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Integrating seaweed ethnoscience with STEM-PjBL in renewable energy learning: Could this approach develop creativity and entrepreneurial skills?

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ABSTRACT

The urgency of this research stems from the lack of application of the Ethnoscience-STEM-PjBL (Science, Technology, Engineering, and Mathematics - Project-Based Learning) approach in renewable energy learning, the limited availability of teaching materials based on local wisdom, and the lack of supporting learning resources. This study aims to describe the perceptions of teachers and students toward renewable energy learning using this approach to foster creativity and entrepreneurial skills. This research employed the sequential embedded design method, involving 30 physics teachers from Lampung Province. Data were gathered through questionnaires and analyzed descriptively. The findings reveal that while teachers generally hold positive perceptions of the Ethnoscience-STEM-PjBL approach, most have yet to implement it in their classrooms. The implication of this study highlights the urgent need to develop culturally relevant teaching materials and provide targeted teacher training. Such efforts are essential to facilitate the effective integration of the Ethnoscience-STEM-PjBL model in renewable energy education, thereby enhancing both student engagement and the relevance of science learning in local contexts.

Integrasi etnosains rumput laut dengan STEM-PjBL dalam pembelajaran energi terbarukan: Apakah pendekatan ini dapat melatih kreativitas dan keterampilan kewirausahaan?

Kata Kunci:

berpikir kreatif, keterampilan kewirausahaan, etnosains, energi terbarukan, pendidikan STEM

ABSTRAK

Urgensi penelitian ini berasal dari rendahnya penerapan pendekatan Ethnoscience-STEM-PjBL (Science, Technology, Engineering, and Mathematics - Project-Based Learning) dalam pembelajaran energi terbarukan, keterbatasan ketersediaan bahan ajar berbasis kearifan lokal, serta kurangnya sumber belajar yang mendukung. Penelitian ini bertujuan untuk mendeskripsikan persepsi guru dan siswa terhadap pembelajaran energi terbarukan dengan pendekatan ini dalam upaya melatih kreativitas dan keterampilan kewirausahaan. Dengan menggunakan metode Sequential Embedded Design, penelitian ini melibatkan 30 guru fisika dari Provinsi Lampung. Data dikumpulkan melalui angket dan dianalisis secara deskriptif. Temuan menunjukkan bahwa meskipun para guru umumnya memiliki persepsi positif terhadap pendekatan Ethnoscience-STEM-PjBL, sebagian besar dari mereka belum menerapkannya dalam kegiatan pembelajaran. Implikasi dari penelitian ini menekankan perlunya pengembangan bahan ajar yang relevan secara budaya dan pelatihan guru yang terarah. Upaya tersebut penting untuk mendukung integrasi model

Ethnoscience-STEM-PjBL secara efektif dalam pembelajaran energi terbarukan,

Contribution to the literature

This research contributes to:

- Developing learning strategies by integrating the Ethnoscience-STEM-PjBL approach in renewable energy learning, focusing on creative thinking and entrepreneurial skills.
- Expanding the perspective on implementing ethno-stem in teaching renewable energy, particularly in coastal areas, to enhance students' awareness of local resources.
- Offering insights into teachers' perceptions and challenges in implementing Ethno-STEM-based renewable energy learning, serving as a reference for curriculum development.

1. INTRODUCTION

The increased human population results in high energy consumption every year. Therefore, endless energy consumption has an impact on environmental damage [1], [2]. Continuous consumption of large amounts of energy without using alternative energy will be fatal to human survival [3]. People need to find sustainable solutions to solve energy problems, one of which is by using bioethanol as an alternative fuel [4]–[6]. Bioethanol is a type of fuel derived from plants that have properties similar to oil [1], [7]. Generally, bioethanol is produced from biomass containing carbohydrates, such as corn, tubers, rice, and sorghum. However, biomass materials are considered staples in the food and feed sector so it is difficult to be the main ingredient in the production of bioethanol in large quantities [8]. One biomass material that is not a staple raw material for the food and feed sector is seaweed [9]. However, the use of seaweed as an ingredient in making bioethanol is still not widely done because of the lack of research and further investigation on this matter [10]. Lampung has areas with many beaches. People who live in areas adjacent to the beach often cultivate seaweed to be sold or processed into food raw materials with low selling value [10]–[12]. The limited knowledge of the community regarding the potential of seaweed as an alternative energy fuel is a problem and challenge that must be resolved by the education sector in the surrounding area.

As the main pillar in increasing community understanding, the education sector has an important role in educating the younger generation about the utilization of local natural resources as alternative energy. One way that can be applied is the project-based learning in school [13], [14]. In this case, the STEM-PjBL approach is considered effective in facilitating renewable energy learning in schools [15], [16]. Besides, learning with STEM projects can train creative thinking skills, which are the demands of 21st-century skills [16], [17].

Ethnoscience is one of the most popular learning strategies and has been implemented in many learning activities [18]–[20]. Carrying the theme of local wisdom found in the environment around students [21], the collaboration between STEM-PjBL and ethnoscience is one of the learning approaches that can train students' 21st-century skills [22], [23]. Creative thinking is required in 21st-century skills. It includes finding ideas to solve a problem [24], [25]. Entrepreneurship is assumed to be one of the variables associated with creative thinking [26]. Problem-solving activities encourage the birth of

innovations, a skill that must be possessed by an entrepreneur [27], [28]. Integrating entrepreneurial skills in students is the basic capital to face the challenges of the current industrial revolution 4.0 in the future [27], [29], [30]. Entrepreneurial skills can train students to create opportunities from a limitation [16], [31].

Ethnoscience-based learning integrated with STEM-PjBL in learning renewable energy has been proven to train students' creative thinking skills and entrepreneurial skills [22], [32]. This claim is supported by previous research indicating that STEM integrated with ethnoscience can influence creative thinking skills and foster entrepreneurial abilities [33], [34]. Other research also proves that Ethno-STEM can train mastery of science concepts [35], [36], creative thinking, environmental attitudes [37], and conservation and entrepreneurial character [38]. Other similar research proves that Ethno-STEM based on trait treatment interaction (TTI) can develop students' critical and creative thinking [39].

The results of the preliminary research analysis conducted on students revealed that only 37% of teachers encouraged students to engage in project activities during learning sessions. Additionally, 53% of teachers were aware of ethno-STEM learning; however, the implementation of Ethnoscience and STEM in renewable energy education had not been widely practised in schools. Most teachers relied on scientific methods and discussions when teaching about renewable energy. Furthermore, teachers encountered several obstacles in delivering lessons on renewable energy. Specifically, 53% of teachers found it challenging to analyze materials with the potential to become alternative energy sources. They also faced limitations in available learning media, lacked sufficient knowledge and information about local energy sources, and had restricted access to devices and props necessary for practical activities on renewable energy. Although most teachers created worksheets independently, 67% had not yet developed worksheets integrating STEM-PjBL for renewable energy topics.

Additionally, props, practicum tools, or hands-on activities related to global issues, particularly renewable energy, were still needed. Moreover, 73% of students were unaware of energy sources that could be processed into renewable energy. This lack of awareness resulted from limited learning media and insufficient information or explanation regarding alternative energy concepts derived from natural resources. Therefore, designing an effective learning program became essential.

Research has been done on bioethanol as a renewable energy, especially from raw materials such as corn, rice, and sorghum [1], [40]. However, the limitations of these materials in the food sector encourage the search for other alternatives, such as seaweed, which is abundant and does not compete with food needs [41]. In education, STEM-PjBL and ethnoscience approaches have been proven effective in improving science understanding, creative thinking, and environmental awareness [24], [33], [34]. However, its implementation in renewable energy learning is still limited, especially regarding the utilization of bioethanol from seaweed [6], [8]. In addition, the lack of learning media and limited information is still an obstacle in schools. Therefore, this research focuses on developing an Ethnoscience-STEM-PjBL-based learning program to train students' creative thinking and entrepreneurial skills in the context of renewable energy.

The unavailability of learning programs that can facilitate ethnoscience-based renewable energy learning integrated with STEM-PjBL to train creative thinking skills and entrepreneurship was an opportunity for researchers to develop learning programs. Therefore, it was necessary to further investigate teachers' perceptions of the need for this learning program. This study provides empirical data on teacher perceptions of ethno-STEM-based renewable energy learning that can serve as a reference in curriculum development relevant to the needs of coastal areas. This study aimed to describe teachers'

perceptions of learning programs using the ethnoscience approach of seaweed cultivation integrated with STEM-PjBL to train students' creative thinking and entrepreneurial skills in order to adapt to the evolution of industry and society in the future.

2. METHOD

The method employed was a mixed method with a sequential embedded design. This approach combined quantitative and qualitative methods carried out sequentially or simultaneously with different weights, according to the research objectives. This research was conducted in high schools and vocational schools in Lampung, Indonesia, involving 30 physics teachers as research subjects. Data were collected through questionnaires distributed online using Google Forms to explore teachers' perceptions of the learning approach. The data obtained from the questionnaire was then analyzed using quantitative and qualitative approaches.

Furthermore, quantitative analysis was carried out by calculating the percentage of respondents' answers for each question item on the questionnaire. The results were then presented in tables and percentages that illustrate the distribution of respondents' answers. The qualitative results were presented in quotations that support the interpretation of the data. This research obtained ethical approval and was conducted in compliance with the principles of research ethics, including in the aspects of writing and citing.

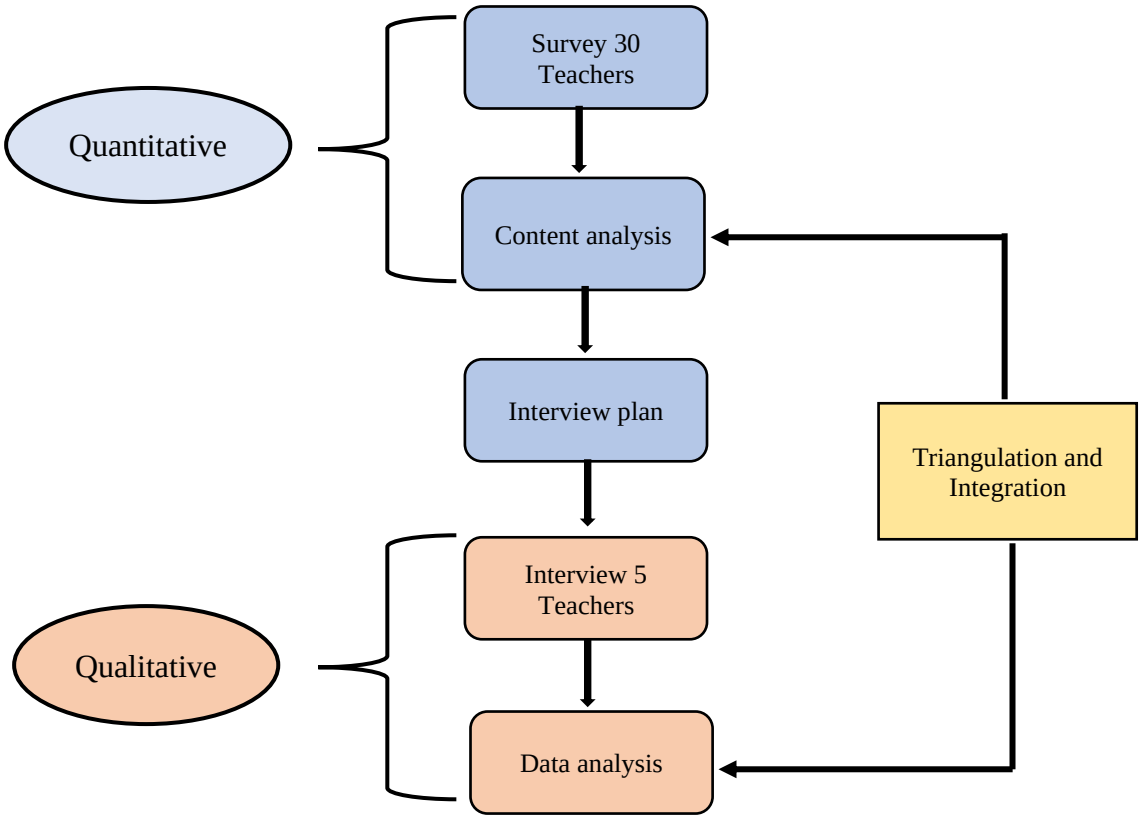

Figure 1. Research Design Scheme

3. RESULTS AND DISCUSSION

The questionnaire results provided an overview of teacher perceptions of the application of the ethnoscience approach integrated with the STEM-PjBL learning model in training students' creative thinking abilities and entrepreneurial skills. The questionnaire was designed with several main indicators, such as teachers' understanding of the concepts

of ethnoscience and STEM-PjBL, teachers' understanding of student's creative thinking and entrepreneurship skills, and teachers' understanding of the potential of renewable energy sources in their area and the need for appropriate teaching materials and learning strategies. The results of the analysis showed that most teachers did not have an adequate understanding of the concepts of ethnoscience and STEM-PjBL. Also, there were some obstacles in its implementation, such as limited resources and student readiness. The result can be seen in Table 1.

Table 1. The Interpretation Results of the Teacher Perception Questionnaire

Number	Question	Percentage (%)	
		Yes	No
1	Teacher's Understanding of Ethnoscience	42	58%
2	Teachers' understanding of creative thinking skills	73	37
3	Teachers' understanding of entrepreneurship skills	33	67
4	The use of Stem-PjBL integrated teaching materials	33	67
5	The use of teaching materials that implement ethnoscience	40	60
6	Teachers' understanding of local energy sources in their area	55	45
7	Teachers' understanding of managing the potential of local natural resources into alternative energies	83	17
8	The use of interactive teaching materials during class	68	32
9	Teachers measure initial skills before teaching	75	25
10	The need for renewable energy materials	98	2
11	The need for classroom teaching strategies	96	4

The results showed that 58% of teachers were not aware of ethnoscience due to their habit of teaching using a single approach and the lack of literacy and exploration of diverse teaching strategies that could make classroom learning more engaging. A total of 55% of teachers understood the potential of natural resources as alternative energy raw materials in their area. Furthermore, regarding teachers' understanding of creative thinking skills, the findings were quite positive, with a percentage of 73%. This indicated that, in conducting classroom learning, teachers had implemented strategies that trained students' creativity. However, the percentage for entrepreneurial skills was low at 33%, suggesting challenges in integrating these skills into physics learning. One contributing factor to this gap was the theoretical nature of physics, which focused more on science-based problem-solving and was often less directly linked to entrepreneurial aspects. Although creative thinking skills could serve as a foundation for developing an entrepreneurial mindset, entrepreneurial skills also require an understanding of management, marketing, and product innovation, which may not have been sufficiently emphasized in physics education [38].

The use of teaching materials is an important factor in training students' creativity and entrepreneurial skills, especially project-based teaching materials. However, only 33% of teachers applied project-based teaching materials, and only 40% linked their teaching materials with local wisdom in their area. Teachers' understanding of local natural resources in their region was also relatively low, at 55% of the total sample. As a result, teachers had limited knowledge of how to manage local natural resources into renewable energy products or alternative energy sources. In addition, 32% of teachers had not used interactive teaching materials. Therefore, most teachers responded positively to the design of learning programs that incorporated teaching materials based on STEM-PjBL and ethnoscience for teaching physics concepts, particularly on renewable energy.

The results of the teacher response statements indicated that teachers understood ethnoscience as a learning approach that linked science with local wisdom. Teachers who grasped the concept of ethnoscience were better able to connect learning—especially

physics material—with local culture, making the learning experience more meaningful and relevant to students' lives. Relevant research also suggested that integrating culture into learning environments enhanced students' creativity in thinking [42]. When students saw that physics learning was directly related to their surrounding culture and environment, they were motivated to learn. In addition, integrating ethnoscience into STEM-PjBL-based learning provided a meaningful learning experience. Through project-based learning, students could explore and develop innovations in various aspects of local culture using a systematic scientific approach.

This approach encourages students to think critically and creatively. As relevant research proves, the STEM-PjBL approach trains students' creativity [43], [44] because students not only understand traditional technology but also adapt and improve its effectiveness using STEM principles. They identified creative thinking skills as the ability to generate ideas and think outside the box, while entrepreneurial skills were associated with innovation and the creation of economic opportunities [45]. In practice, creative thinking is trained through discussion and problem-solving, while entrepreneurship is developed by encouraging students to create products of economic value. Relevant research also mentions that project-based STEM can improve students' entrepreneurial skills [45], [46]. Teachers who understand these two concepts and implement them in classroom learning can help students connect science with their daily lives, not only improving academic understanding but also encouraging students to create local wisdom-based solutions that can benefit their environment.

However, the implementation still faced obstacles, such as limited project-based teaching materials and a lack of learning resources on renewable energy. Teachers mostly used modules, reference books, and the internet, applying scientific, STEM, and contextual approaches. They agreed that integrating ethnoscience with STEM-PjBL is necessary to train students' creativity and entrepreneurial skills, highlighting the need to strengthen the development of teaching materials and learning resources. The results of the teacher response statement can be seen in Table 2.

Table 2. Results of Teacher Response Statement

Number	Question	Teacher's Response
1	What do you know about ethnoscience learning?	Learning that connects with local wisdom Science learning and local knowledge
2	What are creative thinking skills?	Generating ideas Thinking out of the box
3	How do you train creative thinking skills in physics learning?	Discussing and practicing solving problems Ask essential questions
4	What are entrepreneurial skills?	Come up with ideas and innovations to make something of value Creative in creating opportunities
5	How do you train entrepreneurial skills in physics?	Provide opportunities for students to create a skill Teaching students to make products that have economic value
6	What teaching materials do you often use for learning?	Module Book Reference Student worksheet Internet
7	What kind of approach do you use to teach renewable energy?	Scientific STEM Contextual
8	What obstacles do you often encounter in learning renewable energy?	Lack of information and understanding about renewable energy

		Not understanding the materials that can be used as alternative energy sources Not many learning resources about renewable energy Lack of learning videos
9	Do you think an ethnoscience-based learning program integrated with STEM-PjBL would be necessary to train students' creative thinking and entrepreneurial skills?	Yes, for study materials Yes, as a variety of learning

Based on the research findings, the integration of ethnoscience-based renewable energy learning with STEM-PjBL was needed to create learning that is contextual and relevant to students' environments. The main obstacles faced by teachers, such as the lack of learning resources and understanding of alternative energy, indicated the need for a more applicable approach. With this method, students not only understand concepts more deeply but also develop creative thinking and entrepreneurial skills through the exploration of local resources. These findings confirmed that project-based learning and local wisdom could improve student engagement as well as the effectiveness of science learning [47]. Therefore, the development of teaching materials and teacher training are crucial steps to ensure optimal implementation. The design of the integration of ethnoscience and STEM-PjBL in the teaching program, which was developed based on interview results, can be seen in Figure 2.

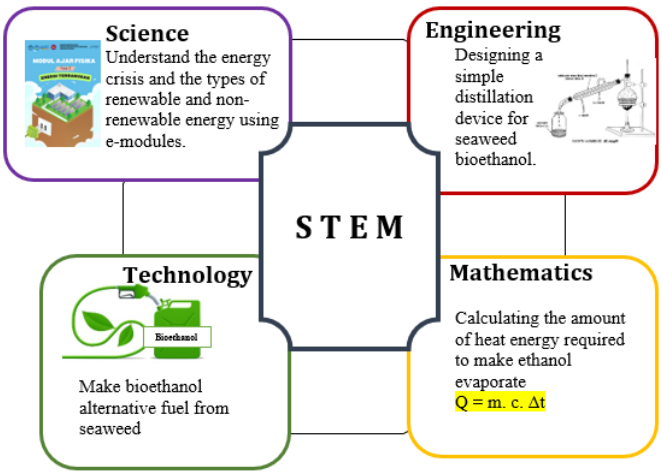

Figure 2. The Design of STEM Integration in Teaching Material

To overcome the limitations of teaching materials and increase the effectiveness of ethnoscience-based learning and STEM-PjBL, innovation in learning media is needed. One way that can be applied is the development of teaching materials in the form of electronic modules. Electronic modules are teaching materials that are efficiently designed and organized based on the curriculum. This allows more practical and flexible access through electronic devices, such as cell phones or laptops. By using electronic modules based on STEM-PjBL, learning can be more interactive and accessible, thus helping students understand the concept of renewable energy more deeply to train students' thinking skills [44]. E-modules can help teachers as one of the teaching materials and teaching references, and can help students to learn and read subject matter anywhere and anytime. Therefore, e-modules are effective for students and teachers in the teaching and learning process. In this study, physics concepts and renewable energy materials are

designed to be presented in learning modules that integrate ethnoscience and STEM-PjBL. In addition, the development of an e-worksheet was planned as a further step to train students' creative thinking and entrepreneurship skills. Through this e-worksheet, students will be directed to design alternative energy products in the form of bioethanol from seaweed with the right procedures to maximize the learning process.

This study had several limitations, including a small sample size and a focus on teachers' perceptions without considering students' perspectives, which are essential for evaluating the impact on creativity and entrepreneurship. The implementation of STEM-PjBL in renewable energy education was also constrained by teachers' limited understanding and inadequate facilities. Future research should expand the sample size, involve students, focus on teacher training, and assess both the immediate and long-term impacts on students' skills.

4. CONCLUSION

The survey results indicate that teachers have a positive perception of the STEM-PjBL integrated ethnoscience-based renewable energy learning program in fostering students' creative thinking and entrepreneurial skills. However, while most teachers have implemented STEM in schools, the application of STEM-PjBL remains limited, particularly in the context of renewable energy. This limitation is primarily due to a lack of understanding and inadequate school infrastructure to support effective learning. These findings highlight the need for developing teaching materials and providing teacher training to enhance the implementation of Ethnoscience-STEM-PjBL in renewable energy learning.

AUTHOR CONTRIBUTION STATEMENT

CRP contributed to collecting and analyzing the data, drafting the initial manuscript and editing. AA and KH contributed to designing the study and developing the research instruments. All authors have read and approved the final version of this manuscript.

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