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IMPACT OF THE STUDENT FACILITATOR AND EXPLAINING MODEL INTEGRATED WITH SOCIO-SCIENTIFIC ISSUES ON ANALYTICAL THINKING SKILLS IN BIOLOGYEDUCATION

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ABSTRACT

This study aimed to examine the effect of the Student Facilitator and Explaining (SFE) model integrated with Socio-Scientific Issues (SSI) on students' analytical thinking in biology learning. The research used a quasi-experimental method with a non-randomized control group pretest-posttest design. Samples were selected using purposive sampling, consisting of an experimental class applying the SFE-SSI model and a control class using Problem-Based Learning (PBL). Data were collected through essay tests and observation sheets, and then analyzed using One-Way ANCOVA. The results showed a significant effect of the learning model on analytical thinking [$F(1,69) = 12.245$, $p < 0.001$, $\eta p^2 = 0.151$]. It is concluded that the SFE model, when integrated with SSI, effectively enhances students' analytical thinking in biology learning.

INTRODUCTION

Education serves a vital role in shaping individuals to meet the demands of an increasingly dynamic and globalized world. In Indonesia, this role is emphasized in Article 3 of Law No. 20/2003 on the National Education System, which declares that national education aims to develop students' potential, character, and civilization to build an intelligent and dignified nation. One of the essential strategies to achieve this vision is the development of a relevant and innovative curriculum that fosters active engagement and higher-order thinking skills. In response to these challenges, the Indonesian government introduced the Merdeka Curriculum as a significant transformation in the national education system. This curriculum aims to strengthen student, the students' ability to take active control and make meaningful decisions in their own learning journey promote holistic development, which encompasses the comprehensive growth of cognitive, emotional, social, and physical aspects, and encourage active participation through interactive methods such as group discussions and inquiry-based learning (Gumilar et al., 2023) (Darling-Hammond et al., 2020).

Despite these efforts, our findings from interviews and classroom observations at SMA Negeri 9 Kota Jambi reveal several critical issues in the learning process that demand immediate attention. Students demonstrate low reading interest, overdependence on smartphones, and a lack of involvement in classroom discussion. These factors have led to disorganized information processing, superficial understanding, and a non-conducive learning environment. Students often use mobile devices during lessons for entertainment rather than learning. Furthermore, many students struggle to connect knowledge from multiple sources and lack the critical reading habits necessary to develop a strong foundation for analytical reasoning (Awalyah et al., 2024). Minimal engagement in discussions hinders their ability to question, reflect, and evaluate information, consequently undermining their analytical thinking skills, which are fundamental to effective learning.

To address these issues, we propose innovative learning approaches that foster analytical thinking. One such approach is the Student Facilitator and Explaining (SFE) model, which encourages students to take an active role as facilitators by presenting and explaining material to their peers. This model has demonstrated positive outcomes in enhancing student comprehension and motivation to read (Riadi et al., 2022; Sabo & Fadhilah, 2021). When integrated with the Socio-Scientific Issues (SSI) approach, which presents real-world social and scientific problems as learning content, the model has the potential to significantly enhance critical and analytical thinking. SSI encourages students to analyze controversial issues, consider multiple perspectives, and make reasoned decisions based on evidence(Laksono et al., 2023; Utomo & Muna, 2024; Zeidler et al., 2019). This integration supports analytical thinking components such as distinguishing, organizing, and attributing information in a meaningful context, offering a promising future for education.

Although both SFE and SSI have been studied separately, there has been no research investigating their combined impact on analytical thinking in biology learning at SMA Negeri 9 Kota Jambi. Therefore, this study addresses the crucial research question: "What is the effect of the Student Facilitator and Explaining (SFE) model integrated with Socio-Scientific Issues (SSI) on students' analytical thinking skills in biology learning?" The proposed hypothesis is that integrating SFE and SSI significantly improves students' analytical thinking abilities, a question of paramount importance in the field of education.

In biology education, the human immune system is a crucial topic that requires not only factual knowledge but also higher-order thinking skills to understand its complex mechanisms and socio-scientific relevance. Developing students' analytical thinking skills in this area is essential for fostering critical reasoning and informed decision-making regarding health-related issues. The objective of this study is to investigate the impact of integrating the SFE learning model with SSI on students' analytical thinking skills within the context of biology education, specifically in relation to the topic of the human immune system. The research employs a quasi-experimental method using a Non-Randomized Control Group Pretest-Posttest Design.

The study involves two groups: an experimental class that applies the SFE integrated with SSI, and a control class using Problem-Based Learning (PBL). The participants are eleventh-grade students from SMA Negeri 9 Kota Jambi. Data were collected through analytical thinking essay tests and observation sheets, which were validated for instructional implementation. Using a Non-Randomized Control Group Pretest-Posttest design and the statistical method One-Way ANCOVA, this study provides a rigorous analysis of the impact of the Student Facilitator and Explaining model, integrated with Socio-Scientific Issues, on students' analytical thinking skills in biology learning.

MATERIALS AND METHODS

This study was conducted at SMA Negeri 9 Kota Jambi, a renowned institution known for its progressive approach to science education, in January 2025, during the even semester of the 2025/2026 academic year. The research subjects were 72’s Class XI Science. The research employed a quantitative approach using a quasi-experimental design, specifically a non-equivalent control group pretest-posttest design. Quasi-experimental research involves treatment, impact measurement, and experimental units, all without random assignment, to create comparison groups. This design utilizes existing classes selected through purposive sampling, meaning the sample was chosen based on specific criteria rather than being randomly selected.

The sample, carefully selected to ensure representativeness, consisted of two classes: Class XI F1, the experimental group, taught using the Student Facilitator and Explaining (SFE) model integrated with Socio-Scientific Issues (SSI), and Class XI F2, the control group, taught using the Problem-Based Learning (PBL) model. The sample was selected through purposive sampling, which enables the researcher to select participants based on specific objectives (Lenaini et al., 2021, p. 34). Before sample selection, homogeneity and normality tests were conducted to ensure comparability of the two groups based on biology test scores.

Normality testing was performed using the Kolmogorov-Smirnov test, with results indicating that both classes had normally distributed data: Class XI F1 [$W(36) = 0.141$, $p = 0.069$] and Class XI F2 [$W(36) = 0.137$, $p = 0.083$]. Homogeneity testing was conducted using Levene's Test, which showed homogeneous variances [$F(1, 70) = 0.089$, $p = 0.766$]. These results validated the comparability of both classes before treatment.

The indicators of analytical thinking skills measured in this study include the ability to differentiate, organize, and attribute. To collect data, essay-type tests (pretest and posttest) were employed, specifically designed to assess these indicators of students' analytical thinking skills. (Inayati et al., 2024). Preliminary interviews were also conducted with biology teachers to understand existing conditions and instructional practices (Hafni Sahir, 2024).

The instruments used in this study were rigorously validated through expert judgment and pilot testing. Content validity was ensured by consulting subject matter experts to assess the relevance and clarity of the items. Additionally, the instruments underwent reliability testing, yielding acceptable Cronbach's alpha values, which indicate internal consistency. Moreover, instruments such as tests, teaching modules, and student worksheets were further validated through content validity, item validity, item difficulty, and discriminating power analyses conducted using SPSS 27 (Joko Widiyanto, 2018; Keterampilan et al., 2021; Muhammad Darwin Marianne Reynelda Mamondol Salman Alparis Sormin Yuliana Nurhayati Hardi Tambunan Diana Sylvia I Made Dwi Mertha

Adnyana Budi Prasetiyo Pasionista Vianitati Antonius Adolf Gebang, 2021). According to N. P. Dewi et al. (2020), learning tools, such as teaching modules and student worksheets, must meet specific validity criteria. This comprehensive validation ensured that all tools met appropriate pedagogical standards.

The research applied the syntaxes of the Student Facilitator and Explaining (SFE) model integrated with Socio-Scientific Issues (SSI), following these steps: 1) Identifying the problem students observed and discussed socio-scientific issues relevant to the biology topic being studied. 2) Formulating hypotheses regarding the effects of the SFE-SSI model on students' analytical thinking skills was clearly stated. 3) Planning the treatment, experimental, and control groups was established, with teaching materials and procedures prepared accordingly. 4) Pretest administration: Both groups completed a pretest to assess baseline analytical thinking skills. 4) Treatment implementation: The experimental group received instruction using the SFE model integrated with SSI, encouraging active student facilitation and structured inquiry. The control group received traditional instruction using the PBL model. 5) Posttest administration following the treatment, both groups took a posttest. 6) Data analysis: Using a Non-randomized Control-Group Pretest-Posttest design, the data were analyzed with one-way ANCOVA. Pretest scores served as covariates to statistically control for initial group differences, allowing for a precise estimation of treatment effects.

RESULTS AND DISCUSSION

This study involved two classes: an experimental class and a control class, with the topic of study being the human immune system. Before implementing the research, the researcher meticulously developed instructional instruments, including a teaching module, student worksheets, and test items. These instruments then underwent a rigorous validation process by the academic advisor, who served as the instrument validator. The validation process, which assessed content accuracy, language clarity, construct alignment, and layout feasibility, was thorough and comprehensive. Each parameter was evaluated using a Likert scale, and the results showed that all instruments achieved scores in the "very valid" category, indicating their credibility and feasibility for classroom implementation.

The research was carried out using two different learning models in the control and experimental classes. To ensure that the learning models were implemented as planned, the researcher involved an observer who meticulously monitored the implementation using an observation sheet. The observations were conducted throughout the entire series of lessons, from the first meeting to the last, by a student from the Biology Education study program. The observation data were collected in numerical form, where each successfully implemented syntax of the learning model was scored 1, and unimplemented syntax was scored 0. This quantitative data was then converted into percentages, and the observation results were also described qualitatively, providing a comprehensive view of the implementation process.

The implementation of the learning syntax was carried out with great success, with each stage achieving a 100% success rate. This indicates that all steps of the Student Facilitator and Explaining (SFE) model, integrated with Socio-Scientific Issues (SSI), were implemented as planned, providing reassurance about the study's outcomes.

Table 1. Syntax implementation

Meeting	**Experimental Class**		**Control Class**	
	Percentage (%)	**Criteria**	**Percentage (%)**	**Criteria**
1	100	Excellent	100	Excellent
2	100	Excellent	100	Excellent
3	100	Excellent	100	Excellent
4	100	Excellent	100	Excellent

During the implementation, several challenges were encountered, particularly related to time constraints. The available time for group discussions and student presentations was often insufficient due to several factors, including difficulties in managing students during group work and presentations, particularly considering the diverse characteristics of the students, some of whom were shy and reluctant to speak in front of their peers. Moreover, the time required for each student to present their ideas or discussion outcomes tended to be lengthy, which prevented all students from participating equally and optimally. These conditions made the discussion and presentation process less effective and efficient, underscoring the need for the teacher to carefully manage time and student groups to ensure a smooth learning process.

The pretest and posttest scores for students' analytical thinking abilities are presented below. The average pretest scores for analytical thinking in the experimental and control classes were 52.46 and 61.64, respectively. Meanwhile, the average posttest scores for the experimental and control groups were 74.61 and 64.03, respectively. The experimental class demonstrated higher analytical thinking scores than the control class, as evidenced by the statistical analysis. The average scores of students' analytical thinking skills are illustrated in Figure 1.

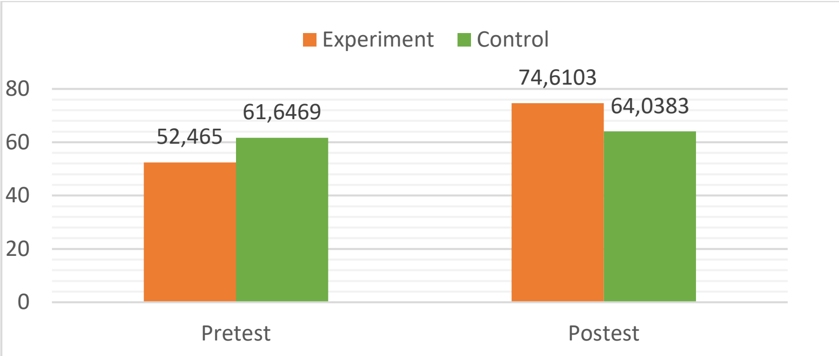

Figure 1. Comparison of Analytical Thinking Scores in Experimental and Control Classes

Notably, the highest pretest score was achieved in the "Organizing 1" indicator, with the experimental class scoring 93.75 and the control class scoring 92.36. This trend continued in the posttest, with the "Organizing 1" indicator also yielding the highest scores of 97.22 and 95.13 in the experimental and control classes, respectively.

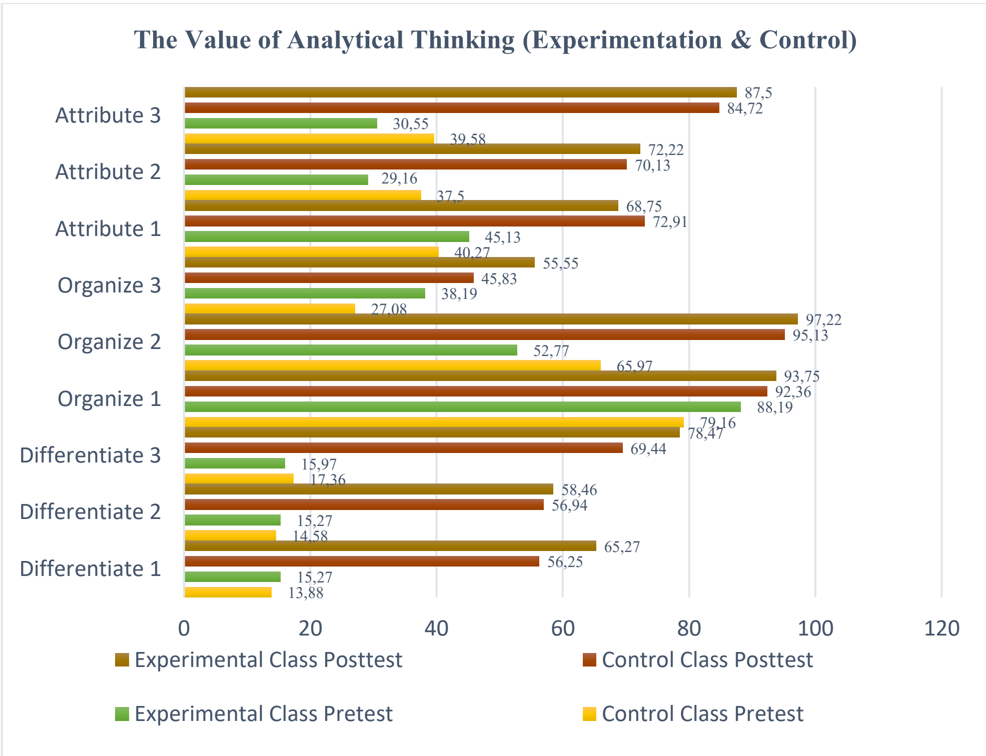

Figure 2. Student analytical thinking indicator score

On the other hand, the 'Differentiating' indicators present a different picture. The lowest pretest score was found in 'Differentiating 1', with scores of 15.27 for the experimental class and 13.88 for the control class. The lowest posttest score was in 'Differentiating 3', with scores of 58.46 and 56.94. These indicators call for a deeper understanding and further investigation, making them crucial for educators and researchers to consider.

Based on the results of the prerequisite tests conducted, it was found that the assumptions required for hypothesis testing using One-Way ANCOVA were fulfilled. Therefore, hypothesis testing in this study was conducted using parametric statistics, specifically the One-Way ANCOVA. The results of the analysis are presented in Table 1.

Table 2. Results of One-Way ANCOVA

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2087.071[a]	2	1043.536	6.123	.004	.151
Intercept	16450.616	1	16450.616	96.523	.000	.583
Pretest	190.920	1	190.920	1.120	.294	.016
Class	**2087.006**	**1**	**2087.006**	**12.245**	**.001**	**.151**
Error	11759.822	69	170.432			
Total	358331.477	72				
Corrected Total	13846.893	71				

Based on Table 2, the results of the One-Way ANCOVA test show that there is a significant effect of the learning model (class type) on students' posttest scores while controlling for the pretest scores, with the obtained value of \[$F(1,69) = 12.245$, $p < .001$, $\eta p^2 = .151$]. Since the p-value is less than .05 and the partial eta squared value is .151, this indicates a moderate effect size, meaning that the applied learning model had a significant impact on students' analytical thinking outcomes.

The study was conducted at SMAN 9 Kota Jambi during the 2024/2025 academic year, consisting of four meetings each for both the experimental and control classes, focusing on the immune system topic. The experimental class applied the Student Facilitator and Explaining (SFE) model integrated with Socio-Scientific Issues (SSI), while the control class used the Problem-Based Learning (PBL) model. Learning instruments, such as the ATP (Learning Objectives Flow), Teaching Module, and Student Worksheets (LKPD), were validated by experts before implementation, according to

Riswakhyuningsih (2022). Validation of the ATP ensures that learning objectives, content, time allocation, methods, and models align with curriculum standards and are feasible for implementation.

The test instrument consisted of nine essay questions, validated through item analysis. (Nasution et al., 2024).Confirm that all items were valid in measuring analytical thinking. According to Gustiani (2023), good validity ensures that test results are both reliable and meaningful. Discrimination index analysis revealed that the items ranged from good to excellent, indicating they could effectively distinguish between high- and low-ability students. The difficulty index placed all items in the medium category, which is ideal for balancing challenge and accessibility (Sarwiningsih, 2017).

The reliability coefficient of the test was 0.90, indicating very high reliability (Samritin, 2017). With the test being both valid and reliable, it was administered as a pretest before the learning intervention. Both the experimental and control classes received the same essay-based pretest to assess students' baseline understanding of the material.

The average pretest score in the experimental class was 52.46, with a maximum score of 80.55 and a minimum of 22.22. In the control class, the average was 61.64, with a maximum of 80.55 and a minimum of 30.55. These results indicate a low initial understanding, likely due to students not yet having received instruction on the immune system topic.

The intervention was carried out over four sessions. Posttests, consisting of the same essay questions, were given afterward to measure the effect of the learning models. The average posttest score in the experimental class rose to 74.61 (max 91.66, min 61.11), while in the control class, it reached 64.03 (max 86.11, min 27.77). The 10.5-point difference in posttest averages demonstrates the experimental class's improved performance.

As shown in Figure 4.2, the analytical thinking indicators of Differentiating, Organizing, and Attributing improved significantly in the experimental class. For example, the difference between one indicator increased from 15.27 (pretest) to 65.27 (posttest), showing the intervention's success. (Saifuddin et al., 2015) link this improvement to the SFE model, which allows students to explain content and draw conclusions collaboratively. (Nurhadi, 2022) It adds that SSI stages, such as science clarification, strengthen this process.

Organizing indicators also showed notable gains. For example, Organizing 3 rose from 45.83 to 97.22, reflecting students' improved ability to structure information. According to Amin & Sumendap (2022), the SFE model's presentation and closure phases help build this skill. SSI phases like problem analysis and meta-reflection also reinforce this (Zeidler, 2014).

Specifically, in the context of the immune system, the SFE model guides students to collaboratively explain complex immunological processes, such as antigen-antibody interactions, thereby deepening their understanding through peer learning and scaffolding (Wong et al., 2025). Meanwhile, the SSI approach contextualizes immune system concepts within societal issues such as vaccination debates, prompting students to analyze multiple perspectives, evaluate scientific evidence, and construct reasoned arguments (Ayeni et al., 2022). This combination fosters higher-order analytical skills, enabling students to not only comprehend the biological mechanisms but also critically assess their implications in real-life contexts.

Attributing indicators followed the same trend. Attributing 3 improved from 30.55 to 87.50.(Maulana Jamaludin & Marini, 2022) emphasize how SFE encourages accurate attribution through explanation and peer discussion. (Isa et al., 2023) further stress how summarizing ideas deepens understanding. SSI elements, such as science clarification (Qamariyah et al., 2021) and refocusing on socio-scientific dilemmas (Sadler et al., 2016), also contributed to students' ability to apply knowledge in real-world contexts. Notes that attributing is cognitively demanding, requiring deep reflection and a solid foundation in organizing skills. The combination of SFE and SSI encourages meaningful, context-based learning (Fatimah et al., 2022; Lutfi Baehaqi et al., 2023), making students more engaged and analytical. Even the PBL model used in the control class improved students' performance by simulating real-world problem-solving (Tsaqifatul Haqiyah et al., 2024).

Low pretest scores in both groups confirmed students' initial unfamiliarity with analytical thinking. However, after applying SFE integrated with SSI, the experimental class exhibited significant posttest gains, aligning with Tamsil et al. (2022), who found that conceptual knowledge rose steadily with each learning cycle. This improvement supports the conclusion that the SFE-SSI model enhances analytical thinking through active explanation, discussion, and connecting science to real-world issues. Found similar gains in problem-solving when using SSI-focused learning. Also reported an increase in student activity and achievement from 45.7% to 86.8% after using the SFE model (Alpandi, 2019).

The One-Way ANCOVA test confirmed a significant effect of the learning model on analytical thinking outcomes, \[$F(1,69) = 12.245$, $p < .001$, $\eta p^2 = .151$], with a moderate effect size. Both SFE-SSI and PBL placed students at the center of active learning. This study uniquely integrates the Student Facilitator and Explaining (SFE) model with Socio-Scientific Issues (SSI) to specifically target the enhancement of students' analytical thinking skills in biology, particularly within the context of the immune system topic. Unlike prior studies that often focus on traditional or single-method approaches, this research combines an interactive facilitation technique with real-world socio-scientific contexts, providing a comprehensive pedagogical innovation. The use of SFE-SSI syntaxes extends beyond knowledge acquisition to developing critical thinking, argumentation, and meta-cognitive reflection, which are crucial for scientific literacy.

The findings suggest that integrating SFE and SSI models can effectively improve analytical thinking skills, supporting educators in fostering higher-order cognitive abilities that prepare students for complex scientific and societal challenges. This approach encourages educators to adopt active learning strategies that are intertwined with socio-scientific contexts, enhancing students' ability to analyze, evaluate, and apply biological concepts, such as the immune system, in authentic, real-life scenarios. Additionally, the moderate effect size underscores the practical significance of this combined learning model, prompting further research and curriculum development that integrate facilitation and socio-scientific inquiry for comprehensive science education.

In SFE, students act as facilitators who explain material to peers, enhancing their critical and analytical thinking (Mustikasari, 2019). PBL emphasizes solving real-life problems collaboratively(Saputro et al., 2020). The structure of SFE aligns with PBL through peer teaching, teamwork, and the sharing of solutions. Both models emphasize critical thinking and collaborative learning, essential for 21st-century skills (Dewi et al., 2018). In both, the teacher plays a crucial role as a facilitator who guides reflection and deeper understanding.

Three components drive the development of analytical thinking in both models: Differentiating essential information (Mustikasari et al., 2019), Organizing information logically, and Attributing knowledge to real contexts (Purnamasari et al., 2024). Thus, the SFE model, when integrated with SSI, effectively enhances students' analytical thinking, supported by collaborative learning, contextual analysis, and reflective teaching.

CONCLUSION

This study confirms that the implementation of the Student Facilitator and Explaining (SFE) learning model, integrated with the Socio-Scientific Issue (SSI) approach, had a significant effect on students' analytical thinking skills. The hypothesis test result, which showed a significance value of 0.001 ($p < 0.05$), and the large effect size (partial eta squared value of 0.151) both underscore the substantial impact of the applied model.

The integration of the SFE and SSI models in science learning is not just about academic achievement, but about fostering active, student-centered engagement that cultivates essential 21st-century skills and, more importantly, scientific literacy and citizenship. By connecting biological concepts to real-world socio-scientific issues, students not only master scientific content but also learn to evaluate evidence, analyze diverse perspectives, and develop reasoned arguments. This prepares students to responsibly engage with complex societal challenges related to science, such as debates over immunization or environmental concerns, thereby fostering scientifically informed citizenship. For society, the SFE and SSI models contribute to creating a scientifically literate population capable of making informed decisions and participating in public discourse on socio-scientific matters.

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