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The Effect of Socio-Scientific Inquiry Based Learning (SSIBL) Model Assisted by Nearpod on Students' Problem-Solving Skills on Alternative Energy Material

Helmina Pebriyanti[1], Yanti Sofi Makiyah[1*], Ernita Susanti[1], Luthfi Rahman[2]
[1]Universitas Siliwangi, Tasikmalaya, Indonesia
[2]Richard Hartmann Schule Berufliches Schulzentrum Für Technik III, Chemnitz, Germany

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ABSTRACT

Objective: *This study aims to examine the effect of implementing the Socio-Scientific Inquiry Based Learning (SSIBL) model assisted by Nearpod on students' problem-solving skills.* ***Method:*** *This research employed a quasi-experimental method with a nonequivalent control group design. The study involved experimental and control groups selected through a purposive sampling technique. Both groups were administered a pretest and a posttest. The instruments used in this study included a problem-solving skills test in the form of an essay questions and an observation sheet to assess the implementation of learning.* ***Results:*** *The findings of this research are as follows: (1) There was an increase in the average scores before and after the treatment. (2) The N-gain scores in both classes showed no significant difference (medium category), which was attributed to differences in instructional duration. (2) The implementation of SSIBL learning in both sessions were classified as high, with average percentages of 86.09% and 88.41%.* ***Novelty:*** *This research integrates SSIBL and Nearpod to improve students' problem-solving skills in alternative energy materials.*

INTRODUCTION

Education is a fundamental component of human development, as it fosters cognitive skills and shapes national character. In the era of globalization, the education sector has undergone significant transformations, particularly with the integration of 21st century educational principles. These changes necessitate curriculum reforms to align with global advancements and enhance educational quality. One such reform is the implementation of the Independent Curriculum (*Kurikulum Merdeka*), introduced to address the evolving demands of the global landscape (Indarta et al., 2022). The adoption of the Independent Curriculum has led to structural modifications in the education system, particularly at the high school level. Learning is now categorized into two phases: Phase E for grade 10 and Phase F for grades 11 and 12 (Pusat Kurikulum Dikbud Ristek, 2021). In phase E, physics education for grade 10 emphasizes contemporary global challenges, such as alternative energy materials (Kementerian Pendidikan dan Kebudayaan, 2022). As a results, students must develop essential competencies to support physics learning and meet the challenges of 21st century education.

Twenty-first-century education is centered on three core competencies: thinking, acting, and living in the world (Indarta et al., 2022; Jayadi et al., 2020). Thinking competencies include critical thinking, problem-solving, and creative thinking. Among these, problem-solving skills are essential for individuals to effectively address and resolve challenges (Jayadiningrat & Ati, 2018). The development of problem-solving skills plays a crucial role in equipping students with the necessary competencies to navigate real-life situations (Karmila et al., 2023). Furthermore, these skills are closely linked to the ability to integrate knowledge with real-world contexts. The ability to connect acquired knowledge with factual situations enhances one's capacity to construct understanding and engage in active thinking to generate solutions (Retno et al., 2019). Therefore, fostering problem-solving skills is crucial in preparing students to tackle the challenges of contemporary society.

Problem-solving skills in Indonesia, based on data from the Programme for International Student Assessment (PISA), remain relatively low (Simatupang & Ionita, 2020), which may impact students' learning outcomes. PISA data suggest that further efforts are required to enhance the quality of education in Indonesia, particularly in problem-solving skills, to meet future global demands (Babullah et al., 2024). The stages of problem-solving skills in learning include identifying the problem, posing questions, identifying assumptions, justifying solutions, producing alternate strategies, and evaluating the quality of a solution (Nitko & Brookhart, 2014). Identifying the problem involves students recognizing and analyzing the given problem description to understand its context. Posing questions refers to the process of formulating relevant inquiries related to the identified problem, which helps in deepening comprehension. Identifying assumptions requires students to express their underlying assumptions or hypotheses regarding the problem situation, enabling them to critically evaluate different perspectives. Justifying solutions involves students proposing and explaining possible solutions, particularly in the context of alternative energy. Producing alternative strategies allows student to explore additional approaches beyond the primary solution, fostering creative problem-solving. Finally, evaluating the quality of a solution entails assessing the effectiveness and feasibility of both primary and alternative solutions. These stages collectively strengthen students' capacity for critical thinking, enable systematic problem analysis, and facilitate the development of well-reasoned solutions to real-world challenges.

According to the findings of the preliminary study, State Senior High School 1 Tasikmalaya has adopted the independent curriculum, in which the grade 10 physics curriculum incorporates contextual content. However, conventional teaching models are still predominantly used in physics instruction. The post-COVID-19 conditions have contributed to a lack of student learning readiness, making it difficult for students to connect prior knowledge with new concepts. Furthermore, the preliminary study on problem-solving skills revealed that students' average scores fall into the low category, with an average achievement for only 39.56%. The implementation of ineffective learning models may be a contributing factor to students' limited problem-solving skills (Dewi et al., 2021). Several studies have attempted to enhance students' problem-solving skills by implementing various innovative learning models. Approaches such as Problem-Based Learning (PBL) are known to foster students' critical thinking and active participation during instructional activities (Hidaayatullaah et al., 2020; Lolanessa et al., 2020; Simanjuntak et al., 2021). Similarly, inquiry-based learning supports students in contextualizing problems and constructing their own understanding (Agustina et al., 2020; Hajrin et al., 2019; N. R. B. Santoso & Widodo, 2023). The Contextual Teaching and Learning (CTL) model has also been shown to help learners connect academic content with real-life situations (Buulolo et al., 2022; Kurniasih, 2021).

While these approaches have demonstrated effectiveness, they generally do not incorporate socio-scientific issues as a core component of instruction. Given that the independent curriculum emphasizes contextual and life-relevant learning, there is a growing need for pedagogical models that promote reflective thinking and social awareness. The SSIBL model addresses this need by encouraging students to engage with real-world scientific issues in a reflective and critical manner. However, its implementation in physics education, particularly on the topic of alternative energy, remains limited. Therefore, this study integrates the SSIBL model with digital learning support through Nearpod in the context of alternative energy. This combination offers a novel approach to enhancing students' problem-solving skills through a meaningful and socially relevant physics learning experience.

Building on the findings of the preliminary study, implementing a learning model that effectively strengthens students' problem-solving skills is crucial. One potential solution to address this issue is the Socio-Scientific Inquiry Based Learning (SSIBL) model. SSIBL is an inquiry-based learning approach that integrates scientific methods with social considerations (Levinson, 2018). Inquiry-based learning enables students to cultivate problem-solving skills through active engagement in educational activities (Aminulloh et al., 2020; Gunawan et al., 2020). The SSIBL model is built upon three core pillars: citizenship education, socio-scientific issues (SSI), and inquiry-based science education (Levinson, 2018). In the context of physics education, particularly in the study of alternative energy, the SSIBL model involves presenting socio-scientific problems related to alternative energy sources. The approach aims to improve students' problem-solving ability by fostering their capacity to analyze and assess scientific and social challenges in real-world contexts.

The SSIBL model is closely related to STEM education. The concept of Socio-Scientific Issues (SSI) in SSIBL integrates scientific concepts with the social context of everyday life. SSIBL learning encourages students to explore solutions to socio-scientific issues, which are inherently linked to STEM disciplines (Levinson, 2018). Moreover, the SSI context in SSIBL offers the advantage of utilizing scientific knowledge to address real-world challenges, thereby meeting societal needs through science-driven approaches (Alcaraz-Dominguez & Barajas, 2021; McGregor et al., 2023). The inclusion of SSI in STEM learning allows students to engage with subjects that are meaningful in real-world contexts and frequently discussed in society (Johnson et al., 2020). Furthermore, integrating real-world contexts into learning can strengthen students' capacity to apply acquired knowledge, thereby fostering a deeper understanding of the subject matter (A. M. Santoso & Arif, 2021).

Socio-scientific problems in physics education can be linked to contemporary issues in science and technology, such as the development and implementation of alternative energy sources. The content of SSI can be controversial, as addressing these issues requires both scientific and social perspective (Garrido Espeja & Couso, 2020; Leung et al., 2020). These issues are often relevant and widely discussed in various media from multiple perspectives (Nida et al., 2021). The SSIBL model is a student-centered approach in which students engage in asking questions, formulating problems, expressing opinions, and developing solutions to teacher-presented problems (Knippels & Van Harskamp, 2018). Addressing socio-scientific problems requires students to construct arguments and articulate their viewpoints, enabling them to apply classroom knowledge to real-world scientific and societal challenges (Mujahidin et al., 2021).

To support the implementation of SSIBL, Nearpod is integrated as a digital learning tool. Nearpod has been shown to enhance students' learning motivation by improving engagement, attention, and participation (Abdullah et al., 2022), and it is also able to support students' self-paced learning (Qiao, 2022). Additionally, Nearpod offers several advantages, such as a variety of interactive features, fostering active learning, promoting a focused learning attitude, and stimulating students' curiosity (Oktafiani & Mujazi, 2022). Therefore, the SSIBL model supported by Nearpod, can serve as an effective instructional approach in physics education, facilitating students' ability to express opinions, make informed decisions, and develop solutions related to alternative energy issues. This study aims to examine the effect of SSIBL assisted by Nearpod on students' problem-solving skills.

RESEARCH METHOD

General Background

A quasi-experimental approach with a pretest-posttest framework was implemented in this research to analyze differences between two groups (Creswell, 2012). The research was carried out in grade 10 at State Senior High School 1 Tasikmalaya during the even semester of the 2023/2024 academic year. A nonequivalent control group design was implemented, in which both groups underwent a pretest and a posttest to assess their abilities. The experimental group received instruction using the SSIBL model integrated with Nearpod, while the control group was instructed using the direct instruction model assisted by Nearpod.

Sample / Participants / Group

The population in this study comprises all grade 10 classes at State Senior High School 1 Tasikmalaya in the 2023/2024 academic year, totaling six classes. The sample was selected through purposive sampling, a method involving selection based on predefined criteria (Sugiyono, 2019). Two classes were chosen as research samples: class X-3 served as the experimental group, and class X-6 served as the control group.

Instrument and Procedures

This study utilized two types of instruments, namely test and non-test instruments. The test instrument was a problem-solving skills assessment consisting of six questions, of which four were deemed valid for use in this study. Each question incorporated all problem-solving skills indicators as defined by Nitko & Brookhart (2014), including identifying the problem, posing questions, identifying assumptions, justifying solutions, producing alternative strategies, and evaluating the quality of a solution. This instrument was administered to students before the treatment (pretest) and after treatment (posttest). Additionally, this study utilized a non-test instrument in the form of an observation sheet. The observation sheet was used to assess the implementation of each phase of the SSIBL model and was completed by three observers.

Data Analysis

Data obtained from observer assessments pertain to the implementation of SSIBL-based learning, as conducted by teachers from the beginning to the end of the learning process. The implementation was evaluated based on the adherence to the stage of the SSIBL model, using a scoring rubric (Firdausichuuriyah & Nasrudin, 2017). The percentage categories for learning implementation are presented in Table 1.

Table 1. Percentage Category of Learning Implementation

Score (%)	Criteria
0 – 20	Very bad
21 – 40	Bad
41 – 60	Enough
61 – 80	Good
81 - 100	Excellent

(Firdausichuuriyah & Nasrudin, 2017)

The pretest and posttest results obtained from students were then analyzed. The percentage score for each problem-solving skill indicator was calculated using the equation proposed by Mustofa & Rusdiana, (2016).

$$P_x = \frac{R_x}{ns_x} \times 100\% \quad (1)$$

Table 2 presents the criteria used to categorize problem-solving skill indicators based on the interval scores obtained from the test results.

Table 2. Problem-Solving Indicator Categories

Nilai	Category
$80 < P_x \leq 100$	Very high
$60 < P_x \leq 80$	High
$40 < P_x \leq 60$	Moderate
$20 < P_x \leq 40$	Low
$P_x \leq 20$	Very low

(Mustofa & Rusdiana, 2016)

Several data analysis techniques were employed in this study, including the normality test, which was assessed the distribution of the research data, and the homogeneity test, which evaluated the similarity of variances. Hypothesis testing was conducted using an independent sample t-test with a significance level of 0.01. Additionally, the N-gain test was used to measure the improvement in students' problem-solving skills, with the results interpreted based on the criteria presented in Table 3.

Table 3 N-gain Criteria

Value	Category
$g \geq 0.7$	High
$0.3 \leq g \leq 0.7$	Medium
$g < 0.3$	Low

RESULTS AND DISCUSSION

Results

The problem-solving skills test was administered as both a pretest and posttest in both classes, which received different treatments during the study. Table 4 presents the results of the study.

Table 4. Data Statistical of Pretest and Posttest of Problem-Solving Skills

Data	Pretest		Posttest	
	Experiment	Control	Experiment	Control
N	31	31	31	31
Minimum score	16	15	40	35
Maximum score	43	39	62	58
Ideal score	68	68	68	68
Average	31.03	26.52	51.97	47.90
Variance	45.10	39.39	38.50	26.22
Standard deviation	6.72	6.28	6.20	5.12

Based on Tabel 4, students who correctly answer all items will achieve a maximum score of 68, representing the ideal score. The data also indicate that the average pretest and posttest scores in the experimental class are higher than those in the control class. These results suggest that the SSIBL model assisted by Nearpod has a more positive impact on students' problem-solving skills compared to the Direct Instruction model assisted by Nearpod. The research data underwent further analysis using the N-gain test, with the findings summarized in Table 5. This test aimed to evaluate the improvement of students' problem-solving skills in both groups before and after the implementation of different learning models. The N-gain test results suggest that both groups fall within the same category, although a slight variation is observed in the obtained scores.

Table 5. N-gain Test Results

Class	N-Gain	Category
Experiment	0.57	Medium
Control	0.51	Medium

The two classes exhibited differences in their pretest and posttest score improvements. However, as presented in Table 4, the experimental class achieved a higher average posttest score compared to the control class. This variation indicates that applying the SSIBL model with Nearpod support is more effective than utilizing the Direct Instruction model with Nearpod assistance. Furthermore, this difference suggests that the SSIBL model, supported by Nearpod, has a positive impact and contributes to enhancing students' problem-solving skills.

Additionally, the posttest data were used for perquisite testing before conducting hypothesis testing. The Chi-square (χ^2) test was utilized to assess normality, yielding $\chi^2{}_{count}$ values of 10.88 in the group received the SSIBL and 8.77 in the group taught using the Direct Instruction model, with a critical value of $\chi^2{}_{(0.995)(3)} = 12.88.$ Since $\chi^2{}_{count} < \chi^2{}_{table},$ the dataset met the normality assumption. Additionally, homogeneity was evaluated through Fisher's test, yielding $F_{count} < F_{table}\,(1.47 < 1.84)$, indicating that the data has a homogeneous variance. Table 6 presents the results of the hypothesis test, conducted at a significance level of 0.01.

Table 6. Hypothesis Test Result

Data	t_{count}	t_{table}	Summary
KPM Posttest Score	2.82	2.39	H_a accepted

Hypothesis testing using the t-test at a 99% confidence level confirmed the acceptance of H_a, indicating that the SSIBL model supported by Nearpod significantly influences students' problem-solving skills in the context of alternative energy material. The observation findings regarding the implementation of SSIBL learning are presented in Table 7. According to the data, the implementation in both the first and second sessions is categorized as "excellent", with average scores of 86.09% in the first session and 88.41% in the second. These results suggests that all stages of SSIBL can be effectively implemented.

Table 7. Implementation Data of the SSIBL Learning Model

No.	Phase	1 Percentage	2 Percentage
1	Introduction	92	84
2	Main Activities		
	Introduction of the dilemma	91.11	95.56
	Initial opinion-forming	86.67	97.78
	Creating a need-to-know	86.67	86.67
	Inquiry	83.33	90
	Dialogue	73.33	80
	Decision making	86.67	80
	Reflection	80	86.67
3	Closing	95	95
	Average	86.09	88.41

Discussion

The effect of the SSIBL model assisted by Nearpod on students' problem-solving skills can be attributed to its student-centered approach, which promotes active engagement in the classroom. According to Rauch & Radmann (2020), learning activities that incorporate the SSIBL model encourage active student participation by facilitating investigation, promoting analytical thinking, fostering self-reflection, and engaging students in discussions on SSI. Moreover, SSIBL learning is based on socio-scientific problems, and problem-based learning has been shown to enhance students' reasoning and logical thinking during the problem-solving process (Ningrum & Fauziah, 2021). Furthermore, Abdullah et al. (2022) stated that Nearpod supports active student engagement in learning activities. In this study, Nearpod supported the learning process by integrating videos, interactive questions, and material presentations related to alternative energy.

The SSIBL model consists of seven stages: introduction of the dilemma, initial opinion-forming, creating a need-to-know, inquiry, dialogue, decision-making, and reflection (Ariza et al., 2021). Based on these seven stages, students are introduced to the issue of alternative energy and guided to identify the problem through the introduction of the dilemma and initial opinion-forming stages. These two stages correspond to the problem identification indicator. The problem is introduced to students through video presentations. Figure 1 provides an example of the video display used in these two stages.

Figure 1. Video Display in Nearpod for Introduction to Alternative Energy Issues

Figure 1 presents an image from the video material used to initiate students' engagement with the learning problem. The video serves as a medium to contextualize the issue and guide students in understanding it. In this example, as depicted in Figure 1, students are introduced to the challenge of equitable distribution of electrical energy across Indonesia. Students are introduced to the problem situation through Nearpod video presentations, which are also supplemented with open-ended questions to encourage them to express opinions based on the problem context depicted in the video, as shown in Figure 2. Furthermore, the problem related to alternative energy is also presented in a worksheet, where students are required to identify the problem.

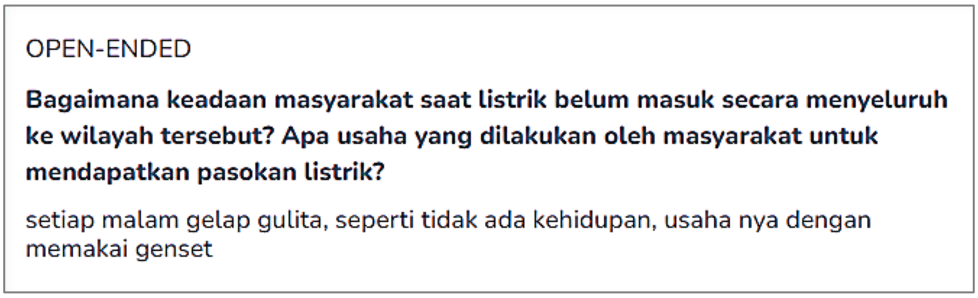

Figure 2. Example of Questions in a Video Show on Nearpod

As shown in Figure 2, the questions are constructed based on the video stimulus presented earlier in Figure 1. There questions function as formative tools to elicit students' conceptual understanding and interpretation of the socio-scientific issue. Students are also encouraged to pose questions related to the alternative energy issues identified in the previous stage, facilitating deepen understanding of the problem. This stage corresponds to the pose questions indicator, which aims to support students in the process of finding solutions to the given problem. Alternative energy concepts are further introduced during the inquiry stage, where materials are presented through Nearpod and explained by the teacher, as illustrated in Figure 3. At this stage, students also independently explore additional references related to the topic and its associated issues. The inquiry stage aligns with the identify assumptions indicator, as the findings from students' investigations provide relevant information that serve as the foundation for formulating assumptions and perspectives regarding the problem presented by the teacher.

Figure 3. Activities in the Inquiry Stage

In the problem-solving process, students are given time to discuss learning materials and alternative energy issues with their group members. This activity facilitates the formulation of solutions to address the identified problems. The discussion takes place during the dialogue stage, which also related to the identify assumptions indicator. At the decision-making stage, corresponding to the justify solution indicator, students formulate and propose solutions to the alternative energy problems. These solutions are then reviewed in the reflection stage, which aligns with the evaluate the quality of a solution indicator. Through the activities embedded within these seven stages, the learning process is structured to enhance students' problem-solving skills.

The learning process in the group that implemented the SSIBL model with Nearpod support was monitored across two sessions. This observation aimed to evaluate how well instructional activities aligned with the planned learning materials (Sari, 2020). Observation data were collected using the SSIBL implementation observation sheet, completed by three observers. The average percentage of learning implementation for both meetings fell into the "excellent" category, with 86.09% in the first meeting and 88.41% in the second meeting. In the first meeting, limited learning time posed a challenge, causing some activities in the SSIBL stages to be less than optimal. This issue was addressed in the second meeting by simplifying certain activities, ensuring a smoother learning process. Despite these challenges, the observation results showed an increase in implementation percentage, reinforcing that the learning activities were effectively conducted.

Meanwhile, the Direct Instruction model in learning activities is teacher-centered rather than student-centered (Setyawan & Riadin, 2020). In this model, students have limited opportunities to explore information related to the learning materials, which may result in lower active engagement. According to Shah (2020), this model typically relied on textbooks and worksheets rather than utilizing electronic media, such as computers. Therefore, due to the dominance of the teacher's role, students in the control class demonstrated lower problem-solving skills compared to those in the experimental class, as their opportunities for exploration were limited. Although Nearpod was also used to assist learning in this class, the structured nature of the Direct Instruction model still limited student engagement. Figure 4 displays the posttest findings of the study, presented as the average percentage of problem-solving skill indicators.

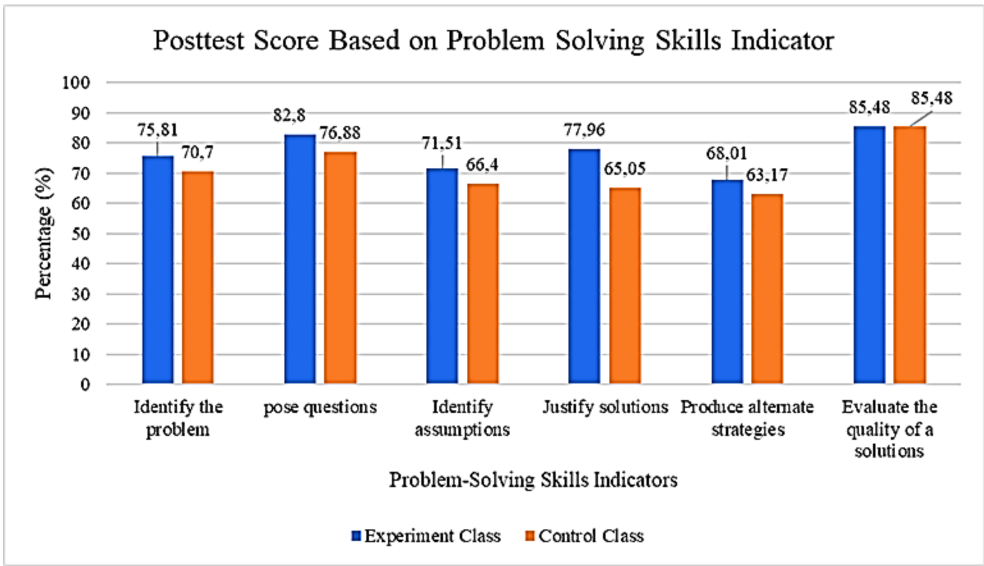

Figure 4. Comparison of Posttest Scores of Experimental and Control Classes

Figure 4 illustrates that the highest proportion of indicators in both classes pertain to evaluate the quality of a solution. The identical percentage of this indicator in both classes is attributed to the suboptimal implementation of learning activities in the experimental class due to limited instructional time. Time constrains can lead to reduced interaction during learning (Lestari, 2015). Furthermore, according to Masitoh et al. (2017), restricted learning time may result in students drawing varying conclusions on the learning topic, leading to insignificant differences in one of the tested indicators.

The indicator with the lowest percentage in both classes is produce alternate strategies. In this indicator, students are expected to formulate alternative strategies that can serve as potential solutions to the problem. The low percentage is attributed to the incomplete and inaccurate alternative solutions provided by students. Additionally, a problem-solving process that does not align with relevant theories and studied material can lead to incorrect alternative solutions (Hidayatulloh et al., 2020). Meanwhile, the other indicators demonstrate relatively high percentage. In the identify the problem indicator, students are able to recognize and describe the issues and events presented in the reading material. For the pose questions indicator, students can formulate questions relevant to the problems and material being studied. In the identify assumptions indicator, students successfully identify and articulate assumptions based on the given problems. Lastly, in the justify solutions indicator, students are able to determine appropriate solutions supported by correct reasoning aligned with the learning material.

According to the N-gain test results, the improvement in problem-solving skills in both the experimental and control groups was classified as medium, with respective scores of 0.57 and 0.51. The difference between the two classes was relatively small, which can be attributed to the differences in the duration of learning implementation. The experimental class only had two hours of lessons, while the control class had three hours of lessons. This discrepancy was caused by external factors that led to changes in the lessons schedule. The lack of an effective learning schedule contributed to the insignificant difference in the impact of the treatment on students (Jayanti & Amin, 2018). Additionally, limited learning time resulted in suboptimal learning activities, leading to rushed material delivery and reduced interaction between teachers and students (Lamadang et al., 2024; Pratama et al., 2023). This issue also disrupted time management during lessons, which according to Sahito et al. (2016), can influence learning outcomes. Consequently, this limitation affected the improvement of students' problem-solving skills, resulting in only a minor distinction between two classes.

The findings of this study align with the research by Sa'dah et al. (2022), which indicates that implementing that SSIBL model can improve problem-solving skills. This improvement is attributed to the fact that SSIBL based learning not only emphasizes the teacher's role but also promotes discussions and interactions that support students in developing their problem-solving skills. Similarly, Hanifah et al. (2021) assert that learning based on SSI can impact students' problem-solving skills by introducing issues that stimulate curiosity and encourage critical thinking. Consistently, Katrien (2022) also found that incorporating SSI into learning activities supports the development of problem-solving skill by encouraging students to critically engage with real-world issues. Furthermore, research by Alpianti & Amelia (2024) demonstrates that students' problem-solving skills can be improved through the integration of worksheets within the SSI approach. This study demonstrates that the SSIBL model assisted by Nearpod can be effectively implemented in physics learning, particularly on topics that can be linked to socio-scientific issues, such as alternative energy in 10th-grade high school. The positive impact of this model is evident in its influence on students' problem-solving skills. Incorporating SSIBL into the problem-solving process encourages students to utilize their knowledge in formulating solutions and exploring alternative approaches to address real-world challenges. Effective problem-solving also requires students to comprehend, analyze, and think critically to connect socio-scientific issues with the physics concepts being studied.

CONCLUSION

Fundamental Finding: The implementation of the SSIBL model has the potential to enhance students' problem-solving skills, as indicated by the increase in posttest scores in the experimental class. All stages of the SSIBL model were successfully implemented, with high levels of student engagement observed. **Implication:** The integration of the SSIBL model with Nearpod can effectively support the development of students' problem-solving skills. **Limitation:** The shortened duration of learning in the experimental class may have contributed to the minimal N-gain observed. Additionally, this study assessed problem-solving skills only within the context of alternative energy material. **Future Research:** Future research should investigate improved time management strategies and the integration of alternative media for various physics topics.

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Helmina Pebriyanti
Department of Physics Education Faculty of Teacher Training and Education, Universitas Siliwangi,
Jl. Siliwangi 24, Tasikmalaya West Java, 46115, Indonesia
Email: helminapebriyantii20@gmail.com

***Yanti Sofi Makiyah (Corresponding Author)**
Department of Physics Education Faculty of Teacher Training and Education, Universitas Siliwangi,
Jl. Siliwangi 24, Tasikmalaya West Java, 46115, Indonesia
Email: yanti.sofi@unsil.ac.id

Ernita Susanti
Department of Physics Education Faculty of Teacher Training and Education, Universitas Siliwangi,
Jl. Siliwangi 24, Tasikmalaya West Java, 46115, Indonesia
Email: ernita.susanti@unsil.ac.id

Luthfi Rahman
Technical System Planner Steel & Metal Construction Technology,
Richard Hartmann Schule Berufliches Schulzentrum Für Technik III,
Annaberger Str. 186, 09120 Chemnitz, Germany
Email: luthfir68@gmail.com