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Developing a Problem-Based Learning Model Integrated with Socio-Scientific Issues to Enhance Pre-Service Primary Teachers' Argumentation Skills: A Need Analysis

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ABSTRACT

Background. Argumentation skills are essential competencies in 21st-century science education, particularly for pre-service primary school teachers. However, students' scientific argumentation skills remain relatively low, especially in constructing claims, using evidence, and providing scientific reasoning. Innovative learning models that integrate contextual and argumentative learning experiences are therefore needed in higher education.

Purpose. This study analyzed the need for developing a Problem-Based Learning (PBL) model integrated with Socio-Scientific Issues (SSI) to enhance the argumentation skills of pre-service primary school teachers.

Method. A descriptive survey design was employed involving 35 pre-service primary school teachers from Universitas Jambi and 5 lecturers teaching science education courses at several Indonesian universities. Data were collected using open-ended and close-ended questionnaires and analyzed through descriptive statistical analysis and qualitative categorization techniques.

Results. Students perceived the current condition of science learning at a moderate level (M = 3.40), while lecturers reported a higher perception (M = 4.35), indicating that although science learning has provided discussion opportunities, it has not yet systematically supported students' scientific argumentation skills. The integration of PBL and SSI in current instructional practices received high ratings from both groups (students: M = 4.18; lecturers: M = 4.48). Notably, the strongest agreement was found regarding the need to develop a PBL-SSI integrated model (students: M = 4.61; lecturers: M = 4.82), confirming a strong demand for a structured learning model to better support scientific argumentation among pre-service teachers.

Conclusion. Developing a PBL-SSI integrated learning model is necessary to support the improvement of argumentation skills among pre-service primary school teachers. These findings serve as a foundation for designing innovative science learning models that promote scientific argumentation, critical thinking, and contextual learning in Indonesian higher education.

KEYWORDS

Argumentation Skills, Need Analysis, Pre-Service Primary Teachers, Problem-Based Learning, Socio-Scientific Issues

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INTRODUCTION

The rapid advancement of science and technology in the twenty-first century has transformed the competencies expected of future teachers. Beyond mastering scientific concepts, pre-service teachers are expected to develop scientific literacy, critical thinking, evidence-based reasoning, and scientific argumentation to support informed decision-making and meaningful science learning. Recent studies emphasize that scientific literacy should include learners' abilities to reason about the ethical-socio-political dimensions of science and to evaluate evidence in complex social contexts (Sjöström, 2025). In addition, teacher education should provide inquiry-oriented learning experiences that prepare pre-service teachers to facilitate scientific reasoning and discussion in science classrooms (Strat et al., 2024). Scientific thinking and critical thinking are also considered core intellectual processes in science education because they enable learners to evaluate claims, examine evidence, and justify conclusions (García-Carmona, 2025). More specifically, recent studies on pre-service and elementary teacher education indicate that argumentation competence must be deliberately developed through validated learning progressions, argument-driven inquiry, and explicit argumentation-based pedagogy (Altun & Ozsevgec, 2025; Palma-Jiménez et al., 2025; Şahin Kalyon & Özdem Yılmaz, 2025). Therefore, strengthening scientific argumentation during teacher education has become an important priority for preparing competent primary school teachers.

Scientific argumentation is widely recognized as a fundamental competency in science education because it enables learners to construct scientific knowledge, critically evaluate evidence, justify claims using scientific reasoning, and make informed decisions on complex scientific issues. Consequently, scientific argumentation has become one of the essential learning outcomes in science education, particularly in teacher education programs, where pre-service teachers are expected not only to understand scientific concepts but also to facilitate evidence-based discussions in their future classrooms. Despite its recognized importance, numerous studies have consistently reported that many pre-service teachers continue to experience difficulties in constructing complete scientific arguments, particularly in integrating claims, evidence, and scientific reasoning. These findings highlight the need for instructional approaches that explicitly support the development of scientific argumentation in higher education.

However, accumulating evidence indicates that scientific argumentation remains a persistent challenge in science education. Argumentation-oriented learning can strengthen students' critical thinking and argumentation abilities when learners are supported to coordinate claims, evidence, warrants, and rebuttals (Demircioglu et al., 2023). Foundational studies also show that quality scientific argumentation requires explicit attention to argument structure, evidence use, classroom discourse, rebuttal, and assessment criteria (Berland & Reiser, 2009; Driver et al., 2000; Duschl & Osborne, 2002; Erduran et al., 2004; Kuhn, 2010; Osborne et al., 2004; Osborne, 2010; Sampson & Clark, 2008; Sandoval & Millwood, 2005). This implies that teacher education programs need explicit instructional structures, not merely general discussion activities, to cultivate high-quality scientific arguments. Without such structures, pre-service teachers may be able to express opinions but may still struggle to justify their claims using relevant scientific evidence and reasoning.

These problems were also identified among students in the Primary School Teacher Education Program at Universitas Jambi. Preliminary observations during science learning indicated that students still experienced difficulties in constructing arguments consisting of claims, evidence, and scientific reasoning. Students generally provided brief answers without presenting comprehensive scientific explanations when analyzing scientific phenomena or educational problems. Considering that pre-service primary teachers will later be responsible for developing elementary students' scientific thinking, strengthening their scientific argumentation skills has become an important educational priority.

Recent studies have shown that scientific argumentation develops more effectively when students engage in authentic problem-solving, collaborative inquiry, and evidence-based discussion. Problem-Based Learning (PBL) provides these learning experiences by encouraging students to actively construct knowledge while solving contextual problems. Classical and recent evidence indicates that PBL supports knowledge construction, collaboration, inquiry, problem solving, and critical thinking when it is implemented with adequate scaffolding and facilitation (Barrows, 1986; Dochy et al., 2003; Gijbels et al., 2005; Hmelo-Silver, 2004; Hmelo-Silver et al., 2007; Savery J.R, 2006; Schmidt et al., 2011; Strobel & van Barneveld, 2009;

Walker & Leary, 2009; Yew & Goh, 2016). More recent reviews and meta-analyses similarly suggest that PBL contributes positively to science achievement, critical thinking, and reflective reasoning, particularly when students are required to analyze problems, evaluate information, justify solutions, and reflect on their reasoning processes (Lu et al., 2025; Su et al., 2025; Yu & Zin, 2023). These findings indicate that PBL is a relevant instructional basis for strengthening scientific argumentation in teacher education.

Although Problem-Based Learning (PBL) provides meaningful problem-solving experiences, its potential to foster scientific argumentation can be strengthened by incorporating authentic socio-scientific contexts. Socio-Scientific Issues (SSI) require learners to connect scientific concepts with social consequences, evaluate evidence, consider multiple perspectives, and justify decisions. SSI scholarship emphasizes that learners' reasoning about science-related social issues requires informal reasoning, ethical consideration, evidence evaluation, dialogue, and decision-making (V. Dawson & Carson, 2020; V. M. Dawson & Venville, 2010; Eastwood et al., 2012; Evagorou & Osborne, 2013; Lee et al., 2013; Sadler, 2004; Sadler et al., 2016; Sadler & Zeidler, 2005; Tal & Kedmi, 2006; Zeidler et al., 2005). This orientation is aligned with current scientific literacy scholarship, which emphasizes that science education should engage learners with ethico-socio-political reasoning and decision-making in real-world contexts (Sjöström, 2025). When SSI contexts are combined with argumentation-oriented instruction, learners have structured opportunities to formulate claims, evaluate evidence, construct warrants and rebuttals, and make reasoned decisions (Demircioglu et al., 2023; Friedrichsen et al., 2016). Therefore, integrating PBL with SSI offers a promising instructional framework for promoting evidence-based scientific argumentation among pre-service primary school teachers.

Despite the promising contributions of PBL and SSI, several important research gaps remain. First, most previous studies have focused on secondary school students rather than pre-service primary school teachers. Second, studies generally investigated PBL and SSI separately instead of integrating both approaches into a comprehensive instructional model. Third, limited studies have conducted systematic needs analyses as the basis for developing an integrated PBL-SSI model in teacher education. In addition, implementing PBL-SSI in higher education remains challenging because of limited instructional time, large class sizes, lecturers' readiness to facilitate argumentative discussions, and the limited availability of scientific argumentation assessment instruments. Taken together, these gaps highlight the need for a comprehensive needs analysis to identify current instructional conditions and stakeholders' expectations as the empirical basis for developing an integrated PBL-SSI learning model for primary teacher education.

Addressing these research gaps requires empirical evidence that reflects the actual instructional conditions and expectations of both lecturers and pre-service primary school teachers. Recent studies have emphasized that developing scientific argumentation and critical thinking requires explicit instructional support, inquiry-based learning experiences, and well-designed learning environments (Arifin et al., 2025; Strat et al., 2024; Yu & Zin, 2023). In addition, the literature on scientific argumentation highlights that learning environments should provide scaffolds for constructing claims, using evidence, explaining reasoning, and revising arguments through peer dialogue (Berland & McNeill, 2010; Hmelo-Silver et al., 2007; McNeill et al., 2006, 2016). Teacher-related studies further suggest that pre-service teachers need pedagogical design capacity and explicit practice in argumentation before they are expected to facilitate evidence-based classroom discourse (Altun & Ozsevgec, 2025; Knight-Bardsley & McNeill, 2016; Palma-Jiménez et al., 2025; Şahin Kalyon & Özdem Yılmaz, 2025). Therefore, conducting a needs analysis is an essential first step before developing a Problem-Based Learning model integrated with Socio-Scientific Issues (PBL-SSI). This study aims to identify the current conditions of science learning, lecturers' and students' needs, and their expectations regarding the development of a PBL-SSI learning model to enhance scientific argumentation among pre-service primary school teachers.

The novelty of this study lies in providing a comprehensive needs analysis as the empirical foundation for developing a learning model that integrates Problem-Based Learning (PBL), Socio-Scientific Issues (SSI), and scientific argumentation specifically for pre-service primary school teachers. Unlike previous studies, which generally examined argumentation, PBL, or SSI separately and were predominantly conducted in secondary education contexts, this study integrates these three components within primary teacher education. The findings contribute to the science education literature by identifying the instructional needs and expectations of both students and lecturers, thereby providing a research-based foundation for the systematic development of an integrated PBL-SSI learning model. Furthermore, this study represents the first phase of a research and development process that will inform the subsequent expert validation, pilot implementation, and effectiveness evaluation of the proposed learning model. Accordingly, it establishes an empirical basis for designing a contextually relevant and evidence-informed PBL-SSI learning model to strengthen scientific argumentation among future primary school teachers.

RESEARCH METHODOLOGY

This study employed a descriptive research design to describe and analyze the need for developing a Problem-Based Learning (PBL) model integrated with Socio-Scientific Issues (SSI) to improve the argumentation skills of pre-service primary school teachers. Descriptive research was used to obtain information regarding current learning conditions, lecturers' and students' needs, and problems encountered in argumentative learning in science education courses.

The participants consisted of lecturers and students from Primary School Teacher Education programs at several universities in Indonesia. The study involved 35 students from Universitas Jambi and 5 lecturers teaching science education courses from Universitas Jambi, Universitas Riau, Universitas Bengkulu, and UIN Sultan Thaha Jambi. Participants were selected purposively based on their involvement in science learning activities and their experiences in discussion-based and problem-solving learning.

This study employed purposive sampling because the participants were intentionally selected based on their direct experience in science education courses, particularly the Basic Science Concepts course. The selected students had experienced discussion-based science learning and were therefore able to provide information-rich responses regarding their learning experiences, argumentation skills, and the need for developing a Problem-Based Learning model integrated with Socio-Scientific Issues (PBL-SSI). Purposive sampling is considered appropriate for needs analysis research because the objective is to obtain in-depth information from participants who possess characteristics relevant to the research objectives rather than to achieve statistical generalization.

The research procedures began with a preliminary study through classroom observations and short interviews to identify problems related to students' argumentation skills. The next stage involved developing research instruments in the form of open-ended and close-ended questionnaires to identify lecturers' and students' needs regarding the development of a PBL model integrated with SSI. Open-ended questionnaires were used to obtain in-depth information about learning experiences, challenges, and expectations related to the learning model to be developed. Meanwhile, close-ended questionnaires were used to identify participants' perceptions and levels of need regarding argumentative and socio-scientific issue-based learning.

The research instruments consisted of open-ended and close-ended questions using a Likert scale. The lecturers' questionnaire included aspects related to learning model needs, implementation of argumentative learning, and the use of socio-scientific issues in science education. The students' questionnaire included aspects related to learning experiences, argumentation skills, discussion activities, and the need for contextual and interactive learning.

Prior to data collection, the questionnaire underwent content validation by a science education expert to evaluate the relevance, clarity, construct representation, language, presentation, and readability of each questionnaire item. Following the expert validation, the revised questionnaire was piloted with 40 pre-service primary school teachers.

Table 1. Instrument Validation and Reliability

Aspect	Result	Interpretation
Expert validation	Mean = 4.40/5.00	Highly appropriate
Pilot test	n = 40	—
Cronbach's Alpha	0.918	Excellent reliability

Data were collected online using Google Forms. Participants were asked to complete the questionnaires based on their experiences and perceptions of the learning process. Quantitative data from the close-ended questionnaires were analyzed using descriptive statistics, including percentages and average scores for each indicator. Qualitative data from the open-ended questionnaires were analyzed through data condensation, data display, categorization, and conclusion drawing to obtain a comprehensive understanding of the needs for developing a PBL model integrated with SSI (Miles et al., 2014).

The results of the data analysis were used as the basis for designing a PBL-SSI learning model suitable for improving the scientific argumentation skills of pre-service primary school teachers.

RESULT AND DISCUSSION

The results of the needs analysis were derived from open-ended and close-ended questionnaires administered to students and lecturers involved in science education courses. The analysis aimed to identify problems encountered in current learning practices, particularly those related to scientific argumentation skills, as well as the need for developing a Problem-Based Learning (PBL) model integrated with Socio-Scientific Issues (SSI). The summarized findings are presented in Tables 2 and figure 1.

Table 2. Students' and Lecturers' Needs Analysis Results

Aspect	Students	Lecturers
Current Conditions of Science Learning in Primary School Teacher Education Programs	3.40	4.35
The Implementation of Problem-Based and Socio-Scientific Issues-Based Learning	4.18	4.48
The Need for Developing a PBL Model Integrated with SSI	4.61	4.82

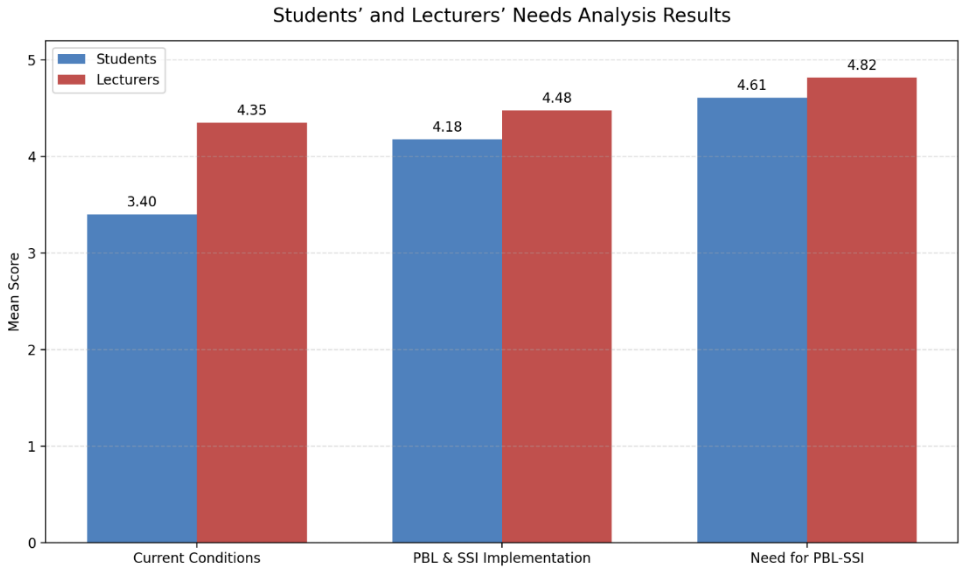

Figure 1. Students' and Lecturers' Needs Analysis Results

The findings indicate that students' argumentation-related learning experiences were perceived at a moderate level. Although students had opportunities to participate in discussions, their scientific argumentation skills were not yet fully developed, particularly in constructing evidence-based claims, linking evidence to reasoning, and providing scientific rebuttals.

Current Conditions of Science Learning in Primary School Teacher Education Programs

The results of the student questionnaire analysis showed that science learning in Primary School Teacher Education programs has provided opportunities for students to engage in discussions and express their opinions. However, students' scientific argumentation skills have not yet developed optimally. Most students stated that they still experience difficulties in presenting scientific arguments clearly, using evidence to support their opinions, and explaining the relationship between evidence and the claims they make.

These findings were reinforced by the lecturers' questionnaire results, which indicated that students are generally able to express simple opinions but have not yet been able to develop complete scientific arguments. Lecturers stated that students still face difficulties in using data, facts, and scientific concepts as the basis for their arguments. In addition, students' ability to provide scientific rebuttals to opposing opinions remains relatively low.

Based on the open-ended questionnaire responses, most students reported that science learning activities have primarily focused on practical work and experiments but have not adequately developed argumentative activities. Discussions conducted during learning have not fully encouraged students to defend their opinions using scientific evidence. Students also revealed that they often feel less confident when asked to present arguments during classroom discussions.

On the other hand, lecturers stated that limited instructional time, the lack of argumentative learning tools, and low student participation are major obstacles in implementing learning activities that effectively train scientific argumentation skills. These conditions indicate that science learning in Primary School Teacher Education programs still requires more contextual, interactive, and argumentative learning innovations.

The Implementation of Problem-Based and Socio-Scientific Issues-Based Learning

The results of the study showed that problem-based learning has been implemented in several science learning activities; however, its implementation has not yet been systematically integrated with scientific argumentation activities and socio-scientific issues. Students stated that the use of real-world problems in learning activities increases their learning interest and makes learning more meaningful.

Students also gave positive responses to learning activities that connect science concepts with social and environmental issues in society. According to the students, issue-based learning makes it easier for them to understand science concepts while simultaneously training their critical thinking skills regarding various real-life problems.

The lecturers' questionnaire results indicated that the integration of Socio-Scientific Issues (SSI) in science learning is still rarely implemented in a structured manner. Lecturers generally only use simple contextual examples without developing in-depth argumentative discussions related to socio-scientific issues. In fact, lecturers acknowledged that the use of real-world issues can help students analyze problems from multiple perspectives and train evidence-based decision-making skills.

The Need for Developing a PBL Model Integrated with SSI

The needs analysis results indicated that both lecturers and students have a high level of need for the development of a PBL model integrated with SSI. Students stated that learning activities based on real-world problems and socio-scientific issues are highly needed to make science learning more interesting, interactive, and capable of improving scientific argumentation skills.

Students also expressed the need for: a). More intensive argumentative discussion activities, b). Teaching materials and worksheets based on real-world problems, c). Guidelines for constructing scientific arguments, and, d). Argumentation assessment rubrics to help students understand the quality of their arguments.

Meanwhile, lecturers stated that a learning model integrating PBL, SSI, and scientific argumentation is highly needed in Basic Science Concept courses in Primary School Teacher Education programs. Lecturers also emphasized the importance of learning syntax that systematically includes problem orientation, investigation, argumentative discussion, solution presentation, and learning reflection.

These findings indicate that the development of a PBL model integrated with SSI has a high level of urgency in supporting the improvement of pre-service primary school teachers' argumentation skills. The results showed that the argumentation skills of pre-service primary school teachers at Universitas Jambi had not yet developed optimally, particularly in constructing scientifically justified claims, providing appropriate evidence, and linking evidence to scientific reasoning. This pattern is consistent with (Demircioglu et al., 2023), who demonstrated that argumentation-oriented science activities improve critical thinking and argumentation when learners are guided to coordinate claims, evidence, warrants, and rebuttals. Similar perspectives are found in major argumentation studies emphasizing that scientific argument quality depends on evidence use, reasoning coherence, rebuttal, and dialogic evaluation (Berland & Reiser, 2009; Driver et al., 2000; Erduran et al., 2004; Kuhn, 2010; Osborne et al., 2004; Sampson & Clark, 2008; Sandoval & Millwood, 2005)

The findings also indicated that science learning activities tended to focus more on practical and experimental activities without providing sufficient opportunities for in-depth argumentative discussions. Limited learning time was identified as one of the factors influencing students' low argumentation skills. Students had not been adequately trained to defend opinions, criticize arguments, and evaluate scientific evidence during classroom discussions. This finding indicates that practical and experimental activities should not stand alone as procedural learning activities. Within a PBL-SSI framework, practical work needs to be connected to problem analysis, evidence evaluation, claim construction, reasoning, and rebuttal so that students are explicitly guided to transform observations and data into scientifically justified arguments. Thus, practical work needs to be deliberately connected to argument construction rather than treated merely as a procedural activity. This interpretation is reinforced by research on scientific explanations and evidence use, which indicates that students need structured support to transform observations and data into well-justified explanations (McNeill et al., 2006; Sandoval & Millwood, 2005).

Furthermore, argumentation should be positioned not only as a communication activity but also as a cognitive process for constructing scientific understanding. When students are required to justify claims with evidence and reasoning, they are encouraged to examine the quality of their explanations and the validity of their conclusions. (Demircioglu et al., 2023) provide empirical support for this position by showing that argumentation-oriented learning can develop both critical thinking and argumentation abilities. (Berland & McNeill, 2010) further show that students' scientific argumentation develops progressively when instructional contexts support increasingly complex argument structures. Recent pre-service teacher studies similarly demonstrate that argument-driven inquiry and learning progression-based instruction can improve future teachers' understanding and skills of argumentation (Palma-Jiménez et al., 2025; Şahin Kalyon & Özdem Yılmaz, 2025). Therefore, the current needs analysis confirms the importance of designing learning activities that explicitly integrate claim construction, evidence evaluation, reasoning, and rebuttal.

In this context, Problem-Based Learning (PBL) becomes a relevant learning alternative to improve students' argumentation skills. PBL enables students to learn through solving real-world problems, thereby encouraging critical thinking, discussion, and collaboration. Through inquiry processes, students can develop their ability to construct arguments based on data and scientific evidence. These findings are consistent with (Barrows, 1986; Hmelo-Silver, 2004; Hmelo-Silver et al., 2007; Savery J.R, 2006; Schmidt et al., 2011; Yew & Goh, 2016), who emphasized that PBL supports learning through facilitated problem solving, scaffolding, collaboration, self-directed inquiry, and knowledge integration. They are also aligned with (Yu & Zin, 2023), who emphasized that critical-thinking-oriented PBL adaptations require students to analyze problems, justify solutions, and reflect on their reasoning.

The implementation of PBL in science education also supports constructivist learning, which positions students as active participants in constructing knowledge through learning experiences. However, PBL should be implemented with clear scaffolding so that students do not only solve problems but also articulate the reasoning behind their solutions. Meta-analytic studies indicate that the effectiveness of PBL depends on problem type, disciplinary context, assessment form, facilitation quality, and alignment between learning activities and assessment demands (Dochy et al., 2003; Gijbels et al., 2005; Strobel & van Barneveld, 2009; Walker & Leary, 2009). Therefore, PBL activities in this study context need to be designed to include evidence searching, group investigation, argument construction, peer critique, and reflection.

However, the implementation of PBL needs to be enriched through the integration of Socio-Scientific Issues (SSI) to create more contextual and argumentative learning environments. SSI integration allows students to connect science concepts with social issues occurring in society, encouraging them to consider multiple perspectives before making decisions. This rationale aligns with (Sadler, 2004), (Sadler & Zeidler, 2005), (Sadler et al., 2016), (Tal & Kedmi, 2006), and (Zeidler et al., 2005), who emphasized the importance of informal reasoning, moral judgment, evidence evaluation, classroom culture, and decision-making in SSI-based science education. It also aligns with (Sjöström, 2025) Vision III of scientific literacy, which emphasizes the ethico-socio-political dimensions of science education and the importance of preparing learners to reason about science-related decisions in society.

Therefore, the integration of SSI into PBL should not be treated as a simple addition of real-life examples. It requires systematic scaffolding that guides students to identify scientific evidence, weigh social consequences, justify decisions, and communicate arguments. Such integration is consistent with high-citation evidence showing the importance of argumentation-oriented learning (Demircioglu et al., 2023), scientific explanation scaffolding (McNeill et al., 2006), SSI-based reasoning and character development (Eastwood et al., 2012; Lee et al., 2013), and critical-thinking-oriented PBL adaptations (Yu & Zin, 2023). In this sense, PBL-SSI can create a learning environment in which scientific concepts, social relevance, and argumentation processes mutually reinforce one another.

The findings further revealed that students responded positively to learning activities connected to real-world issues. Students perceived science learning integrated with socio-scientific issues as more engaging, contextual, and relevant to everyday life. This finding can be interpreted through current scientific literacy scholarship, which argues that science learning becomes more meaningful when learners are invited to connect scientific knowledge with social, ethical, and decision-making dimensions of real-world problems (García-Carmona, 2025; Sjöström, 2025). It is also consistent with studies showing that SSI contexts can support collaborative argumentation, climate-related argumentation, and science-content learning when students are guided to evaluate evidence and justify decisions (V. Dawson & Carson, 2020; V. M. Dawson & Venville, 2010; Evagorou & Osborne, 2013; Sadler et al., 2016). Taken together, these findings suggest that embedding authentic socio-scientific issues into science learning not only enhances students' perceived relevance of science but also creates meaningful opportunities for evidence-based discussion and the development of scientific argumentation.

The students' needs for problem-based worksheets, scientific argumentation guidelines, and argumentation assessment rubrics indicate that learning model development should not only focus on instructional syntax but also on supporting learning tools. Students' argumentation quality can improve when learning is supported by argumentative scaffolding and clear assessment instruments. This implication is consistent with research showing that argumentation and critical thinking improve when learners are provided with structured opportunities to analyze problems, evaluate evidence, and justify reasoning (Arifin et al., 2025; Berland & Reiser, 2009; Demircioglu et al., 2023; Sampson & Clark, 2008; Yu & Zin, 2023). In addition, SSI curriculum design studies indicate that worksheets, prompts, and modeling tasks need to explicitly connect scientific content with social decision-making and argument construction (Eastwood et al., 2012; Friedrichsen et al., 2016; Lee et al., 2013). Through systematic learning tools, students can better understand the structure and quality of scientific arguments.

Recent evidence further suggests that the need for supporting learning tools should be interpreted as a pedagogical design issue, not merely as a material development issue. A systematic review of SSI teaching reported that SSI pedagogy is commonly organized around higher-order thinking, science content knowledge, environmental and health-related issues, and group discussion as a dominant teaching method (Högström et al., 2025). This supports the present finding that students and lecturers require structured worksheets, argumentation guides, and assessment rubrics, because SSI learning requires students to connect scientific concepts with ethical, social, and decision-making dimensions rather than simply discuss contextual examples.

Evidence from the Indonesian context also reinforces the relevance of integrating problem solving and SSI for strengthening scientific argumentation. (Alberida et al., 2026) reported that a socio-scientific issue-based problem-solving model significantly improved students' scientific argumentation and scientific writing skills through systematic real-world problem-solving stages. Although the present study has not yet tested effectiveness, these findings provide an empirical rationale for developing a PBL-SSI model whose syntax deliberately moves students from problem identification, evidence investigation, argument construction, rebuttal, decision-making, and reflection.

At the teacher education level, recent studies emphasize that pre-service teachers require repeated and scaffolded opportunities to rehearse facilitation of argumentation-focused discussions. (Mikeska et al., 2025) showed that digital simulations can support preservice teachers' facilitation of argumentation in mathematics and science, while (Park Rogers et al., 2026) found that teacher educators used modeling, video analysis, discussion organization, and reflection to help pre-service teachers practice argumentation-focused facilitation. These findings strengthen the implication that the proposed PBL-SSI model should include lecturer guidance, peer critique, reflective practice, and explicit prompts for claim-evidence-reasoning-rebuttal construction.

Furthermore, the need for SSI integration in primary teacher education is supported by recent research on pre-service elementary science teachers. (Bautista, 2025) found that teaching through social justice science issues can help pre-service elementary teachers understand science as socially situated, while also revealing challenges related to knowledge boundaries, teacher roles, and interdisciplinary integration. This is important for the present study because PGSD students will later teach science to elementary pupils; therefore, PBL-SSI learning should prepare them not only to understand scientific concepts but also to facilitate context-sensitive, ethically aware, and evidence-based discussions.

Overall, the findings indicate that developing a PBL model integrated with SSI has strong potential to improve pre-service primary school teachers' argumentation skills while creating more active, contextual, interactive, and meaningful science learning. Nevertheless, this potential should be interpreted as a basis for model development rather than as evidence of effectiveness, because the present study was limited to a needs analysis stage.

Despite its potential benefits, implementing a Problem-Based Learning model integrated with Socio-Scientific Issues (PBL-SSI) in higher education is not without challenges. One important issue is the management of large classes, where facilitating meaningful discussions, monitoring students' participation, and providing individual feedback on scientific argumentation can be difficult. Since PBL-SSI emphasizes collaborative inquiry and evidence-based discussion, lecturers are required to allocate sufficient instructional time and employ effective classroom management strategies to ensure that all students actively engage in the learning process. Recent reviews of inquiry-based and PBL-oriented learning also indicate that learning outcomes depend strongly on task design, scaffolding, and facilitation quality (Gijbels et al., 2005; Hmelo-Silver et al., 2007; Schmidt et al., 2011; Strat et al., 2024; Yu & Zin, 2023).

Another challenge concerns lecturers' pedagogical readiness and the availability of appropriate instructional resources. Facilitating socio-scientific discussions requires lecturers to guide students in evaluating scientific evidence, considering multiple perspectives, and constructing well-supported arguments rather than simply delivering scientific content. In addition, assessing students' scientific argumentation requires valid assessment rubrics capable of evaluating claims, evidence, reasoning, and rebuttals. Studies of teachers' argumentation instruction show that learning goals, pedagogical content knowledge, classroom norms, and teachers' design capacity strongly shape how argumentation is enacted in science classrooms (Knight-Bardsley & McNeill, 2016; McNeill et al., 2016). Therefore, successful implementation of the PBL-SSI model should be accompanied by lecturer professional development, adequate learning resources, and assessment tools that support evidence-based scientific argumentation.

These implementation challenges may be more evident in developing-country contexts, where higher education institutions often face constraints related to class size, instructional time, and access to learning resources. Nevertheless, these limitations should not be viewed as barriers to adopting PBL-SSI. Instead, they highlight the importance of designing flexible instructional strategies that accommodate local educational contexts while maintaining opportunities for scientific discussion and evidence-based argumentation. Consequently, the proposed PBL-SSI model should be adaptable to institutional conditions without compromising its core principles of contextual problem solving, inquiry, and scientific argumentation (Arifin et al., 2025; Barrows, 1986; Hmelo-Silver, 2004; Savery J.R, 2006; Strat et al., 2024; Tal & Kedmi, 2006).

CONCLUSION

The findings indicate that the argumentation skills of pre-service primary school teachers at Universitas Jambi have not yet developed optimally, particularly in constructing claims, using evidence, and providing scientific reasoning. Current science learning activities have provided opportunities for discussion; however, they have not systematically trained students' scientific argumentation skills.

The needs analysis results demonstrate that both lecturers and students require a more innovative, contextual, and interactive learning model to support the development of students' argumentation skills. A Problem-Based Learning model integrated with Socio-Scientific Issues is considered relevant because it connects science concepts with real-world problems and encourages students to think critically, engage in discussions, and make evidence-based decisions.

Furthermore, the development of a PBL-SSI learning model should be supported by learning tools such as problem-based worksheets, scientific argumentation guidelines, and argumentation assessment rubrics to ensure optimal implementation. Therefore, the results of this study can serve as an important foundation for developing a PBL model integrated with SSI to improve pre-service primary school teachers' argumentation skills.

This study was limited to the needs analysis stage involving a relatively small number of participants from several universities and did not include the development, validation, or implementation of the proposed learning model. Therefore, future research should focus on developing the PBL-SSI model, followed by expert validation to examine its content validity, construct appropriateness, and instructional feasibility before classroom implementation. Subsequently, the validated model can be piloted and evaluated in broader educational settings to examine its effectiveness in enhancing scientific argumentation skills. In addition, the model is recommended for adaptation and implementation in other teacher education study programs, such as science, mathematics, and subject-specific teacher education programs, to examine its applicability across different disciplinary contexts.

DECLARATION OF AI AND AI ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this work the author(s) used ChatGPT in order to support language editing and manuscript organization. All scientific interpretations, analyses, and conclusions were independently conducted and verified by the authors. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

AUTHORS' CONTRIBUTION

Author 1: Conceptualization, Investigation, Formal analysis, Writing – original draft.
Author 2: Supervision, Methodology, Validation, Writing – review & editing.
Author 3: Supervision, Validation, Writing – review & editing.
Author 4: Supervision, Data curation, Writing – review & editing.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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