based e-Worksheet on substance pressure material stated that 96.08% of the products produced using the STEM-PBL approach were very suitable for use in the learning process. Learning is able to guide students to produce simple projects. Students gain more meaningful learning, thereby triggering students' interest and motivation. This learning is appropriate if it is realized in the form of LKPD teaching materials. Research conducted Rizkika et al. (2022) on the development of STEM-based e-Worksheet on substance pressure material stated that 96.08% of the products

produced using the STEM-PBL approach were very suitable for use in the learning process.

**Conclusion**

Based on the results of the analysis carried out on the needs of MA PP Ahlul Quran Palembang students and teachers, that 80% of students find it difficult to learn renewable energy material. All students and teachers strongly agree if teaching materials are developed in the form of PBL-based e-Worksheet with a STEM approach so that they can improve students' creative thinking abilities and can be used as teaching materials to support learning by students both at school and independently at home.

**Acknowledgments**

The article was funded by DIPA of Public Service Agency of Universitas Sriwijaya, 2023. SP DIPA-023.17.2.677515 /2024, On November 24, 2024. In accordance with the Rector's Decree Number: 0016/UN9/SK.LP2M.PT/2024, On Juni 24, 2024.

**Author Contributions**

Conceptualization, L, K, I, S.; methodology, K, M, I, S.; validation, K and M.; formal analysis, I, K, investigation, I, L.; all authors have read and agreed to the publish version of the manuscript.

**Funding**

This research that is independently funded by researchers, does not receive funding from outside parties.

**Conflicts of Interest**

The author declares no conflict of interest.

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