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Comparison of the Learning Outcomes in the Ecology Course Using Socio-Scientific Problem based Learning and Stimulus Environment Problem Solving Models

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ABSTRACT

Learning that is still dominated by teacher-centered approaches tends to result in passive student participation and low learning outcomes. This study aims to compare the effectiveness of the Socio-Scientific Problem-Based Learning (SSPBL) model and the Stimulus Environment Problem Solving (SEPS) model in improving student learning outcomes in the Ecology course. The research employed a quasi-experimental design involving two groups of fourth-semester Biology Education students at Universitas Muhammadiyah Surakarta in the even semester of the 2023/2024 academic year. Each group consisted of 20 students; one was taught using the SSPBL model, and the other using the SEPS model. Data were analyzed using the independent sample t-test and effect size analysis.The results showed that the SSPBL group achieved significantly higher cognitive learning outcomes than the SEPS group in both Cycle I (sig. = 0.041) and Cycle II (sig. = 0.049). The effect size results further confirmed the high effectiveness of the SSPBL model, with values of 2.846 (Cycle I) and 3.413 (Cycle II), categorized as "high." These findings indicate that the SSPBL model is more effective in improving learning outcomes, particularly in developing higher-order thinking skills through the integration of scientific concepts and socio-scientific issues. This study recommends the implementation of the SSPBL model in science education to foster deeper conceptual understanding and critical thinking among students.

KEYWORDS

Socio-Scientific Problem-Based Learning,
Stimulus Environment Problem Solving,
Learning Outcomes

1. Introduction

Learning is a process of interaction between instructors and students, as well as other supporting elements in the educational environment. The instructor plays a crucial role in determining the quality of learning, which affects not only the mastery of material but also the development of problem-solving, analytical, and critical thinking skills (Ratih et al., 2021, Nugroho et al, 2025). Therefore, instructors are expected to select appropriate teaching models that encourage active student participation to improve learning outcomes (Yew & Goh, 2016). However, current learning practices are still largely teacher-centered. Students tend to passively receive information, show limited motivation to explore independently, and struggle with applying knowledge to real-life problems (Saputri, 2019). This condition highlights the urgency of implementing learning models that shift the focus from the teacher to the student.

One potential solution is to adopt active learning models such as Socio-Scientific Problem-Based Learning (SSPBL) and Stimulus Environment Problem Solving (SEPS). These models engage students in real-world problems and encourage them to identify, analyze, and solve contextual issues collaboratively (Effendi & Fauziah, 2022; Nopiyanto & Syafrial, 2023; Fita et al, 2021). SSPBL is rooted in the socio-scientific issues (SSI) framework, which views science learning as inseparable from ethical, cultural, and political contexts. Zeidler et al. (2005) emphasized that learning science through SSI not only promotes scientific literacy but also fosters moral reasoning and responsible citizenship. Therefore, SSPBL is not merely a cognitive model it is also affective and ethical, making it especially relevant for addressing current global challenges through education.

The SSPBL model begins with socio-scientific issues that are close to students' lives, helping them to connect scientific content with ethical and social considerations. It emphasizes reasoning, argumentation, and values-based decision-making, supporting not only conceptual understanding but also civic competence. Meanwhile, the SEPS model fosters direct interaction with environmental stimuli, encouraging exploration and experiential learning through observation and response. These approaches are not only effective in enhancing conceptual understanding but also in building collaborative skills, creativity, and motivation. They provide opportunities for teamwork, peer discussion, and self-reflection critical skills in facing real-world challenges (Rahmawati, 2024; Jariah & Aminatun, 2022). Moreover, the implementation of such models aligns with constructivist learning theory, which asserts that students learn best through experience and interaction. When actively engaged, students are more likely to construct meaningful understanding and become autonomous learners (Nopiyanto & Syafrial, 2023).

In biology education, particularly in the ecology course, students are expected to not only understand scientific content but also connect it to environmental and societal issues. Higher-order thinking skills are essential to navigate complex ecological topics such as climate change, pollution, and sustainability (Heong et al., 2012; Osman et al., 2013; Turiman et al., 2012). SSPBL is well suited to such themes, as it integrates scientific literacy with real-world reasoning and reflective thinking. SEPS, while also relevant, tends to emphasize observation over argumentation and values-based decision-making.

Despite the promising nature of both models, studies that directly compare SSPBL and SEPS in higher education particularly in ecology courses are still limited (Zeidler et al., 2005; Sadler, 2011). Most research examines these models in isolation, without providing evidence of their comparative effectiveness under the same learning context. Given that ecological literacy is a foundational component of sustainability education, understanding which pedagogical model better supports its development is essential. Comparing SSPBL and SEPS provides critical insight not only for educators but also for curriculum developers aiming to integrate environmental education with character and civic education. This gap needs to be addressed, especially considering the need to determine the most effective instructional strategies for ecology education. Understanding how each model contributes to learning outcomes will help educators design instruction that better supports students' ecological literacy and critical thinking.

Based on these considerations, this study aims to compare the learning outcomes of fourth-semester Biology Education students at Universitas Muhammadiyah Surakarta in the Ecology course using the Socio-Scientific Problem-Based Learning model and the Stimulus Environment Problem Solving model.

2. Method

This study employs a quantitative approach with a quasi-experimental design using a non-equivalent control group design. It involves two groups of students, each consisting of 20 participants. The first group follows the Socio-Scientific Problem-Based Learning (SSPBL) model, while the second group adopts the Stimulus Environment Problem Solving (SEPS) model.

This research was conducted at the Biology Education Study Program, Universitas Muhammadiyah Surakarta (UMS) during the second semester of the 2023/2024 academic year, from January to August 2024. The population of this study consists of all fourth-semester Biology Education students at UMS, with the sample comprising students from classes A and B. The sampling technique used was purposive sampling, where two classes were selected: class A as the experimental group applying the SSPBL model and class B as the comparison group using the SEPS model.

The intervention was carried out over two learning cycles. Each cycle comprised three meetings that addressed key topics in the ecology course, including population dynamics, ecosystem interactions, and environmental sustainability. The SSPBL group was engaged through structured problem-solving sessions integrating current socio-scientific issues, while the SEPS group participated in stimulus-based

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exploration using natural environmental observations. A pre-test was administered to both groups prior to treatment to assess baseline cognitive understanding. Following each cycle, a post-test was administered to evaluate learning outcomes after implementation of the respective models.

The research instrument consisted of a multiple-choice cognitive test designed to measure student understanding in the ecology course. The test items were constructed based on Bloom's taxonomy (levels C2–C4) and aligned with course learning indicators. The instrument underwent expert validation by two biology education lecturers and one senior biology teacher to ensure content validity. Instrument reliability was analyzed using Cronbach Alpha, resulting in a reliability coefficient of 0.78, which indicates acceptable internal consistency. Data analysis was conducted using the Two Independent Sample Test, a non-parametric alternative to the independent sample T-test, which is suitable for ordinal data and does not require the assumption of a normal distribution (Ergin & Koskan, 2023). This test aims to determine whether there is a significant difference between the two independent groups based on their post-test results.

The hypothesis testing procedure allows the researcher to evaluate whether differences in treatment resulted in statistically significant differences in learning outcomes (Rafiq et al., 2023). In addition, effect size analysis was conducted using Cohen's d to determine the magnitude of the difference between groups. Interpretation followed standard criteria: small (0.2), medium (0.5), and large (≥0.8). This analysis was used to support statistical findings with practical significance. Prior to hypothesis testing, the assumptions of normality and homogeneity were assessed using the Kolmogorov–Smirnov test and Levene's test, respectively. The results confirmed that data met the criteria for parametric or non-parametric analysis as appropriate.

3. Results and Discussion

The use of cycle 1 and cycle 2 in this study is based on the basic principles of action research, which emphasizes efforts to improve and enhance the quality of learning continuously. Each cycle is designed to go through the stages of planning, implementation, observation, and reflection. Cycle 1 serves as the initial stage to implement the learning model (in this case SS-PBL or SEPS) and identify its strengths and weaknesses in practice. The results of this cycle become the basis for reflection and revision of learning strategies in cycle 2, so that the implementation of the model in the next cycle becomes more optimal and focused (Kemmis & McTaggart, 1988). Repeating through two cycles can strengthen the internal validity of the study because the findings are not based on just one intervention. Consistency of results between cycles can increase confidence in the effectiveness of the model being tested (Burns, 2010).

The cognitive learning outcomes of cycles I and II were tested using the independent sample t-test to determine the differences in learning outcomes between the class using the Socio-Scientific Problem-Based Learning model and the class using the Stimulus Environment Problem Solving model. The results of the t-test can be seen in Table 1.

Table1. Results of the t-test for Cognitive Learning Outcomes in Cycles I and II

Cycle	*Test Type*	*Sig.*	*Conclusion*
I	Independent Sample T-test	0,041	There is a difference
II	Independent Sample T-test	0,049	There is a difference

Based on Table 1, it can be seen that the analysis using SPSS shows significance in Cycle I with a value of 0.041 < 0.05, indicating that there is a difference in the mean learning outcomes between the class using the Socio-Scientific Problem Based Learning model and the class using the Stimulus Environment Problem Solving model. In Cycle II, the significance value is 0.049 < 0.05, which also indicates a difference in the mean learning outcomes between the two classes.

After confirming that there is a difference in learning outcomes between the class using the Socio-Scientific Problem Based Learning model and the class using the Stimulus Environment Problem Solving model, the effectiveness of both models can be evaluated using the effect size test. The effect size results for the use of both models from Cycle I & II can be seen in Table 2.

Table 2. Results of the t-test for Cognitive Learning Outcomes in Cycles I and II

Cycle	*Socio-scientific pbl*			*SEPS*			*Effect Size*	*Category*
	Mean	*SD*	*N*	*Mean*	*SD*	*N*	*Cohen's d*	
I	22,14	3,116	20	18,87	3,121	20	2,846	High
II	28,34	3,624	20	23,91	3,411	20	3,413	High

Based on Table 2, the effect size calculation for Cycle I yielded a value of 2.846, which falls into the high category. In Cycle II, the effect size value was 3.413, also falling into the high category. This indicates that the Socio-Scientific Problem-Based Learning (SSPBL) model is highly effective in improving learning outcomes. The substantial increase in effect size from Cycle I to Cycle II suggests that students became more accustomed to the SSPBL model and increasingly benefited from its features in promoting deeper learning and engagement.

Based on the results of the t-test, it can be concluded that there is a significant difference and an improvement in the application of the SSPBL model on higher-order thinking skills from Cycle I to Cycle II. The most significant effect occurred in Cycle II, which may be attributed to the students' improved adaptation to the model and increased motivation in responding to socio-scientific problems presented during the learning activities. In addition to the increased t-test values and the percentage of improvement in each cycle, another piece of evidence for the improved learning outcomes is the effect size test. The use of effect size helps determine the magnitude of the impact of the SSPBL model on students' learning outcomes. These results confirm not only statistical significance but also practical significance, showing that the model has a large and meaningful impact on students' learning. These findings are in line with Sadler (2011); Nugroho et al (2025), who argues that socio-scientific issue-based instruction can enhance students' ability to reason, analyze, and evaluate information critically. Furthermore, Zeidler et al. (2005); Zeidler et al (2019) emphasized that engaging students in controversial, real-world science issues develops their reflective judgment and fosters both cognitive and moral growth.

Learning is a process of interaction that occurs between the instructor and students, as well as various other elements that support the process. Instructors play a critical role in determining the quality of learning. In the context of 21st-century learning demands, which are closely tied to the era of Industry 4.0 and Society 5.0, teaching must cultivate not only scientific knowledge but also the ability to make informed, ethical decisions in complex real-world scenarios (Ratih et al., 2021). SSPBL provides a relevant framework for this challenge.

Biology education does not only focus on understanding biological concepts, but also involves an understanding of the nature of biology, scientific practice, scientific inquiry, and the relationship between biology, technology, and society. The inquiry process itself involves higher-order thinking skills, which are essential for problem-solving (Heong et al., 2012; Osman et al., 2013; Turiman et al., 2012; Nugroho et al, 2025). Therefore, in biology education, students need to be equipped with higher-order thinking skills to support the achievement of maximum learning outcomes.

Higher-order thinking skills include the development of mental abilities derived from basic skills already possessed by the individual. These skills encourage students to find information and knowledge on their own, as well as to develop attitudes and values needed in the learning process (Saputri et al., 2019; Prasetyowati et al, 2020). SSPBL directly supports this development by providing opportunities for exploration, argument construction, and ethical consideration within meaningful social contexts. Unlike conventional learning models, SSPBL requires students to critically assess multiple perspectives, justify their positions with scientific evidence, and evaluate the societal implications of science-related decisions. These demands inherently promote cognitive flexibility, empathy, and scientific reasoning, which are central components of scientific literacy in the modern era.

The main advantage of SSPBL lies in the contextualization of learning through social-scientific issues. These issues are directly related to students' daily lives, so they can foster curiosity, relevance, and concern for real problems in the surrounding environment. In the process, SSPBL not only emphasizes problem solving, but also develops critical thinking skills, ethical decision-making, and scientific argumentation, which are integral parts of 21st-century learning (Zeidler & Nichols, 2009; Sadler, 2011).

Meanwhile, the SEPS model does involve elements of environmental stimulation, but this approach tends to be exploratory and observational, with an emphasis on responses to physical environmental stimuli. Although effective in increasing engagement and initial understanding, this approach has not fully touched on the complex aspects of value-based decision-making and scientific ethics, as facilitated by SSPBL (Rahmawati, 2024). In SEPS, the learning tends to remain at the level of surface exploration, lacking the depth of dialogic reasoning or structured problem resolution that characterizes SSPBL.

In addition, SSPBL usually adopts a collaborative and discursive approach, where students engage in group discussions, debates, and collective problem solving. This not only enriches their understanding of content but also improves social and communication skills. These interactions help develop interpersonal competencies such as negotiation, empathy, and collective reasoning—skills that are necessary in both academic and professional contexts. Thus, the advantages of SSPBL compared to SEPS lie in the complexity and depth of the cognitive processes, the relevance of learning to students' lives, and its alignment with the competency demands of 21st-century education. These aspects make SSPBL not only more effective in improving cognitive learning outcomes but also in cultivating the broader goals of education namely, preparing students to become informed, reflective, and responsible citizens.

4. Conclusion

The results of this study indicate a significant difference in learning outcomes between the class implementing the Socio-Scientific Problem-Based Learning (SSPBL) model and the class implementing the Stimulus Environment Problem Solving (SEPS) model, as confirmed by the t-test results. [Perbaikan] The effect size analysis further reinforces this finding, showing that the SSPBL model falls within the high-effectiveness category, particularly in enhancing students' higher-order thinking skills. The learning gains observed across two instructional cycles demonstrate not only statistical significance but also meaningful pedagogical impact, suggesting that SSPBL offers a robust framework for promoting deep learning, critical reasoning, and ethical reflection in science education.

Based on these findings, it is recommended that teachers and lecturers begin to adopt the SSPBL model in science learning, especially in subjects that demand complex reasoning, social relevance, and moral decision-making. Its collaborative and issue-driven approach is particularly well-suited to addressing the learning demands of the 21st century. Educational institutions and curriculum developers should consider integrating the SSPBL model into formal instructional design and teacher professional development programs. This integration may help cultivate scientific literacy, socio-scientific reasoning, and civic competence among students competencies that are increasingly vital in today's information-rich, value-laden society. Future research is encouraged to further explore the effectiveness of SSPBL across various educational levels (e.g., primary, secondary, tertiary) and disciplines beyond biology. Comparative studies involving other active learning models may also enrich our understanding of when and how SSPBL works best under different learning contexts and student characteristics. Moreover, longitudinal studies are needed to assess the long-term impact of SSPBL on students' attitudes, reasoning habits, and problem-solving behaviors. Such insights are critical for informing sustained innovation in science education and ensuring that pedagogical strategies truly prepare learners for real-world challenges.

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