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Analysis of Teachers' Needs in Renewable Energy Learning Programs Using SSI Integrated with PjBL-STEM to Enhance Collaborative Problem-Solving and Entrepreneurial Skills

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Abstract: This preliminary study explores the needs of teachers and students in physics learning, focusing on renewable energy topics. Using a survey method, data were collected from 24 high school physics teachers in Lampung Province via Google Forms. The findings were analyzed to identify educational gaps and propose solutions. Results reveal a pressing need for learning programs that enhance Collaborative Problem-Solving and Entrepreneurial Skills. While 83.30% of teachers reported integrating Project-Based Learning STEM (PjBL-STEM) into their teaching, only 23.50% of worksheets used were PjBL-STEM-based, and just 26.70% were self-created. Teachers faced challenges such as limited time and difficulty initiating development. Additionally, only 54.20% of teachers were familiar with the Sustainable Development Goals (SDGs). The study also highlights gaps in skill assessment, with 75% of teachers not evaluating Collaborative Problem-Solving Skills and 87.50% not assessing Entrepreneurial Skills. Despite using teaching media and worksheets, these gaps suggest a need for more robust tools and methods.The findings underscore the importance of developing renewable energy learning programs integrated with PjBL-STEM. Such programs can address existing challenges, promote SDG awareness, and equip students with critical skills for collaboration and entrepreneurship in the context of physics education.

Keywords: Collaborative; Entrepreneurial Skills**;** Problem solving; PjBL-STEM; Renewable energy; SSI

Introduction

In the 21st century, the ability to solve problems collaboratively has become an essential skill for success in education and the workforce (Abdurrahman et al., 2019). Skill development models have shifted toward collaboration and problem-solving to meet the demands of an increasingly interconnected and complex world (Yildiz, 2020). Collaborative Problem-Solving (CPS), as highlighted by (Buseyne et al., 2023) involves not only resolving issues together but also making collective decisions. This aligns well with physics education, where solving problems requires activities such as analyzing, interpreting, evaluating, and reflecting on real-world situations (Fiteriani et al., 2021). Unlike other disciplines, physics problems challenge students to find solutions that are not immediately apparent, necessitating the integration of mathematical and scientific reasoning (Santoso & Wulandari, 2020).

Effective support in learning, often referred to as scaffolding, plays a critical role in nurturing CPS (Khamcharoen et al., 2022). Teachers can facilitate collaborative learning environments where students exchange ideas, share knowledge, and work toward a common goal (Chen et al., 2021). Through collaboration, students not only gain a deeper understanding of the

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subject matter but also refine their ability to address complex issues together (Wahdah et al., 2023). This interaction fosters peer correction and mutual growth, strengthening their problem-solving skills (L. D. Lestari, 2020). Such an approach is essential for physics education, where students benefit from working in teams to tackle problems that mimic real-life challenges (S. Lestari, 2021).

Beyond CPS, entrepreneurial skills are another crucial competency in modern education. These skills encourage creativity, innovation, and teamwork, enabling students to develop practical solutions and products (Nurjaya et al., 2020). Incorporating entrepreneurial elements into education trains students to communicate effectively, collaborate in teams, and think innovatively (Akmal et al., 2020). The entrepreneurial skills can be gradually instilled by connecting theoretical knowledge with practical applications, such as creating tangible products (Sudarmin et al., 2023). This integration not only enhances student engagement but also prepares them for real-world challenges that demand both technical and interpersonal skills (Dewi et al., 2023).

Renewable energy, a pressing socio-scientific issue (SSI), provides an ideal context for integrating CPS and entrepreneurial skills into physics education (Muntari et al., 2024). SSI are science-based societal issues with multiple perspectives and solutions, making them highly relevant to fostering critical thinking (Deta et al., 2021). The topic of renewable energy, closely tied to global sustainability efforts, aligns with the Sustainable Development Goals (SDGs), particularly the goal of ensuring access to affordable and clean energy (Setyowati et al., 2022). By exploring renewable energy issues, students not only learn about science but also understand their role in addressing climate change and supporting sustainable practices (Elavarasan et al., 2020).

The Project-Based Learning (PjBL) model, combined with Science, Technology, Engineering, and Mathematics (STEM) education, offers a powerful framework for addressing renewable energy topics. PjBL-STEM emphasizes student-centered learning through projects that solve real-world (Trichkova-Kashamova et al., 2024). This approach enhances student engagement and helps them develop critical competencies such as collaboration, creativity, and discipline (Kain et al., 2024). In the context of physics education, PjBL-STEM can be enriched with tools like student worksheets to guide experiments and problem-solving activities (Mezinska et al., 2024).

Despite its potential, current physics education practices often fail to adequately develop CPS and entrepreneurial skills. Surveys show that many teachers face challenges in designing and implementing effective learning programs due to time constraints and a lack of resources (Friedrich et al., 2024). Moreover, existing teaching materials, such as worksheets, are rarely integrated with PjBL-STEM principles, further limiting their effectiveness in promoting 21st-century skills (Wijnia et al., 2024). Addressing these gaps requires innovative approaches that connect theoretical knowledge with practical, real-world applications (Gao et al., 2020).

As the world grapples with environmental changes and energy crises, integrating renewable energy education into school curricula becomes increasingly urgent (Kaldaras et al., 2024). PjBL-STEM offers a solution by linking global sustainability challenges to classroom learning (Palid et al., 2023). By engaging with renewable energy topics, students gain a deeper understanding of the interplay between science and societal needs, empowering them to contribute to sustainable development efforts (Matthews et al., 2024). This approach also prepares students to address global challenges by equipping them with the skills needed to innovate and collaborate effectively (Zulyusri et al., 2023).

Project-Based Learning (PJBL) integrated with STEM (Science, Technology, Engineering, and Mathematics) and Socio-Scientific Issues (SSI) is an innovative educational approach aimed at enhancing students' learning experiences by connecting academic knowledge with real-world issues (Hasibuan et al., 2022). PJBL encourages active student participation, critical thinking, and problem-solving skills by engaging students in long-term projects that address complex, real-world problems (Subiki et al., 2023). This method promotes deep learning, as students are required to collaborate, think critically, and apply their knowledge in practical contexts. When integrated with STEM, PJBL allows students to explore interdisciplinary topics, fostering a deeper understanding of how scientific principles can be applied in engineering, technology, and mathematics fields to solve societal problems (Nuraini et al., 2023).

On the other hand, SSI involves integrating social and ethical issues related to science and technology into learning. This approach allows students to understand the broader implications of scientific discoveries and innovations on society and the environment (Dusturi et al., 2024). By incorporating SSI into STEM education, students can see how their learning is directly related to real-world challenges, especially those concerning sustainability and societal well-being (Yani & Afrianis, 2022). The combination of PJBL-STEM with SSI promotes not only scientific and technical skills but also critical thinking, ethical reasoning, and the ability to engage in informed debates on complex issues (Ardiansyah et al., 2020).

Incorporating these approaches into physics education, especially in renewable energy topics, can significantly enhance students' ability to collaborate, solve problems, and think entrepreneurially (Wijnia et al., 2024). These skills are crucial for developing students' 21st-century competencies and preparing them for future careers in science, technology, and innovation. By focusing on real-world issues like renewable energy, students can gain a better understanding of global challenges and contribute to sustainable solutions through collaborative efforts and entrepreneurial thinking (Rahmania, 2021). Therefore, integrating PJBL-STEM with SSI offers a powerful framework for addressing the educational needs of the future generation (Afrijhon et al., 2022).

This study aims to bridge the gap between the urgency of 21st-century skill development and the shortcomings of current physics education practices (Kurniahtunnisa et al., 2023). By developing a renewable energy learning program based on SSI integrated with PjBL-STEM, the research addresses critical gaps in teaching methodologies (Ginting et al., 2023). Unlike previous studies that focused on isolated aspects of skill enhancement, this research combines CPS, entrepreneurial skills, and renewable energy education into a cohesive framework. This comprehensive approach not only aligns with global sustainability goals but also prepares students to tackle real-world problems with creativity, collaboration, and innovation.

Method

This research is a preliminary study aimed at determining the needs of teachers and students in the learning process, particularly in the context of physics subjects related to renewable energy. This study uses a mixed-method approach, and the strategy employed is the Sequential Explanatory Design by combining both qualitative and quantitative data collection and analysis. The selected research method involves a survey conducted among 24 high school physics teachers in Lampung Province, using Google Forms. The collected data was then selected and analyzed to identify and address these educational needs.

The questionnaire consisted of 20 questions for teachers. These questions covered personal background information, teaching aids, and the learning process in programs utilizing SSI strategies to enhance students' collaborative problem-solving and entrepreneurial skills. Additionally, the questionnaire aimed to align learning objectives with the Sustainable Development Goals (SDGs). Each aspect contained open-ended questions, allowing for a variety of perspectives from the respondents. The questionnaire was randomly distributed to high school physics teachers. The collected data was then selected and analyzed to identify and meet these educational needs. The survey results were analyzed by calculating the percentage of responses for each item, and the interpretation of respondent answers was presented in descriptive narrative form, categorized as very good, good, fairly good, and not good. Both studies share equal priority with triangulation and integration. The schematic research design can be seen in the following figure.

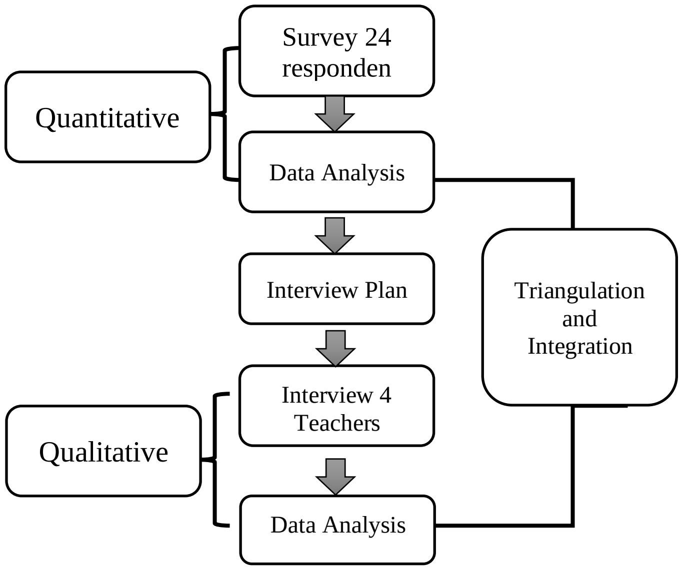

Figure 1. The Schematic Research Design

Figure 1 illustrates the schematic research design in the stages of sequential research, starting with quantitative research followed by qualitative research, adhering to the stages of the sequential explanatory design. Quantitative data collection and analysis (survey of 24 respondents) are used to test or generalize based on the initial findings, and qualitative research is conducted to build upon these initial findings (interviews with 4 teachers). Instruments are developed based on the findings from the initial stage to obtain overall prevalence on a larger scale.

Result and Discussion

The results and discussion of the data obtained in the form of a questionnaire related to the learning program on the topic of renewable energy integrated within the PjBL-STEM context are presented in Figure 2.

Based on Figure 2, the analysis of teacher needs in A1 shows that 54.20% of teachers are unfamiliar with the Socio-Scientific Issues (SSI) approach, while 45.80% are familiar with it. This gap highlights that many teachers have yet to connect science with relevant social issues. However, the SSI approach is essential for enhancing students' critical and analytical thinking. Teachers unfamiliar with SSI tend to use conventional methods, which are not always relevant to students' social contexts and real-life situations. Therefore, more training and outreach are needed to address this knowledge gap so that the SSI approach can be more widely implemented in education.

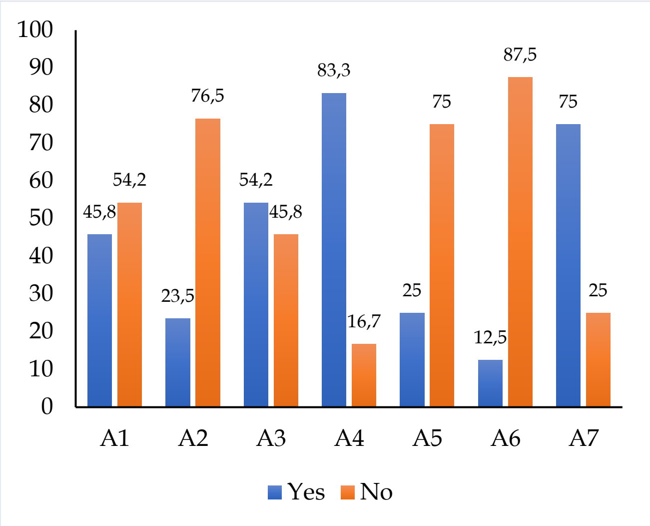

Figure 2. Analysis Results of Teacher Needs

Explanation:
A1 = Teacher's knowledge of the SSI (Socio-Scientific Issue) approach.
A2 = Implementation of student worksheets integrated with the PjBL-STEM learning model.
A3 = Knowledge of the Sustainable Development Goals (SDGs) in education.
A4 = Teacher's experience in creating biogas as a form of utilizing renewable bioenergy sources.
A5 =Teacher's experience in assessing students' Collaborative Problem Solving skills in learning.
A6 =Teacher's experience in assessing students' Entrepreneurial Skills in learning.
A7 =Teacher's challenges in the process of teaching renewable energy topics.

In A2, 76.50% of teachers have not applied the PjBL-STEM learning model to renewable energy topics, while 23.50% have. PjBL-STEM has significant potential in comprehensively connecting science and technology concepts. This method allows students to learn through real projects that involve developing analytical and technical skills. The percentage of teachers who have not implemented this method may be due to a lack of understanding of how to design student worksheets and skills in managing project-based learning. Additional training is essential to help teachers effectively integrate PjBL-STEM into renewable energy education.

Teachers' knowledge of the Sustainable Development Goals (SDGs) in education, as shown in A3, reveals that 54.20% of teachers are familiar with the concept, while 45.80% are not. SDGs, particularly goal 4 related to quality education, are highly relevant for improving the quality and accessibility of education. Teachers who understand SDGs are better equipped to integrate sustainability principles into their teaching materials and pedagogical approaches. However, for teachers unfamiliar with SDGs, more efforts are required to enhance their understanding through training and seminars, enabling them to play a role in conveying sustainability concepts to students.

In A4, 83.30% of teachers have never created biogas as a form of renewable energy from bioenergy, while 16.7% have. Biogas as a renewable energy source can be used in teaching to introduce students to sustainability and environmentally-friendly energy concepts. Teachers who have implemented biogas projects have likely seen the benefits of helping students understand the process of converting natural resources into usable energy. To encourage more teachers to engage in such projects, support in the form of practical training and adequate facilities is necessary.

As seen in A5, 75% of teachers have not assessed students' Collaborative Problem Solving (CPS) skills in learning, while 25% have. CPS is an essential skill in the modern era, demanding collaboration and the ability to solve complex problems. CPS skills can be assessed through projects or group activities that require cooperation to solve problems. Teachers who have already assessed these skills can serve as examples for others in applying evaluations of CPS skills, which are beneficial for students' development.

In A6, 87.50% of teachers have not assessed students' entrepreneurial skills in teaching physics-related renewable energy topics, while only 12.5% have. Integrating entrepreneurship into renewable energy topics helps students develop creativity, innovation, and business skills by identifying economic opportunities in renewable energy. Teachers who have assessed these skills often involve students in practical projects, such as designing renewable energy devices or conducting business simulations. These entrepreneurial skills allow students to not only understand renewable energy concepts but also see them as practical solutions and business opportunities in the future.

The challenges in teaching renewable energy, as revealed in A7, show that 75% of teachers face difficulties, while 25% do not. Most teachers struggle with this material due to limited resources, such as a lack of teaching aids and facilities needed for practical demonstrations. Insufficient technical knowledge and curriculum support also pose barriers to effectively teaching renewable energy. To address these challenges, additional training, improved facilities, and curriculum development are needed to better support renewable energy education in schools.

The following are the results of interviews conducted with several teachers regarding programs utilizing SSI strategies to enhance students' collaborative problem-solving and entrepreneurial skills. These interviews aim to gain deeper insights into school practices regarding whether such programs have been implemented. The data collected has been summarized in the table below to facilitate understanding and analysis. The following table is presented. The questionnaire results were reinforced by interviews with four (4) high school teachers in Bandar Lampung. The interview results are presented in Table 1.

Table 1. Interview Results with Teachers

Questions	Response Questions
What do you know about the SSI (Socio-Scientific Issue) approach?	• An approach that represents issues or problems in social life that are conceptually closely related to science, offering relatively subjective solutions.
Do you use student worksheets integrated with the PJBL STEM model when teaching Renewable Energy?	• No, we still adopt and modify according to the school's conditions because it can be confusing to start. • There hasn't been an opportunity to create one. • We don't use student worksheets because we adjust it to classroom conditions.
What do you know about the term Sustainable Development Goals (SDGs)?	• I know, SDGs are a series of sustainable development goals set by the UN. • Teaching is based on the need for the future due to environmental changes. • Sustainable education that can be used continuously.
How do you create biogas as a form of utilizing renewable energy from bioenergy?	• Digesting waste, fermented by bacteria that produce methane gas and other gases. • Students bring fresh fruit and vegetable peels, add water and brown sugar to aid fermentation. Everything is mixed in the given proportions and placed in an airtight container for 3 months, maintaining a pH below 4. Once ready, it is filtered
How do you assess students' Entrepreneur Skills?	• By observing how quickly and efficiently students solve problems during experiments. • By observing active communication or cooperation between students to achieve a common goal.
How do you assess students' Collaborative Problem-Solving skills?	• rom simple projects that provide solutions to existing issues and could be sold to the community. • Generating ideas based on lessons to pursue entrepreneurship. • Using project-based learning models can be an alternative to train entrepreneurial skills.
What challenges do you face in teaching renewable energy?	• Lack of information or knowledge about Renewable Energy. • Difficulty in understanding how to link materials that can be used as Renewable Energy. • Lack of images or explanatory videos.

This aligns with the questionnaire results, which show that most teachers have not yet used student worksheets integrated with the Project-Based Learning (PJBL) STEM model for renewable energy topics. Many teachers expressed difficulties in initiating the creation of structured student worksheets, primarily due to time constraints and a lack of understanding in developing worksheets that align with the PJBL STEM concept. Additionally, some teachers preferred adopting or updating existing materials to make implementation in the classroom easier, rather than creating new student worksheets from scratch. This situation is exacerbated by the limited opportunities or training provided to teachers to develop innovative and relevant student worksheets for their schools.

The questionnaire results clearly indicate that the implementation of Project-Based Learning (PjBL) integrated with STEM in the context of renewable energy content is not yet optimal in many schools. Although this approach is widely recognized for its potential to enhance students' problem-solving and entrepreneurial skills, there is still a significant gap in its effective application in the classroom. Teachers report that while they understand the theoretical benefits of PjBL-STEM, many struggle to implement it effectively due to a lack of structured resources, adequate training, and guidance on how to integrate this model into their existing curriculum.

Moreover, despite the growing awareness of the importance of teaching skills such as collaboration, creativity, and critical thinking, many educators still face challenges in adapting their teaching methods to incorporate these elements in a meaningful way. The results of the survey highlight the need for more comprehensive support systems that can provide teachers with practical tools, resources, and professional development opportunities. Structured training programs would empower educators to confidently apply PjBL-STEM strategies in their classrooms, ensuring that students benefit from this innovative teaching approach. Therefore, it is clear that for PjBL-STEM to be fully effective in promoting 21st-century skills in students, a concerted effort to support teachers through continuous training and resource development is essential.

Conclusion

This study shows that the majority of physics teachers in Lampung Province are not familiar with the SSI approach 54.20% and have not applied PJBL-STEM in teaching renewable energy 76.50%. The lack of understanding of SSI and the low implementation of PJBL-STEM methods reflect the need for further training and increased support to integrate these approaches into teaching. Additionally, many teachers have not utilized biogas as a practical example of renewable bioenergy 83.30% and have not assessed Collaborative Problem Solving (CPS) skills 75%, which are important for developing 21st-century skills.

The majority of teachers also have not assessed students' entrepreneurial skills in the context of renewable energy, particularly bioenergy 87.50%. These skills are essential for fostering innovation and economic opportunities in the use of renewable energy sources like bioenergy. Most teachers face challenges in teaching renewable energy topics, including limited facilities and technical knowledge 75%. To improve the quality of teaching, further training is needed for teachers on SSI approaches, PJBL-STEM, CPS skills, and entrepreneurship. Support in the form of better facilities and a more comprehensive curriculum is also needed to encourage the integration of renewable energy topics in schools, in line with sustainability principles and the SDGs.

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Author Contributions

Research design, S.R., A and K.H..; Data collection, S.R.; Data curration and analysis, S.R and A.; Validation, C..E., I. W. D., S dan S.U.; Writing Article, S.R.; Review and Editing, S.R. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

There are no conflicts of interest.

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