

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?

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Abstract: This study aims to describe teachers' perceptions of the Socio Scientific Issue (SSI) approach integrated with the STEM-PjBL learning program in improving students' creative thinking skills on the topic of renewable energy. This research was conducted involving 27 Physics teachers in Lampung province. The method used in this research is mixed method with Sequential Explanatory Design. Data were collected using a questionnaire. The data were analyzed using descriptive analysis. The results of the needs analysis show that 82% of teachers have not used the STEM-PjBL learning model and 93% of teachers have never used the Socio Scientific Issue (SSI) approach in learning renewable energy. Approximately 70% of teachers have not used STEM-PjBL integrated LKPD, and 63% of teachers still use printed books as learning resources. The teaching materials used have not been able to improve creative thinking skills, where 52% of teachers have not used LKPDs that can improve these skills. Based on the results of the needs analysis that has been carried out, most teachers show a positive perception of the development of learning programs based on the Socio Scientific Issue (SSI) approach integrated with STEM-PjBL in improving students' creative thinking skills on the topic of renewable energy.

Keywords: Creative thinking skills; Learning programs; Renewable energy; Socio scientific issue; STEM-PjBL

Introduction

The national education system is currently faced with the problem of developing quality and globally competitive human resources (Fitriani et al., 2023). Education in the 21st century requires schools to be able to create students who are able to compete cognitively, skillfully, and master technology (Syaadah et al., 2023). 21st century skills must be possessed by every learner so that quality human resources can be realized (Syahana & Andromeda, 2021). Learners are required to master

21st century skills which include critical thinking, communication, collaboration and creativity which are important skill aspects that must be mastered by students at the primary to secondary education level (Winata et al., 2020). Creative thinking skills are one of the 21st century skills that must be mastered by learners (Altan & Tan, 2021; Hidayatullah et al., 2021). This skill can train learners in making the right decision when faced with a problem. Fostering creative thinking skills is very important in the world of education so that students can make the right decisions when faced with a

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problem (Paryumi, 2022). However, based on the results of PISA conducted by the Organization for Economic Cooperation and Development (OECD) shows that the creative thinking skills of high school students in Indonesia are still ranked 39 out of 41 countries in 2009, ranked 63 out of 64 countries in 2012, and ranked 60 out of 65 countries in 2015 (OECD, 2019). Therefore, it is important to improve creative thinking skills in school learning.

Other problems are also supported by the science education system in the world which is currently faced with global challenges to anticipate environmental changes related to sustainable development programs (Abdurrahman et al., 2023). Renewable energy is one of the global issues that needs to be followed up as one of the interesting concepts to be discussed in education (Febriansari et al., 2022). In line with the increasing need for energy sources that are increasing due to rapid development, both in the industrial, economic and population sectors (Anisa & Setyaningrum, 2022). This shows that Indonesia as a developing country still needs energy supply as a very important factor in supporting development. The decreasing world oil reserves have encouraged the government to reduce people's dependence on fuel oil and increase the utilization of renewable energy sources. The field of education plays a role in presenting solutions to solving the energy crisis problem through learning on the topic of renewable energy (Abdurrahman et al., 2023). However, the low implementation of environmental education and the use of ineffective learning strategies cause students and most teachers still have many misconceptions about how to process and implement renewable energy sources (Aksan & Çelikler, 2013). Therefore, teachers are required to use effective learning strategies through the selection of learning models and approaches that can prevent misconceptions and build students' conceptual knowledge of the topics taught (Amalia et al., 2023).

Education plays a role in presenting solutions to solving the energy crisis and improving 21st century skills through project-based learning on the topic of STEM-integrated renewable energy (Wicaksono, 2020; Podgórska & Zdonek, 2022). The project-based learning model that is suitable in answering these problems is the STEM-PjBL learning model which can train creative thinking skills, encourage students to be more active and creative in generating new ideas (Firmantara et al., 2023; Haatainen & Aksela, 2021). The STEM-PjBL model is a learning model that is very appropriate to be applied to improve students' higher-level thinking skills (Jayadi et al., 2020; Windasari et al., 2020). One of the high-level skills that can be trained is creative thinking skills. Successful implementation of STEM-PjBL can improve creative thinking skills and encourage students to be

more active in the learning process (Firmantara et al., 2023).

The development of the application of the STEM-PjBL model encourages the integration of this learning model with an approach. One approach that can be integrated with the STEM-PjBL model is the SSI (Socio Scientific Issue) approach. This approach presents social issues in society related to science in learning activities (Espeja & Couso, 2020). Renewable energy as one of the interesting global issues needs to be followed up and discussed in education (Febriansari et al., 2022). The SSI approach can train students in solving problems with various points of view, through discussion, and inference in determining decisions (Alimah, 2021). However, it should be noted that the use of the SSI approach in learning has not been widely adopted in Indonesia, especially in the context of renewable energy materials. This study contributes to the educational literature by evaluating teachers' perceptions of the integration of STEM-PjBL integrated SSI-based learning programs in improving students' creative thinking skills. The focus on improving creative thinking skills in the context of socio-scientific issues has relatively rarely been a major concern in previous research. In addition, the integration of the SSI approach with the STEM-PjBL model has not been comprehensively explored in the context of learning in Indonesia, especially for the topic of renewable energy. Therefore, based on the information above, and to meet the growing needs of education, the author has conducted research on the Development of an SSI-Based Renewable Energy Learning Program Integrated with STEM-PjBL to Improve Learners' Creative Thinking Skills.

Method

Research design and method should be clearly defined. This study used mixed methods, and the strategy used was Sequential Explanatory Design by combining qualitative and quantitative data collection and data analysis. This research was conducted in high schools in the mathematics and natural sciences department in Lampung province, Indonesia. The research subjects were 27 Physics teachers. Data were collected using a questionnaire created through google form and distributed online to find out the teacher's perception of the STEM-PjBL integrated SSI approach with teaching materials used during the learning process. The questionnaire made has three aspects including aspects of creative thinking skills, STEM-PjBL integrated teaching materials and the Socio Scientific Issue (SSI) learning approach. In the preliminary study, an instrument was used in the form of a teacher needs questionnaire and to find out information about the

learning approach used and the results of the analysis of teaching materials used by teachers during learning.

The questionnaire made has three aspects, namely creative thinking skills, STEM-PjBL integrated teaching materials and the Socio Scientific Issue (SSI) learning approach. Furthermore, the results of the questionnaire analysis of teacher needs were described in the form of a percentage, then interpreted qualitatively. The questionnaire uses a Guttman scale that has answer options according to the content of the question, namely: "Yes" and 'No' with scores of '1' and '0'. The results of the questionnaire were analyzed using the percentage of responses from each item and the results of the interpretation of the presentation of respondents' answers in the form of descriptive narratives categorized into very good, good, quite good, and not good. The results of the questionnaire were analyzed using the percentage of responses from each item submitted. These two studies have the same priority as triangulation and integration. The research design scheme can be seen in Figure 1 below.

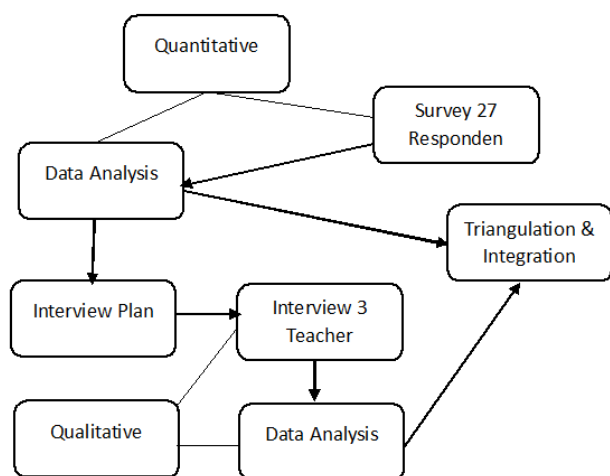


Figure 1. The schematic research design

Figure 1 is a schematic of the research design in sequential research stages, starting with qualitative research and continuing with quantitative research that follows sequential explanatory design stages (A. Shorten and J. Smith). Qualitative data collection and analysis were conducted in the initial stage. Based on the results of the exploratory analysis in the first stage. Then proceed to the next stage with quantitative methods (survey of 27 respondents) to test or make generalizations based on preliminary findings and interpret how the results of qualitative research are built with preliminary findings (interviews with 3 teachers). Build instruments based on the findings in the initial stage to get the overall prevalence in a larger scale

sample. Quantitative and qualitative data analysis was integrated and triangulated.

Result and Discussion

The data obtained in this study are based on data from interviews by three teachers and the results of filling out questionnaires. Interviews conducted with three high school physics teachers in Bandarlampung showed the following results.

a. First Physics Teacher

Based on the results of interviews conducted with the 1st teacher stated that the school has not used the STEM-PjBL learning model because it more often uses the guided inquiry learning model with an inquiry approach. The teaching materials used are also quite complete, however, there are no teaching materials or learning tools that have used the STEM PjBL integrated SSI approach. In addition, the teaching materials used have not been able to train students' creative thinking skills.

b. 2nd Physics Teacher

Based on the results of interviews that have been conducted with the 2nd teacher, it is stated that the school has used the PjBL learning model and learner-centered learning for renewable energy topics. However, the teacher has never applied the STEM-PjBL learning model or the SSI approach. Although the learning has been project-based and has linked issues related to the topic of renewable energy. The teaching materials used are also not SSI-based or integrated with STEM-PjBL.

c. 3rd Physics Teacher

Based on the results of interviews conducted with the 3rd teacher stated that the school had used a project-based learning model. However, this learning is rarely done due to limited teaching materials and practicum facilities. Therefore, renewable energy learning more often utilizes teaching materials such as e-books and learning videos available on the internet. The teacher has also never used the STEM-PjBL integrated SSI learning approach, due to the lack of supporting teaching materials and limited knowledge of the model or approach.

Based on the results of the interviews that have been conducted, it can be seen that some teachers have not implemented the SSI approach integrated with STEM-PjBL due to limited knowledge and teaching materials related to the approach or model. The results of this interview were also reinforced by the results of filling out a questionnaire conducted by 27 physics teachers in Lampung province. The results of filling out the google

form questionnaire regarding teacher perceptions of the Socio Scientific Issue approach using the STEM-PjBL integrated Learning Program in improving creative thinking skills can be seen in Table 1.

The results showed that as many as 82% of teachers considered that creative thinking skills are important to be trained in students. Creative thinking skills are very important to be trained in the world of education so that students can make the right decisions when faced with a problem (Afrijhon et al., 2022; Hasibuan et al., 2022; Kurniahtunnisa et al., 2023; Paryumi, 2022). However, preliminary study data obtained shows that 66% of teachers have never measured students' creative thinking skills, especially on the topic of renewable energy. This is reinforced by data showing that 71% of teachers do not know how to measure these skills. In addition, not a few teachers do not know how to apply the indicators of creative thinking skills in learning activities, so that students' creative thinking skills have not increased optimally. The statement is in accordance with preliminary study data which shows that, of the 27 teachers who filled out the survey, only 66% of teachers applied fluency indicators, 50% applied flexibility indicators, 45% applied originality indicators, and 26% applied elaboration indicators. The teaching materials used have also not been able to maximize creative thinking skills. Data shows that 52% of teachers have not used LKPDs that can train these skills. Ineffective teaching materials make teachers deliver learning using methods that tend to be conventional. This is supported by the results of the study, namely as many as 63% of teachers still lack learning resources, 52% of teachers have not used LKPD, 63% still use printed books, 56% have not used teaching modules and 63% still lack images and videos related to renewable energy topics. In addition to the lack of effective teaching materials, teachers also have not utilized learning media optimally where as many as 78% of teachers have not used the Internet of things as a learning medium for renewable energy and 63% of teachers have not used teaching aids on the topic. This causes 78% of teachers still lack understanding of how to relate materials that can be used as renewable energy and still lack information or knowledge on the topic. The data shows that learning programs that contain effective learning resources in renewable energy learning are still very much needed.

Table 1. Teacher perception questionnaire interpretation results

Question	Percentage (%)	
	Yes	No
Teachers who use the STEM-PjBL learning model in learning renewable energy	18	82

Question	Percentage (%)	
	Yes	No
Teacher who use LKPD in learning renewable energy	48	52
Teachers who use Modules in renewable energy learning	44	56
Teachers who use printed books in renewable energy learning	63	37
Teachers who have used the Internet of things as learning media in learning renewable energy	22	78
Teachers who lack understanding in linking materials that can be used as renewable energy	78	22
Teachers who still lack learning resources on renewable energy material	37	63
Teachers who still lack pictures and video explanations on the topic of renewable energy	37	63
Teachers who still lack information or knowledge on the topic of renewable energy	22	78
Teachers who have used the Socio Scientific Issue (SSI) approach to renewable energy learning	70	93
Teachers who have linked issues or problems in social life with science especially in learning Renewable Energy material	89	11
Teachers who have used props as supporting media in teaching renewable energy Guru yang sudah mengetahui tentang pendekatan SSI (Socio Scientific Issue)	37	63
Teachers who already know about the SSI approach (Socio Scientific Issue)	22	78
Teachers who have used the SSI (Socio Scientific Issue) approach in learning Renewable Energy material	44	56
Teachers who have used Project-based LKPD	30	70
Teachers who have used STEM-PjBL integrated LKPDs	48	52
Teachers who have used LKPD that can improve creative thinking skills	82	18
Teachers who consider creative thinking skills important to be trained in students	34	66
Teachers who have measured students' creative thinking skills in renewable energy learning	71	39
Teachers who do not know how to measure students' creative thinking skills	66	34
Teachers who have implemented learning that provides opportunities for students to generate as many ideas as possible to the questions/problems presented (fluency) related to renewable energy topics	50	50
Teachers who have implemented learning that provides opportunities for learners to transfer ideas to others (flexibility) related to renewable energy topics	45	55
Teachers who have implemented lessons that provide opportunities for learners to provide various interpretations of a problem or		

Question	Percentage (%)	
	Yes	No
question presented (originality) related to the topic of renewable energy		
Teachers who have implemented lessons that provide opportunities for learners to add details to the meaning of solutions from original thoughts to ideas that are being developed (elaboration) related to the topic of renewable energy	26	74

The field of education plays a role in presenting solutions to the problem of energy crisis through the integration of energy-related problems into project-based learning on the topic of renewable energy (Ginting et al., 2023; Kalla et al., 2022; Mairizwan et al., 2022; Podgórska & Zdonek, 2022). The STEM-PjBL model is a project-based learning model that encourages students to solve realistic and contextual problems to provide meaningful learning (Astuti et al., 2019; Haatainen & Aksela, 2021; Setyowati et al., 2022). The STEM-PjBL model is a very appropriate learning model applied to improve students' higher order thinking skills (Ardiansyah et al., 2020; Lestari, 2021; Wahdah et al., 2023; Wahyu et al., 2023). However, the results showed that 82% of teachers have not used the STEM-PjBL learning model in learning renewable energy. Most teachers are more familiar with other learning models such as conventional learning models, problem-based learning models, discovery learning models and inquiry-based learning. The teaching materials used have also not been integrated with STEM-PjBL activities, the data shows 70% of teachers have not used STEM-PjBL integrated LKPD and 56% of teachers have not used project-based LKPD.

The development of the application of the STEM-PjBL model encourages integration with an approach. One approach that can be integrated with the STEM-PjBL model is the SSI (Socio Scientific Issue) approach. Learning with the SSI approach encourages teachers to link problems or issues that are trending in society to provide awareness to students that the learning carried out is closely related to everyday life (Deta et al., 2021; Dewi et al., 2023; Dusturi et al., 2024; Espeja & Couso, 2020). Renewable energy as one of the trending global issues in society is very suitable if taught with the SSI approach. But unfortunately, this approach has not been widely used by teachers, especially on the topic of renewable energy. This is supported by research data showing that as many as 93% of teachers have never used the Socio Scientific Issue (SSI) approach to renewable energy learning. Although 89% of teachers have linked issues or problems in everyday life, especially on this topic. However, the data shows that 63% of teachers do not know thoroughly about the SSI

approach. The results of teachers' questions and responses are in Table 2.

Table 2. Teacher questions and answers

Question	Question Answer
In teaching Renewable Energy material, what learning model do you usually use?	a. Problem Based Learning Model b. Project Based Learning Model c. Discovery Learning Model d. Inquiry Based Learning Model e. STEM-PjBL Learning Model f. Don't know the name of the learning model used
When teaching Renewable Energy material, what learning resources do you use in learning?	a. Reference Books b. LKPD c. Modules d. Learning Videos e. Internet
Which of the statements below are your obstacles in learning Renewable Energy?	a. Lack of teaching aids and practicum facilities to teach renewable energy material b. Lack of learning resources and teaching materials on Renewable Energy c. Lack of learning media and explanatory videos about renewable energy d. Lack of understanding to associate materials that can be used as Renewable Energy
What learning approach do you use in teaching Renewable Energy material?	a. Contextual approach b. Constructivism approach c. Inquiry approach d. STEM (Science, Technology, Engineering, Mathematics) approach e. Scientific approach f. SSI (Socio Scientific Issue) approach
Have you ever linked issues or problems in social life with science, especially in learning Renewable Energy material? If you choose "Ever" which of the following activities do you do in linking social issues or problems with science!	a. Present issues from a science knowledge perspective b. Evaluate social science issues presented c. Assess local, national and global impacts d. Make decisions related to social science issues e. Investigate problems f. Compare alternative solutions g. Determine solutions to be implemented h. Never
Have you ever read about the SSI (Socio Scientific Issue) approach? If you chose "Ever" which of the following statements is the definition of the SSI (Socio Scientific Issue) approach?	a. Approaches that represent issues or problems in social life that are conceptually closely related to science, have relative answer solutions b. Approaches that emphasize cooperation between students in the learning process

Question	Question Answer	Question	Question Answer
	c. Approaches that expose students to real problems that require solving		e. Guide learners to present the results of projects related to the concept being discussed
	d. Approaches that expose students to projects that demand problem solving, research, and application of knowledge in real contexts		f. Guide learners to present the results of projects related to the concept being discussed
	e. Approaches that expose students to projects that demand problem solving, research, and application of knowledge in real contexts		a. Guide learners into the context of the problem and inspire learners to be able to start investigating or investigating a problem related to the concept being discussed
	f. Never		b. Guide learners to choose reference sources related to the material to collect relevant sources of information according to the concept being discussed
Have you ever used the SSI (Socio Scientific Issue) approach in learning Renewable Energy material?	a. If you chose "Never" which of the following activities did you do in Renewable Energy learning	Does the LKPD that you use in the learning process already integrate STEM-PjBL? If you answer "Yes" which of the following statements are contained in the LKPD activities that you use?	c. Guide learners to conduct research and design a project related to the concept being discussed
	b. Presenting issues from a science knowledge perspective		d. Guide learners to test products or solutions to solve problems related to the concept being discussed
	c. Evaluating the social science issues presented		e. Guide learners to present the results of projects related to the concept being discussed
	d. Assessing local, national and global impacts		f. Guide learners to present the results of projects related to the concept being discussed
	e. Making decisions related to social science issues		a. Reference Books
	f. Investigating problems		b. LKPD
	g. Comparing alternative solutions		c. Modules
	h. Determining solutions to be implemented		d. Learning Videos
	i. Never		e. Internet
Have you used LKPD? If you answer "Yes" which of the following statements are used as supporting media in the LKPD that you use?	a. Learning Video	If you were asked to improve creative thinking skills which of the following learning resources could improve those skills?	
	b. PhET Simulation	In improving students' creative thinking skills in learning renewable energy, do you use LKPD? If you answer "Yes" which of the following statements are contained in the LKPD activity that you use?	a. Guide learners into the context of the problem and inspire learners to be able to start investigating or investigating a problem related to the concept being discussed
	c. Teaching Aids		b. Guide learners to choose reference sources related to the material to collect relevant sources of information in accordance with the concept being discussed
	d. Augmented Reality		c. Guide learners to conduct research and design a project related to the concept being discussed
	e. Virtual Reality		d. Guide learners to test products or solutions to solve problems related to the concept being discussed
	f. Internet of Things		
What are the activities in the LKPD that you use in learning renewable energy?	a. Guide learners into the context of the problem and inspire learners to be able to start investigating or investigating a problem related to the concept being discussed		
	b. Guide learners to choose reference sources related to the material to collect relevant sources of information according to the concept being discussed		
	c. Guide learners to conduct research and design a project related to the concept being discussed		
	d. Guide learners to test products or solutions to solve problems related to the concept being discussed		

Question	Question Answer
d. Guide learners to present project results related to the concept being discussed	
e. Guide learners to produce as much as possible the results of the project related to the concept being discussed. guide learners to conduct research and design a project related to the concept being discussed	
f. Guide learners to test products or solutions to solve problems related to the concept being discussed - guide learners to present project results related to the concept being discussed	
g. Guide learners to generate as many ideas or ideas as possible on the questions/problems presented	
h. Guide learners to transfer ideas or ideas to others	
i. Guide learners to provide various interpretations of a problem or problem. Guiding learners to give a variety of interpretations to a problem or question presented	
j. Guiding learners to add details to the meaning of solutions from original thoughts to ideas that are being developed	

A learning program is a series of planned learning activities including learning, teaching, and assessment activities. A learning program provides the basis for a cohesive and integrated learning process by outlining the learning and assessment processes (Ardiansyah et al., 2020). A learning program consists of teaching materials that contain learning activities. Learning activities are elaborated from learning syntax taken from a particular learning model. STEM-PjBL is a learning model that combines the process of inquiry-based activities to encourage students to contextualize projects with existing knowledge and experience, and communicate what has been learned as a result (Campbell & Speldewinde, 2022; Stohlmann, 2020; Wahono et al., 2020; Windasari et al., 2020). The application of STEM-PjBL has several advantages including being able to transfer knowledge and skills to real-world problems, increase learning motivation, and can improve students' math and science scores (Rasmi et al., 2023; Zulyusri et al., 2023). The development of the application of the STEM-PjBL model encourages the integration of this learning model with an approach, one of which is the SSI (Socio Scientific Issue) approach.

Learning with the SSI approach encourages teachers to link problems or issues that are trending in society to give students awareness that the learning carried out is closely related to everyday life (Yani & Afrianis, 2022). Figure 2 shows the appearance of the SSI-based renewable energy learning program integrated with STEM-PjBL in training students' creative thinking skills.

Renewable energy as one of the trendy global issues in society needs to be followed up and discussed in the world of education (Febriansari et al., 2022; Martín-Sánchez et al., 2022; Sossé et al., 2021; Weng et al., 2020). The socio scientific issue approach can provide benefits in learning, one of which is to improve students' creative thinking skills. The SSI approach can encourage students to develop cognitive abilities in contributing to solving problems rationally (Suwono et al., 2023). Improving creative thinking skills through the development of learning programs that integrate approaches and the use of learning models that contain problem-solving activities, especially energy problems, still needs to be done in an effort to meet the growing needs of energy sources (Anisa & Setyaningrum, 2022). One solution that can be done is through the implementation of a STEM-PjBL integrated SSI-based renewable energy learning program in improving students' creative thinking skills.



Figure 2. Display of the developed STEM-PjBL integrated SSI-based renewable energy learning program

Conclusion

Based on the results of the needs analysis that has been carried out, most teachers show a positive perception of the development of LKPD based on the Socio Scientific Issue (SSI) approach integrated with STEM-PjBL in improving students' creative thinking skills on the topic of renewable energy. This statement is reinforced by the results of the needs analysis which

shows that 82% of teachers have not used the STEM-PjBL learning model and 93% of teachers have never used the Socio Scientific Issue (SSI) approach in learning renewable energy. About 70% of teachers have not used STEM-PjBL integrated LKPD, and 63% of teachers still use printed books as learning resources. The teaching materials used have not been able to improve creative thinking skills, where 52% of teachers have not used LKPDs that can improve these skills.

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Author Contributions

Research design, A.T., K.H., and C.E.; Data collection, Writing article, Review and editing, A.T.; Data curation and analysis, A.T. and K.H.; Validation, K.H., C.E., and A. 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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