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Needs Analysis for Developing STEM-PjBL-Based Student Worksheets to Support Creative Problem Solving in Alternative Energy Learning

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Abstract

Alternative energy learning in schools requires instructional materials that can connect scientific concepts with real-world problem solving. However, current learning practices are still often dominated by theoretical explanations, textbook-based instruction, and limited project-oriented activities. This study aimed to analyze physics teachers' needs for developing STEM-PjBL-based student worksheets to support students' Creative Problem Solving (CPS) in alternative energy learning. This study employed a descriptive survey method involving 27 physics teachers in Lampung Province. Data were collected using a teacher needs questionnaire and analyzed using descriptive statistics. The results showed that the teacher needs questionnaire was categorized as very valid, with an average validity percentage of 80.54%. In alternative energy learning, Problem Based Learning was the most frequently used learning model, while Project Based Learning was used by only 33.3% of teachers. Student worksheets and learning videos were the most commonly used learning resources, each used by 85.2% of teachers, while printed books were still used by 63.0% of teachers. Although 85.2% of teachers had used student worksheets and 59.3% had developed their own worksheets, only 48.1% reported using worksheets integrated with STEM-PjBL. Furthermore, 96.3% of teachers stated that they needed student worksheets designed to support students' Creative Problem Solving. These findings indicate a gap between the availability of student worksheets and their integration with structured STEM-PjBL and CPS-oriented learning activities. Therefore, the development of STEM-PjBL-based student worksheets is needed to support more contextual, project-based, and problem-solving-oriented alternative energy learning.

Keywords: Teacher needs analysis; STEM-PjBL; Student worksheets; Alternative energy; Creative problem solving

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INTRODUCTION

The declining availability of conventional energy resources and the increasing demand for energy consumption have raised awareness of the importance of energy conservation and the utilization of alternative energy sources. Energy issues are no longer limited to technological or environmental concerns, but have also become important educational issues because students need to understand how energy is produced, used, conserved, and replaced by more sustainable sources. Therefore, learning about alternative energy sources has become an important part of the national secondary education curriculum to build students' knowledge, skills, and positive attitudes toward sustainable energy use (DeWaters et al., 2013). Educational institutions have an important role in preparing future generations to understand energy-related challenges and to participate in solving them through scientific reasoning and responsible action. In science learning, alternative energy topics provide meaningful opportunities to integrate scientific concepts with real-world problems, technological applications, environmental awareness, and sustainability values (Atina et al., 2025). For this reason, learning approaches that promote active investigation, contextual understanding, and creative problem solving are essential in alternative energy learning (Pramestika et al., 2020).

In the 21st century, the ability to solve problems creatively has become one of the important competencies needed by students to succeed in education, society, and future workplaces (Abdurrahman et al., 2019). Creative Problem Solving (CPS) refers to the ability to solve problems by combining creative thinking and critical thinking in a structured process. Creative thinking enables students to generate diverse and original ideas, while critical thinking helps them evaluate the feasibility, relevance, and effectiveness of these ideas. CPS generally involves several stages, including clarifying problems, generating ideas, evaluating possible solutions, and implementing selected solutions. Through this process, students are encouraged to find connections between concepts, face new challenges, and propose unusual, original, and meaningful resolutions (Gafour & Gafour, 2020). This competence is highly relevant in alternative energy learning because students are expected not only to understand scientific principles, but also to identify energy problems, explore possible resources, design alternative solutions, and evaluate the usefulness of these solutions in real-life contexts (Abdurrahman et al., 2023; Alfalih, 2025; S. Rahayu et al., 2025).

Project-Based Learning (PjBL) and the integration of Science, Technology, Engineering, and Mathematics (STEM) have been widely recognized as promising approaches for 21st-century education (Griffin & Care, 2015; Indarta et al., 2022; Primahardani et al., 2024). PjBL provides students with opportunities to learn through meaningful projects that require them to investigate problems, make decisions, design products, and present their work. Meanwhile, STEM learning encourages students to integrate scientific concepts, technological applications, engineering design, and mathematical reasoning in solving contextual problems. When STEM is integrated with PjBL, learning can become more authentic because students are not only asked to understand concepts, but also to apply them in designing and evaluating solutions. Previous studies have shown that STEM-PjBL can support higher-order thinking skills, collaborative learning, and contextual understanding of scientific phenomena (Abdurrahman et al., 2023; Anggraini et al., 2023; IP Rahayu & Wulandari, 2025). In alternative energy learning, STEM-PjBL is particularly relevant because the topic naturally involves scientific concepts, technological innovation, engineering design, and quantitative reasoning.

In the Indonesian context, the implementation of the Independent Curriculum encourages contextual, student-centered, and project-based learning (Anggreini et al., 2024). This curriculum orientation is aligned with the need to develop learning that gives students opportunities to explore problems, construct knowledge, and produce meaningful solutions. However, current physics learning practices often do not adequately facilitate students' CPS skills. Teachers still face challenges in designing and implementing effective learning due to time constraints, limited learning resources, and limited experience in developing structured project-based activities (IP Rahayu & Wulandari, 2025). In many classrooms, physics learning is still dominated by teacher explanation, textbook-based instruction, and procedural worksheets. As a result, students' involvement in authentic problem-solving activities remains limited. Student worksheets, or LKPD, are frequently used as learning resources, but they are not always designed to guide students through STEM-PjBL activities or CPS stages. Worksheets that only contain summaries, procedural questions, or routine exercises may not be sufficient to promote students' 21st-century skills (S. Rahayu et al., 2025).

Student worksheets have a strategic role in supporting the implementation of STEM-PjBL because they can provide structured guidance for students during learning activities. Well-designed worksheets can help students identify problems, collect information, design projects, test solutions, analyze results, and communicate findings. In alternative energy learning, student worksheets can also connect scientific concepts with local contexts and environmental resources. Several local waste materials and surrounding resources have potential to be used as contextual learning media for alternative energy topics, such as in the development of simple bio-battery or renewable energy projects (Abidin et al., 2020; Attoriq et al., 2024; Hasrolita et al., 2025; Toruan et al., 2024). This potential indicates that alternative energy learning can be designed not only as conceptual learning, but also as project-based learning that encourages students to investigate local problems and develop practical solutions. However, such learning requires worksheets that are explicitly structured based on STEM-PjBL principles and CPS indicators.

Several previous studies have examined STEM integration, project-based learning, and alternative energy education in different contexts (Anggreini et al., 2024; Tseng et al., 2013). Other studies have also investigated the role of STEM-based and project-based approaches in supporting students' critical thinking, creative thinking, numeracy literacy, collaborative problem solving, and renewable energy learning (Ariyatun, 2021; Chairunnisya et al., 2023; IP Rahayu & Wulandari, 2025; S. Rahayu et al., 2025). These studies show that STEM-oriented and project-based learning approaches have strong potential to improve the quality of science learning. However, empirical evidence is still limited regarding the systematic mapping of teachers' needs as a basis for developing STEM-PjBL-based student worksheets that specifically support Creative Problem Solving in alternative energy learning. In Indonesian secondary schools, only a few studies have systematically explored teachers' current learning practices, perceived obstacles, availability of learning resources, and readiness to integrate CPS-oriented activities into alternative energy learning (Tasyani et al., 2025).

A systematic needs analysis is necessary before developing and implementing learning materials or learning models so that the proposed product is aligned with authentic classroom conditions (Abdurrahman et al., 2020; Atina et al., 2025; S. Rahayu et al., 2025). Understanding teachers' pedagogical practices, learning obstacles, perceptions of STEM-PjBL, and needs for student worksheets is important to ensure that the development of learning materials is empirically grounded. Without such analysis, the developed worksheets may not address actual classroom problems or teacher expectations. Therefore, this study aims to analyze physics teachers' needs for developing STEM-PjBL-based student worksheets to support students' Creative Problem Solving in alternative energy learning.

METHOD

This study employed a descriptive survey design with a needs analysis approach. The study was conducted as a preliminary investigation to identify physics teachers' needs for developing STEM-PjBL-based student worksheets to support students' Creative Problem Solving (CPS) in alternative energy learning. A needs analysis was considered important because the development of learning materials should be based on actual classroom practices, teachers' perceived obstacles, and the availability of learning resources. Therefore, the findings of this study were intended to provide an empirical basis for the future development of STEM-PjBL-based student worksheets in alternative energy learning (S. Rahayu et al., 2025; Tasyani et al., 2025).

The participants in this study were 27 physics teachers in Lampung Province. The participants were selected because they had experience teaching physics or science topics related to energy and alternative energy. Their responses were used to describe current learning practices, the use of learning resources, the use and development of student worksheets, and teachers' perceptions of the need for STEM-PjBL-based student worksheets to support CPS. The study focused on teachers as respondents because teachers have direct experience in planning, implementing, and evaluating learning activities in the classroom.

Data were collected using a teacher needs questionnaire distributed online through Google Forms. The questionnaire consisted of closed-ended and open-ended items. The closed-ended items were used to obtain quantitative descriptive data related to teachers' backgrounds, alternative energy learning practices, learning models, learning methods, learning resources, the use of student worksheets, process features contained in student worksheets, and teachers' perceptions of the need for student worksheets that support CPS. The open-ended items were used to obtain additional descriptive information about teachers' experiences, obstacles, and expectations in implementing alternative energy learning.

The teacher needs questionnaire was validated by three physics education lecturers before being used in the study. The validation process focused on four aspects: content eligibility, goal achievement, graphics, and language. The validation was conducted to ensure that the questionnaire items were appropriate for identifying teachers' needs in relation to the development of STEM-PjBL-based student worksheets. The results of the validation were then analyzed using a percentage score and interpreted based on validity criteria. The validation results showed that the questionnaire obtained an average percentage of 80.54%, which was categorized as very valid. This indicates that the questionnaire was appropriate to be used after revisions based on the validators' suggestions.

The data collection process was conducted online. Teachers completed the questionnaire by providing information about their teaching experience, learning practices, learning resources, and the need for student worksheets in alternative energy learning. The use of an online questionnaire enabled the researchers to collect responses efficiently from teachers in different schools within Lampung Province.

The data were analyzed using descriptive statistics and qualitative thematic analysis. Responses from closed-ended items were analyzed using percentages to identify patterns in learning models, learning methods, learning resources, the use of student worksheets, and teachers' perceptions of the need for STEM-PjBL-based student worksheets. Meanwhile, responses from open-ended items were analyzed thematically. The responses were reviewed, coded, categorized, and grouped into recurring themes related to learning practices, implementation obstacles, learning resource availability, and teacher needs. To improve the consistency of the analysis, the categories were reviewed repeatedly and adjusted to the objectives of the study.

This methodological procedure allowed the study to describe teachers' needs systematically and to identify the gap between current classroom practices and the expected characteristics of STEM-PjBL-based student worksheets. The results of the analysis were then used as a basis for recommending the development of student worksheets that explicitly integrate STEM-PjBL principles and CPS-oriented learning activities in alternative energy learning.

RESULTS AND DISCUSSION

Results

This section presents the results of the teacher needs questionnaire validation and the needs analysis related to the development of STEM-PjBL-based student worksheets to support students' Creative Problem Solving (CPS) in alternative energy learning. The results include the validity of the teacher needs questionnaire, respondent characteristics, alternative energy learning practices, the use of learning resources, the use of student worksheets, process features contained in the worksheets, teachers' perceived obstacles, and teachers' perceptions of the need for student worksheet development.

Validation of the Teacher Needs Questionnaire

Before being used to collect data, the teacher needs questionnaire was validated by three physics education lecturers. The validation covered four aspects: content eligibility, goal achievement, graphics, and language. The results of the validation are presented in Table 1.

Table 1. Validation Results of the Teacher Needs Questionnaire

No.	Assessed Aspect	Weight Percentage (%)
1	Content Eligibility	79.17
2	Goal Achievement	79.17
3	Graphics	80.53
4	Linguistics	83.30

No.	Assessed Aspect	Weight Percentage (%)
	Average	80.54
	Criteria	Very Valid

Table 1 shows that the teacher needs questionnaire obtained an average validity percentage of 80.54%, which was categorized as very valid. The highest score was found in the linguistic aspect, with a percentage of 83.30%, while content eligibility and goal achievement each obtained 79.17%. These results indicate that the questionnaire was appropriate for identifying teachers' needs after revisions based on validators' suggestions. Therefore, the instrument could be used to collect data on teachers' learning practices, the use of student worksheets, and the need for STEM-PjBL-based student worksheet development in alternative energy learning.

Characteristics of Teacher Respondents

The respondents in this study were 27 physics teachers in Lampung Province. The characteristics of the respondents are presented in Table 2.

Table 2. Characteristics of Teacher Respondents

Characteristics	Information
School level	Senior High School, 44.4%
	Junior High School/Islamic Junior High School, 40.7%
	Other or unspecified school levels, 14.9%
Average teaching experience	13.76 years
Standard deviation	9.81 years
Median	15 years
Range	0.15 to 33 years

Table 2 shows that the largest proportion of respondents came from senior high schools, with 44.4%, followed by junior high schools or Islamic junior high schools, with 40.7%. The remaining respondents, 14.9%, came from other or unspecified school levels. The respondents had varied teaching experience, ranging from 0.15 to 33 years. The average teaching experience was 13.76 years, with a median of 15 years. These data indicate that the respondents had relatively broad exposure to classroom learning practices, including the teaching of physics and energy-related topics. Therefore, their responses can provide a relevant overview of teachers' needs in developing learning materials for alternative energy learning.

Alternative Energy Learning Practices

Teachers' current practices in alternative energy learning were identified based on the learning models, learning methods, and learning resources they used. The results are presented in Table 3.

Table 3. Alternative Energy Learning Practices

Alternative Energy Learning Practices	Percentage (%)
A. Learning Models	**46.9**
Problem Based Learning (PBL)	77.8
Project Based Learning (PjBL)	33.3
Inquiry	29.6
B. Learning Methods	**55.55**
Discussion	88.9
Experiment	51.9
Lecture	40.7
Demonstration	40.7
C. Learning Resources	**70.4**
Student worksheets/LKPD	85.2
Learning videos	85.2
Internet	66.7

Alternative Energy Learning Practices	Percentage (%)
Printed books	63.0
Module	51.9

Table 3 shows that Problem Based Learning (PBL) was the most frequently used learning model, with 77.8% of teachers reporting its use. In contrast, Project Based Learning (PjBL) was used by only 33.3% of teachers, while inquiry learning was used by 29.6%. These results indicate that although teachers have adopted problem-oriented learning, project-based learning has not yet become a dominant model in alternative energy learning.

In terms of learning methods, discussion was the most frequently used method, with 88.9%. Experiments were used by 51.9% of teachers, while lectures and demonstrations were each used by 40.7%. This pattern indicates that classroom interaction has been encouraged through discussion, but teacher-centered approaches such as lectures and demonstrations are still used in alternative energy learning.

Regarding learning resources, student worksheets or LKPD and learning videos were the most frequently used resources, each with 85.2%. The internet was used by 66.7% of teachers, printed books by 63.0%, and modules by 51.9%. These findings indicate that teachers already use various learning resources, especially worksheets and videos. However, the high use of student worksheets does not automatically indicate that the worksheets are integrated with STEM-PjBL principles or designed to support CPS.

Use of Student Worksheets and Needs for Development

Because student worksheets were widely used in alternative energy learning, further analysis was conducted to identify the use of worksheets, process features contained in the worksheets, and teachers' perceptions of the need for STEM-PjBL-based worksheet development. The results are presented in Table 4.

Table 4. Student Worksheets and Needs for Development

Student Worksheets and Needs for Development	Percentage (%)
A. Indicators of Student Worksheet Use	**72.25**
Using student worksheets/LKPD	85.2
Developing student worksheets independently	59.3
B. Process Features in Student Worksheets	**70.4**
Problem identification	77.8
Choosing reference sources	81.5
Researching and designing projects	63.0
Testing products or solutions	55.6
Presenting results	74.1
C. Integration and Need Perception Indicators	**72.2**
Using STEM-PjBL-integrated student worksheets	48.1
Need for student worksheets that support CPS	96.3

Table 4 shows that 85.2% of teachers had used student worksheets in learning, and 59.3% had developed their own worksheets. These results indicate that student worksheets are already familiar learning materials for teachers. However, only 48.1% of teachers reported using student worksheets integrated with STEM-PjBL. This finding shows a gap between the high use of student worksheets and the limited integration of STEM-PjBL principles in those worksheets.

The process features contained in the worksheets also varied. The most frequently included feature was choosing reference sources, with 81.5%, followed by problem identification, with 77.8%, and presentation of results, with 74.1%. However, more complex project-related activities were less frequently included. Researching and designing projects were reported by 63.0% of teachers, while testing products or solutions was reported by only 55.6%. These findings indicate that existing worksheets tend to facilitate the early stages of problem exploration, but they do not fully support the more advanced stages of project design, solution testing, and evaluation.

The most notable finding is that 96.3% of teachers stated that they needed student worksheets designed to support students' Creative Problem Solving. This result indicates a strong perceived need for the development of student worksheets that are more structured, contextual, and aligned with STEM-PjBL and CPS-oriented learning activities.

Teachers' Obstacles in Alternative Energy Learning

In addition to identifying current learning practices and worksheet use, this study also examined teachers' perceived obstacles in implementing alternative energy learning. The results are presented in Table 5.

Table 5. Teachers' Obstacles in Alternative Energy Learning

Teachers' Obstacles	Percentage (%)
Limited teaching aids and practicum facilities	88.9
Difficulty connecting learning materials to the surrounding environment as a source of alternative energy	29.6

Table 5 shows that the main obstacle reported by teachers was the limited availability of teaching aids and practicum facilities, with 88.9%. Another obstacle was the difficulty of connecting learning materials to the surrounding environment as a source of alternative energy, reported by 29.6% of teachers. These findings indicate that alternative energy learning requires learning materials that are not only conceptually relevant, but also adaptive to classroom limitations and local environmental contexts.

Discussion

The results of this study indicate that alternative energy learning has begun to adopt active and problem-oriented learning practices, but the implementation of project-based learning remains limited. The high percentage of teachers using Problem Based Learning, 77.8%, and discussion methods, 88.9%, suggests that teachers have attempted to involve students in learning activities that require interaction and problem exploration. However, the use of Project Based Learning was only 33.3%, indicating that project-based learning has not yet become the main approach in alternative energy learning. This finding is important because alternative energy topics are strongly connected to real-world problems and technological solutions, which are suitable for project-based learning activities. The limited use of PjBL suggests that teachers may still need more structured guidance, examples, and learning materials to implement project-based activities effectively. This condition is consistent with the view that learning practices in physics still require stronger support to move from concept-oriented instruction toward more active, contextual, and project-based learning (Mazidah et al., 2026).

The results also show that teachers already use various learning resources, especially student worksheets and learning videos. The use of student worksheets reached 85.2%, which indicates that worksheets are common and accessible learning materials in classroom practice. This is a positive condition because student worksheets can serve as a practical medium for guiding students through learning activities. However, the high use of worksheets should not be interpreted as evidence that the worksheets already support STEM-PjBL or CPS. In many cases, worksheets may only contain summaries, routine questions, or procedural tasks. If worksheets are not designed to guide students through problem identification, project design, product testing, and reflection, their contribution to Creative Problem Solving will remain limited.

The finding that only 48.1% of teachers used STEM-PjBL-integrated worksheets confirms the existence of a gap between the availability of worksheets and the quality of their pedagogical structure. Although 59.3% of teachers reported that they had developed their own worksheets, not all of these worksheets were explicitly designed based on STEM-PjBL principles. This means that teachers may have the willingness and initial capacity to prepare learning materials, but they still need support in designing worksheets that integrate science, technology, engineering, mathematics, and project-based learning stages. This finding is in line with previous studies emphasizing the importance of structured learning materials that connect interdisciplinary STEM learning with problem-based and project-based contexts (Anggreini et al., 2024; Sari et al., 2020).

From the perspective of Creative Problem Solving, the existing worksheets appear to facilitate some CPS-related activities, but not yet in a complete and balanced manner. Problem identification was included by 77.8% of teachers, and choosing reference sources was included by 81.5%. These two features are important because they help students understand the problem and collect relevant information before proposing solutions. Presentation of results was also relatively high, with 74.1%, indicating that students are often asked to communicate their work. However, the more complex stages of CPS, such as researching and designing projects, 63.0%, and testing products or solutions, 55.6%, were less frequently facilitated. This pattern suggests that existing worksheets may support initial problem exploration, but they are weaker in guiding students through solution development, testing, evaluation, and improvement.

This imbalance is important because Creative Problem Solving requires more than identifying a problem or finding information. CPS requires students to generate possible solutions, evaluate alternatives, make decisions, implement ideas, and assess the results of those ideas. In the context of alternative energy learning, these stages can be realized through activities such as designing simple alternative energy devices, testing the effectiveness of materials, comparing energy outputs, evaluating design weaknesses, and improving the solution based on evidence. If worksheets do not explicitly guide students through these stages, then CPS development may not occur systematically.

The obstacles reported by teachers further strengthen the need for adaptive and contextual worksheets. The main obstacle was limited teaching aids and practicum facilities, reported by 88.9% of teachers. This condition indicates that the development of STEM-PjBL-based student worksheets should not depend on complex laboratory equipment alone. Instead, worksheets should be designed to use accessible materials, local resources, and simple project activities that can be implemented in real classroom conditions. In addition, 29.6% of teachers reported difficulty connecting learning materials to the surrounding environment as a source of alternative energy. This finding shows that teachers need guidance in transforming local environmental potential into meaningful learning contexts. This point is relevant to project-based STEM learning, which can use contextual and local resources to support critical and creative thinking when learning activities are designed appropriately (Sumarni & Kadarwati, 2020).

The very high percentage of teachers who expressed the need for student worksheets that support CPS, 96.3%, shows strong teacher readiness and acceptance toward the development of STEM-PjBL-based worksheets. This finding indicates that teachers recognize the limitations of existing learning materials and see the importance of worksheets that can guide students through more meaningful problem-solving activities. Teacher readiness is an important factor because the success of STEM-based learning innovation depends not only on the availability of learning materials, but also on teachers' willingness to use and adapt them in the classroom. This is consistent with previous findings that teacher support and readiness are important in implementing STEM-based science learning innovations (Sugianto et al., 2023).

The findings of this study also indicate that the development of STEM-PjBL-based student worksheets should explicitly align the stages of project-based learning with CPS indicators. For example, the problem orientation stage can be connected with problem clarification, the project planning stage with idea generation, the project implementation stage with solution development, and the product testing stage with evaluation and revision. Such alignment is important because the integration of STEM-PjBL and CPS should not be limited to the use of projects or STEM terminology. It should be visible in the structure of the worksheet, the sequence of learning activities, the questions given to students, the project tasks, and the reflection process. Without this explicit alignment, STEM-PjBL worksheets may remain procedural and may not fully support students' Creative Problem Solving.

These results support the argument that alternative energy learning requires student worksheets that are contextual, project-oriented, and structured around problem-solving processes. Previous studies have shown that STEM-PjBL has potential to support students' higher-order thinking, creative thinking, and contextual understanding (IP Rahayu & Wulandari, 2025). However, the present study contributes by mapping teachers' needs as an empirical basis for developing STEM-PjBL-based student worksheets in alternative energy learning. This contribution is important because the development of learning materials should begin with a clear understanding of actual classroom practices, teacher obstacles, and the characteristics of existing learning resources.

Based on the needs analysis, the development of STEM-PjBL-based student worksheets is necessary to bridge the gap between current learning practices and the expected development of students' Creative Problem Solving. The worksheets should provide clear instructions for identifying alternative energy problems, exploring scientific concepts, selecting relevant references, designing projects, testing solutions, presenting findings, and reflecting on the strengths and weaknesses of the proposed solutions. Such worksheets can help teachers implement alternative energy learning that is more contextual, student-centered, and aligned with 21st-century competencies.

The findings of this study provide a rational basis for further research and development. The next stage should focus on designing, validating, and testing the effectiveness of STEM-PjBL-based student worksheets in supporting students' Creative Problem Solving. Further studies may also involve a wider sample and examine the relationship between STEM-PjBL worksheet implementation and students' CPS outcomes more directly. This is consistent with the need for continued development, validation, and effectiveness testing of project-based STEM learning materials in science education (Storina, 2022; Tseng et al., 2013).

CONCLUSION

Based on the results of the needs analysis, this study shows that physics teachers have a strong need for the development of STEM-PjBL-based student worksheets to support students' Creative Problem Solving in alternative energy learning. The findings indicate that teachers have already used various active learning practices and learning resources, especially student worksheets and learning videos. However, Project Based Learning was used by only 33.3% of teachers, and only 48.1% of teachers reported using student worksheets integrated with STEM-PjBL. Although 85.2% of teachers had used student worksheets and 59.3% had developed their own worksheets, the integration of STEM-PjBL principles and CPS-oriented activities was still limited.

The results also show that existing student worksheets have not fully facilitated complete problem-solving processes. Several CPS-related features, such as problem identification, choosing reference sources, and presenting results, were relatively common. However, more complex activities, such as researching and designing projects and testing products or solutions, were less frequently included. This indicates that existing worksheets tend to support initial problem exploration, but do not yet systematically guide students through project design, solution testing, evaluation, and improvement. In addition, teachers reported obstacles such as limited teaching aids and practicum facilities, as well as difficulties in connecting learning materials to the surrounding environment as a source of alternative energy.

The most important finding is that 96.3% of teachers stated that they needed student worksheets designed to support Creative Problem Solving. Therefore, the development of STEM-PjBL-based student worksheets is considered necessary to bridge the gap between current learning practices and the expected implementation of contextual, project-based, and problem-solving-oriented alternative energy learning. These findings provide an empirical basis for the next stage of research and development, particularly in designing student worksheets that explicitly integrate STEM-PjBL stages with CPS indicators.

RECOMMENDATION

Based on the results of this study, the development of alternative energy learning materials should focus on designing STEM-PjBL-based student worksheets that explicitly integrate Creative Problem Solving indicators in each learning stage. The worksheets should guide students to identify contextual energy problems, explore scientific concepts, select relevant information sources, design alternative energy projects, test products or solutions, present findings, and reflect on the strengths and weaknesses of their solutions. This structure is important so that the worksheets do not merely function as procedural learning sheets, but also as scaffolding tools that support students’ problem-solving processes.

The development of student worksheets should also consider the real conditions faced by teachers in schools. Because many teachers reported limitations in teaching aids and practicum facilities, the proposed worksheets should be adaptable, practical, and applicable using simple tools and materials. The use of local environmental resources should also be emphasized so that alternative energy learning becomes more contextual and relevant to students’ daily lives. In this way, STEM-PjBL-based worksheets can help teachers connect scientific concepts with real-world problems and local potential.

For future researchers, the findings of this study can be used as a basis for designing, validating, and testing the effectiveness of STEM-PjBL-based student worksheets in alternative energy learning. Further studies are recommended to involve a larger and more diverse sample of teachers and students to examine the consistency of these findings. Future research should also investigate the direct effect of the developed worksheets on students’ Creative Problem Solving skills through implementation studies or experimental research.

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AUTHOR CONTRIBUTIONS STATEMENT

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CONFLICT OF INTEREST STATEMENT

The authors state no conflict of interest.

INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

ETHICAL APPROVAL

The research related to human use has been complied with all the relevant national regulations and institutional policies in accordance with the tenets of the Helsinki Declaration and has been approved by the authors' institutional review board or equivalent committee.

DATA AVAILABILITY
The data that support the findings of this study are available on request from the corresponding author.

REFERENCES

Abdurrahman, A., Ariyani, F., Nurulsari, N., Maulina, H., & Sukamto, I. (2020). The prospective ethnopedagogy-integrated STEM learning approach: Science teacher perceptions and experiences. *Journal of Physics: Conference Series, 1572*(1), 012082. https://doi.org/10.1088/1742-6596/1572/1/012082

Abdurrahman, A., Maulina, H., Nurulsari, N., Sukamto, I., Umam, A. N., & Mulyana, K. M. (2023). Impacts of integrating engineering design process into STEM makerspace on renewable energy unit to foster students' systems thinking skills. *Heliyon, 9*(4), e15100. https://doi.org/10.1016/j.heliyon.2023.e15100

Abidin, M., Hafidh, A. F., Widyaningsih, M., Yusuf, M., & Murniati, A. (2020). Making biobatteries based on coconut pulp and rotten tomatoes. *Al-Kimiya, 7*(1), 28–34. https://doi.org/10.15575/ak.v7i1.6511

Afifa, M., Wiyono, K., & Sriyanti, I. (2024). Innovative evaluation: Uncovering the need for Ethno-STEM tools in assessing creative thinking in physics education. *Journal of Education and Teaching, 11*(2).

Alfalih, A. A. (2025). Assessing the impact of green technological innovation and human capabilities on renewable energy supply: Evidence from the top-greenest countries. *Sustainable Energy Technologies and Assessments, 73*, 104152. https://doi.org/10.1016/j.seta.2024.104152

Anggraini, D., Abdurrahman, A., & Herlina, K. (2023). Development of a learning program based on multiple representations integrated with PjBL-STEM to foster students' sustainability literacy. *Jurnal Pendidikan Fisika dan Keilmuan (JPFK), 8*(2), 253. https://doi.org/10.25273/jpfk.v8i2.15660

Anggreini, A., Abdurrahman, A., & Kharisma, D. C. (2024). Implementation of Ethno-STEM based inquiry learning model assisted by LKPD to train creative thinking skills learners in the Merdeka curriculum learning. *Journal of Physics: Conference Series, 2900*(1), 012042. https://doi.org/10.1088/1742-6596/2900/1/012042

Ariyatun, A. (2021). Analysis of Ethno-STEM integrated project based learning on students' critical and creative thinking skills. *Journal of Educational Chemistry (JEC), 3*(1). https://doi.org/10.21580/jec.2021.3.1.6574

Atina, A., Herlina, K., & Abdurrahman, A. (2025a). Teachers' perception toward e-LKPD STEM-EDP to improve system thinking skills and creative problem solving skills. *Journal of Science Education Research, 11*(1), 800–808. https://doi.org/10.29303/jppipa.v11i1.9491

Atina, A., Herlina, K., & Abdurrahman, A. (2025b). Teachers' perception toward e-LKPD STEM-EDP to improve system thinking skills and creative problem solving skills. *Journal of Science Education Research, 11*(1), 800–808. https://doi.org/10.29303/jppipa.v11i1.9491

Attoriq, B., Fittuqo, M. S., & Ramadhan, Y. R. (2024). BIO-KOTAK: Composite biobattery of coconut (*Cocos nucifera*) pulp and tofu liquid waste as an alternative renewable portable electricity source. *Padjajaran Chemistry, 2*(2), 76–89.

Chairunnisya, S., Abdurrahman, A., Distrik, I. W., Herlina, K., Rosidin, U., & Rabbani, G. F. (2023). Engineering design process (EDP) strategy integrated PjBL-STEM in learning program: Need analysis to stimulate numeracy literacy skills on renewable energy topic. *Journal of Science Education Research, 9*(12), 11197–11206. https://doi.org/10.29303/jppipa.v9i12.6088

DeWaters, J., Qaqish, B., Graham, M., & Powers, S. (2013). Designing an energy literacy questionnaire for middle and high school youth. *The Journal of Environmental Education, 44*(1), 56–78. https://doi.org/10.1080/00958964.2012.682615

Gafour, O. W. A., & Gafour, W. A. S. (2020). *Creative thinking skills: A review article*. ResearchGate. https://www.researchgate.net/publication/349003763

Griffin, P., & Care, E. (Eds.). (2015). *Assessment and teaching of 21st century skills: Methods and approach*. Springer Netherlands. https://doi.org/10.1007/978-94-017-9395-7

Hasrolita, W., Rahmawati, R., Sulistyowati, R., & Rahman, D. Y. (2025). Development of a bio-battery based on tomato juice and NaCl with tapioca flour as a solid electrolyte matrix. *Jurnal Penelitian Fisika dan Terapannya (Jupiter), 6*(2), 1–8. https://doi.org/10.31851/jupiter.v6i2.15916

Indarta, Y., Jalinus, N., Waskito, W., Samala, A. D., Riyanda, A. R., & Adi, N. H. (2022). The relevance of the independent learning curriculum with 21st-century learning models in the development of the Society 5.0 era. *Edukatif: Jurnal Ilmu Pendidikan, 4*(2), 3011–3024. https://doi.org/10.31004/edukatif.v4i2.2589

Mazidah, L., Sari, N. P. I., Festiana, I., & Falamy, R. A. (2026). Problem-based learning in senior high school physics: A systematic literature review. *Teaching, Learning, and Development, 4*(1), 97–102. https://doi.org/10.62672/telad.v4i1.124

Prajoko, S., Sukmawati, I., Maris, A. F., & Wulanjani, A. N. (2023). Project based learning (PjBL) model with STEM approach on students' conceptual understanding and creativity. *Jurnal Pendidikan IPA Indonesia, 12*(3), 401–409. https://doi.org/10.15294/jpii.v12i3.42973

Pramestika, R. A., Suwignyo, H., & Utaya, S. (2020). The creative problem solving learning model on elementary school students' creative thinking skills and thematic learning outcomes. *Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan, 5*(3), 361. https://doi.org/10.17977/jptpp.v5i3.13263

Primahardani, I., Erlinda, S., & Supentri, S. (2024). Sustainability level analysis of the application of 21st century skills by university students. *AL-ISHLAH: Jurnal Pendidikan, 16*(2). https://doi.org/10.35445/alishlah.v16i2.4750

Rahayu, I. P., & Wulandari, F. (2025). Creative thinking skills through project-based learning (PjBL)-STEM. *Jurnal Pijar Mipa, 20*(5), 864–869. https://doi.org/10.29303/jpm.v20i5.9381

Rahayu, S., Abdurrahman, A., Herlina, K., Suyatna, A., & Ertikanto, C. (2025). Analysis of teachers' needs in renewable energy learning programs using SSI integrated with PjBL-STEM to enhance collaborative problem-solving and entrepreneurial skills. *Journal of Science Education Research, 11*(1), 774–782. https://doi.org/10.29303/jppipa.v11i1.9299

Ratih, A., & Arsih, F. (2024). Implementation of project-based learning in 21st century learning in science learning: A systematic literature review. *International Conference on Education and Innovation*.

Sari, L. P., Hatchi, I., & Kahanna, M. (2020). An effective basic physics teaching module based on project based learning (PjBL) model for physics education students. *Journal of Science Education Research*. https://doi.org/10.29303/jppipa.v9i3.2044

Storina, R. (2022). Implementation of the PjBL-STEM model on student creativity in science subjects at SMP Negeri 5 Batam. *Biodidak, 2*(2), 87–93.

Sugianto, S., Rusilowati, A., Widiyatmoko, A., Puspitasari, D., Arifa, N. M., & Roziqin, R. (2023). STEM-based science learning innovation for elementary, middle, and high school teachers at the Indonesian School of Kuala Lumpur. *Journal of Community Empowerment, 3*(2), 116–121. https://journal.unnes.ac.id/sju/index.php/jce

Sumarni, W., & Kadarwati, S. (2020). Ethno-STEM project-based learning: Its impact on critical and creative thinking skills. *Jurnal Pendidikan IPA Indonesia, 9*(1), 11–21. https://doi.org/10.15294/jpii.v9i1.21754

Tasyani, A., Herlina, K., & Ertikanto, C. (2025). Socio scientific issue integrated STEM-PjBL in teachers' perspective: Can its implementation in learning programs improve students' creative thinking skills on the topic of renewable energy? *Journal of Science Education Research, 11*(1).

Toruan, P. L., Wahyuni, D. P., Rahmawati, R., & Atina, A. (2024). Development of bio batteries utilizing coconut dregs and pineapple extract as alternative energy sources. *Circuit: Jurnal Ilmiah Pendidikan Teknik Elektro, 8*(2), 147. https://doi.org/10.22373/crc.v8i2.20933

Tseng, K.-H., Chang, C.-C., Lou, S.-J., & Chen, W.-P. (2013). Attitudes towards science, technology, engineering and mathematics (STEM) in a project-based learning (PjBL) environment. *International Journal of Technology and Design Education, 23*(1), 87–102. https://doi.org/10.1007/s10798-011-9160-x