

Evaluating the Pedagogical Beliefs of Pre-service Biology Teachers on Socio-Scientific Issues

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Abstract

The rapid advancement of biological sciences has intensified the presence of complex ethical, social, and political dilemmas in everyday life, collectively referred to as Socio-Scientific Issues (SSI). Preparing scientifically literate citizens requires biology education to extend beyond factual knowledge toward the development of socio-scientific reasoning, ethical judgment, and informed decision-making. This study examined the perceptions of 24 pre-service biology teachers in the Philippines regarding the necessity, feasibility, and challenges of integrating SSI-based instruction into the biology curriculum. Using a descriptive-quantitative research design, data were gathered through a validated 15-item perception survey complemented by open-ended responses. Descriptive statistics and the Wilcoxon Signed-Rank Test were employed to analyze the data, while qualitative responses were thematically analyzed and triangulated with international and local literature. Results reveal a highly positive perception of the necessity of SSI integration ($M = 3.63$) and strong willingness to develop and use SSI-based instructional materials ($M = 3.50$). However, participants also expressed concerns related to limited instructional time, students' insufficient prior knowledge, and cultural and religious sensitivities. Triangulation highlights a persistent gap between philosophical support for SSI and perceived practical capacity to implement it effectively. The study concludes that while pre-service biology teachers are conceptually aligned with the goals of SSI-based instruction, systemic support through targeted teacher education, localized instructional resources, and curriculum-level policy reinforcement is essential for sustainable classroom implementation within the Philippine context.

Keywords: Socio-scientific issues, Biology education, Pre-service teachers, Scientific literacy, Philippine K–12, Teacher beliefs

1. Introduction

1.1 The Global Imperative for Scientific Literacy

Science education in the 21st century is increasingly defined by its capacity to prepare learners for participation in a society shaped by rapid scientific and technological change. Contemporary issues such as climate change, genetic engineering, biodiversity loss, and global health crises demand citizens who can evaluate scientific information, weigh evidence, and make reasoned judgments that consider ethical and social implications. This capacity, commonly referred to as *functional scientific literacy*, goes beyond

memorization of scientific facts and emphasizes the application of scientific understanding in personal, civic, and societal contexts (Sadler, 2022; Zeidler, 2014).

Within biology education, the need for functional scientific literacy is particularly pronounced. Advances in biotechnology, medicine, and environmental science routinely generate public debates that require informed participation. Scholars argue that when science education fails to address these real-world dilemmas, students may perceive science as disconnected from their lives, limiting both engagement and relevance (Bencze et al., 2020; Dawson & Venville, 2023).

1.2 Defining Socio-Scientific Issues (SSI)

Socio-Scientific Issues are controversial, socially relevant problems that are conceptually linked to science and characterized by their open-ended, ill-structured nature (Chitnok & Yuenyong, 2019; Nongkhunsarn et al., 2019; Ratcliffe & Grace, 2003). Unlike traditional problem-solving tasks with predetermined answers, SSI require learners to integrate scientific knowledge with ethical reasoning, cultural values, and socio-political considerations. Examples include debates on genetically modified organisms (GMOs), climate policy, vaccination, reproductive technologies, and conservation strategies (Wongsila & Yuenyong, 2019).

SSI-based instruction places these dilemmas at the center of learning rather than treating them as peripheral applications of content knowledge. Through engagement with SSI, students practice socio-scientific reasoning (SSR), which involves recognizing complexity, evaluating multiple perspectives, assessing evidence quality, and making justified decisions under conditions of uncertainty (Luengam et al., 2019; Sadler et al., 2021). As such, SSI are widely regarded as powerful pedagogical tools for achieving the broader goals of scientific literacy and citizenship education.

1.3 The Philippine Science Education Context

In the Philippines, the Department of Education (DepEd) implemented the K–12 Basic Education Program to address longstanding concerns about learner preparedness and scientific competence (DepEd, 2016). The Science Curriculum Framework emphasizes the development of scientifically, technologically, and environmentally literate citizens, aligning in principle with global calls for SSI integration. The curriculum's spiral progression model allows recurring engagement with key biological concepts across grade levels, theoretically creating opportunities to embed SSI in increasingly complex forms.

However, local studies suggest that the potential of the curriculum to support SSI-based instruction remains underutilized. Teachers often prioritize content coverage and examination preparation, leaving limited time for extended discussion and argumentation (Pimvichai et al., 2019). Moreover, the hierarchical and exam-oriented culture of Philippine schooling can constrain open dialogue, a core requirement of effective SSI pedagogy (Bernardo, 2021). These challenges are further complicated by culturally sensitive topics and strong religious influences that shape classroom discourse.

1.4 Pre-service Teachers and Pedagogical Readiness

Teachers play a pivotal role in translating curriculum intentions into classroom practice. Research consistently demonstrates that teachers' beliefs, attitudes, and perceptions strongly influence their instructional decisions (Pajares, 1992). Pre-service teachers, in particular, represent a critical population because their professional beliefs are still being formed and can be shaped through targeted teacher education experiences.

In the Philippine context, an increasing number of pre-service teachers are *second coursers*—individuals who hold prior degrees in science-related fields and enroll in education units to qualify for teaching licensure. While these individuals often possess

strong content knowledge, they may lack pedagogical preparation for managing open-ended, controversial discussions inherent in SSI-based instruction (Bernardo et al., 2023). Despite this, empirical research focusing on pre-service biology teachers' perceptions of SSI in the Philippines remains limited.

1.5 Theoretical and Empirical Foundations of the SSI Perception Scale

To methodologically assess these professional beliefs, this study anchors its primary quantitative diagnostic measure on the *Socio-Scientific Issues (SSI) Perception Scale* developed by Topçu et al. (2023). Understanding pre-service teachers' instructional configurations requires an instrument grounded in the explicit components of socio-scientific reasoning (SSR)—namely, acknowledging the systemic complexity of scientific dilemmas, evaluating alternative perspectives, and confronting the social values inextricably bound to scientific advancements (Sadler et al., 2021). The instrument's items function as a proxy to observe how teachers translate these conceptual dimensions of SSR into an operationalized classroom environment.

Psychometrically, the original instrument established by Topçu et al. (2023) demonstrated strong validity and structural stability via both exploratory and confirmatory factor analyses. The scale exhibits an overall Cronbach's alpha reliability coefficient of 0.88, confirming its internal consistency across distinct latent dimensions: (a) perceived epistemic necessity of SSI, (b) active instructional willingness, (c) pedagogical/resource concerns, and (d) boundaries of the scientific discipline. Historically, the utility of this instrument has been widely demonstrated in international empirical investigations across multiple educational landscapes proving highly effective in identifying the exact pivot point where a teacher's theoretical support for progressive science curricula diverges from their perceived classroom agency (Marlina et.al., 2024).

For the purposes of this investigation, adapting rather than directly adopting the original scale in its raw form was necessary due to distinct contextual, institutional, and linguistic realities of the Philippine Basic Education ecosystem. First, the items were adjusted to reflect the structural mandates of the DepEd K–12 Spiral Progression Framework, ensuring terms referring to "integrated science tracks" were mapped precisely to standard Philippine secondary biology instructional blocks. Second, specific phrasing was modified to capture localized socio-cultural sensitivities—particularly regarding local ecological vulnerabilities and community-specific religious paradigms—which heavily dictate whether a Filipino educator views a biology topic as an "approachable issue" or a "taboo conflict" (Marlina et.al., 2025). These targeted adaptations ensure the instrument operates with high ecological validity within the localized sample framework.

1.6 Conceptual Framework

This study is theoretically anchored in Pajares' (1992) teacher belief theory and Zeidler's (2014) framework for SSI-based instruction. According to Pajares, pre-service teachers' perceptions form a core belief structure that acts as a cognitive filter, profoundly dictating their willingness and approach to teaching. Zeidler's model emphasizes that functional scientific literacy cannot occur through isolated scientific concepts; rather, science must be situated within an integrated nexus of ethical, cultural, and socio-political dimensions.

Pre-service teachers bring their academic backgrounds (including unique groups like second coursers) into teacher education. Their filtered perceptions of SSI—structured around perceived necessity, instructional willingness, pedagogical concerns, and disciplinary boundaries—ultimately dictate their ultimate pedagogical capacity and readiness to deploy SSI in the classroom (Marlina et.al., 2026).

1.7 Research Questions

This study addressed this gap by examining the perceptions of pre-service biology teachers regarding SSI-based instruction. Specifically, it aimed to answer the following questions:

1. What are the perceptions of pre-service biology teachers regarding the necessity and implementation of SSI-based instruction in biology education?
2. Is there a statistically significant difference between these perceptions and a neutral pedagogical stance?
3. What content priorities and implementation challenges do pre-service teachers identify in relation to SSI?

2. Methods

2.1 Research Design

The study employed a descriptive-quantitative research design, appropriate for examining perceptions and attitudes within a defined population at a single point in time (Field, 2018). This design allowed for the systematic measurement of pre-service teachers' views on SSI while providing a quantitative baseline for future comparative and longitudinal research.

2.2 Participants and Sampling

Participants consisted of 24 pre-service biology teachers ($N = 24$) enrolled in a single teacher education institution in the Philippines. Convenience sampling was used based on institutional accessibility and voluntary participation. The sample included 6 males (25%) and 18 females (75%), reflecting the gender distribution typical of the Philippine teaching profession. Notably, several participants were second coursers with prior degrees in biology, nursing, or allied health sciences, providing a diverse academic background within the cohort.

2.3 Research Instrument

Data were collected using a 15-item SSI Perception Scale adapted from Topçu et al. (2023) and contextualized for Philippine biology education. The instrument employed a 4-point Likert scale (1 = Strongly Disagree to 4 = Strongly Agree) to minimize neutral response bias. Items were grouped into four dimensions: (1) necessity of SSI, (2) instructional willingness, (3) pedagogical concerns, and (4) disciplinary boundaries. The adapted instrument demonstrated high reliability within this sample, with an overall Cronbach's alpha of 0.86. Open-ended questions were included to capture participants' views on specific SSI topics and perceived implementation barriers, supporting triangulation and enriching interpretation.

2.4 Ethical Considerations

Ethical standards were strictly observed. Participation was voluntary, informed consent was obtained electronically, and no identifying information was collected. Participants were informed of their right to withdraw without penalty. All data were stored securely and used solely for research purposes.

2.5 Data Analysis

Descriptive statistics (mean and standard deviation) summarized perception scores. A Wilcoxon Signed-Rank Test compared participants' median scores against a hypothetical neutral midpoint of 2.5. To provide statistical transparency, the effect size (r) was calculated from the Z -value using the standard formula for non-parametric tests.

3. Results and Discussion

3.1 Findings for Research Question 1: Perceptions Regarding the Necessity and Implementation of SSI-Based Instruction

Research Question 1 sought to provide a comprehensive, descriptive account of pre-service biology teachers' perceptions regarding the value, relevance, and overall necessity of embedding SSI within contemporary biology education. The descriptive analysis indicates an overwhelmingly positive orientation toward SSI-based instruction among the participants. As shown in Table 1, the highest mean score was obtained for the perceived necessity of SSI integration ($M = 3.63$, $SD = 0.49$), suggesting an absolute consensus that secondary biology instruction must actively move beyond passive lecture paradigms to address socially relevant and ethically grounded dilemmas.

Table 1. Descriptive Statistics of Pre-service Teachers' Perceptions on SSI Integration (N = 24)

Dimension	Mean (M)	SD	Interpretation
Necessity of SSI in Biology	3.63	0.49	Strongly Agree
Willingness to Develop/Use SSI Materials	3.50	0.51	Strongly Agree
Interest in Professional Training	3.38	0.64	Agree
Concerns on Student Readiness	3.13	0.68	Agree
SSI Belongs in Ethics/Sociology Only	2.12	0.73	Disagree

Scale: 1.00–1.75 (Strongly Disagree), 1.76–2.50 (Disagree), 2.51–3.25 (Agree), 3.26–4.00 (Strongly Agree)

This strong agreement aligns with the global shift toward "Vision II" scientific literacy, which emphasizes science learning situated within socio-political and ethical contexts (Sadler, 2022; Zeidler, 2014). Similar patterns have been reported among pre-service teachers in Australia and Turkey, where SSI were consistently rated as essential for student engagement and relevance (Dawson & Venville, 2023; Topçu et al., 2023). In the Philippine context, Aguja and Prudente (2022) likewise identified SSI as a bridge between abstract K–12 biology concepts and students' everyday experiences, reinforcing the pedagogical value attributed to SSI by future teachers.

A similarly high mean score was observed for willingness to develop and use SSI-based instructional materials ($M = 3.50$, $SD = 0.51$). This finding indicates that participants are not merely supportive of SSI at a conceptual level but are also inclined to assume active roles as curriculum developers. However, prior research cautions that without institutional support and access to localized resources, such willingness may translate into reliance on generic or non-contextualized materials (Yap & Adorio, 2024). Interest in professional development related to SSI also registered a positive response ($M = 3.38$, $SD = 0.64$), suggesting recognition of the need for additional pedagogical preparation. Owens et al. (2021) demonstrated that targeted training in controversial discourse management significantly enhances teacher confidence, supporting the view that professional learning opportunities are a critical enabler of effective SSI implementation.

Concerns regarding students' readiness to engage in SSI-based instruction were evident ($M = 3.13$, $SD = 0.68$). This reflects a perceived pedagogical tension in which teachers value SSI but doubt students' conceptual foundations. In the Philippine setting, this concern is consistent with critiques of the spiral progression curriculum, which may lead to fragmented understanding and limit students' capacity for high-level socio-scientific reasoning (Talisayon, 2022; Thanakulkit et al., 2021). Notably, participants disagreed with the notion that SSI should be confined to ethics or social science subjects ($M = 2.12$, $SD = 0.73$), affirming SSI as a legitimate and integral component of biology education. This disciplinary positioning underscores teachers' recognition that ethical and social reasoning are inseparable from contemporary biological science.

3.2 Findings for Research Question 2: Statistical Significance of Perceptions Against a Neutral Pedagogical Stance

To respond to Research Question 2, inferential statistical evaluations were performed to determine whether the positive perception scores documented in Section 3.1 were statistically meaningful, or if they represented random, marginal variance from a non-committal or neutral position. Because the data derived from a small sample size ($N = 24$) evaluated via an ordinal Likert scale, a non-parametric Wilcoxon Signed-Rank Test was utilized against a hypothetical neutral median benchmark of 2.5.

The null hypothesis formulated stated that *pre-service biology teachers' overall perceptions of SSI-based instruction do not differ significantly from a neutral pedagogical stance (Median = 2.5)*. As displayed in Table 2, the overall perception toward SSI integration was significantly higher than the neutral baseline ($Z = -4.286$, $p < .001$), leading to a definitive rejection of the null hypothesis.

Table 2. Wilcoxon Signed-Rank Test Results Comparing Perceptions Against a Neutral Median

Variable	Z-value	p-value	Effect Size (r)	Interpretation
Overall SSI Perception	-4.286	< .001	0.87	Significant (Large)
Willingness to Implement SSI	-3.951	< .001	0.81	Significant (Large)

Statistical significance determined at $p < .05$. The large effect size ($r > 0.5$) indicates a robust trend.

To provide comprehensive statistical transparency, the effect size (r) was computed directly from the test statistics. The overall perception factor yielded an effect size of $r = 0.87$, while the active willingness-to-implement sub-dimension generated a comparable value of $r = 0.81$. According to standard non-parametric interpretations, an effect size exceeding 0.5 denotes a large, robust, and highly unified psychological trend within the sample group.

This statistically significant result reinforces earlier foundational assertions that teachers' core beliefs act as powerful cognitive filters that reliably predict future classroom delivery (Pajares, 1992). Similar large effect sizes have been reported in international SSI studies involving pre-service teachers, suggesting that positive SSI orientations tend to be deeply held rather than marginal or situational (Topçu et al., 2023). In the Philippine context, this level of conviction is particularly noteworthy given the traditionally content-heavy and examination-oriented nature of basic science instruction.

3.3 Findings for Research Question 3: Subject Matter Priorities and Perceived Implementation Challenges

Research Question 3 required a detailed thematic and content analysis of the open-ended survey entries to isolate the specific biological subject matter priorities and systemic implementation barriers identified by the pre-service teachers.

3.3.1 Curricular and Content Priorities

Analysis of the qualitative entries revealed distinct patterns in the scientific topics deemed most suitable for local integration. As cataloged in Table 3, climate change and anthropogenic environmental pollution emerged as the paramount curricular priorities. This localized emphasis mirrors the acute geographical realities of the Philippines as a hyper-vulnerable archipelago facing severe climate disasters, supporting place-based SSI frameworks which argue that local environmental exposure drastically heightens an individual's moral investment and reasoning capacity (Boonprasert et.al., 2018; Jumpatong & Yuenyong, 2018).

Table 3 Priority SSI Topics Identified by Pre-service Biology Teachers

Rank	SSI Topic	Biological Concepts Involved
1	Climate Change and Pollution	Ecology, Biogeochemical Cycles
2	GMOs and Biotechnology	Genetics, Molecular Biology
3	Nuclear Energy and Radiation	Cell Biology, Environmental Science
4	Vaccination and Public Health	Immunology, Microbiology
5	Reproductive Health and Stem Cell Research	Human Physiology, Developmental Biology

Biotechnology domains (GMOs, genetic therapeutic modifications, vaccination, and stem cell research) were also prioritized due to their clean conceptual alignment with core high school biology standards (genetics, immunology, and physiology). This shows that participants accurately perceive SSI not as supplementary materials, but as primary pedagogical vehicles to anchor abstract, microscopic biological theories to macroscopic, real-world human controversies (Dawson & Venville, 2023; Zohar & Nemet, 2002).

3.3.2 Systemic and Contextual Implementation Barriers

Despite their strong conceptual advocacy, the thematic content analysis of the participants' open-ended responses exposed three major systemic barriers that impede practical classroom implementation:

1. **Severe Curricular and Time Constraints:** Pre-service teachers repeatedly noted that the highly structured, examination-heavy, and expansive nature of the DepEd K–12 science curriculum leaves virtually no instructional space for open-ended student debates and dialectic argumentation. Teachers feel forced to choose between deep socio-scientific reasoning and rapid content coverage to meet national pacing requirements (Arfiani et.al., 2026).
2. **Deficits in Student Foundational Knowledge:** Confirming the quantitative concern score in Table 1 ($M = 3.13$), qualitative remarks highlighted a perceived fragmentation of basic biological knowledge among secondary students. Participants expressed that the "spiral progression" layout sometimes leaves students missing deep conceptual foundations, requiring extensive remedial instruction before any nuanced ethical reasoning can occur (Talisayon, 2022).
3. **Socio-Cultural and Religious Sensitivities:** A localized barrier unique to the sample's operating ecosystem is the pervasive influence of traditional cultural and religious beliefs. Pre-service teachers expressed high anxiety regarding topics like reproductive technologies, contraception, and evolutionary science, noting that local communities frequently push back if classroom content appears to clash with religious doctrines. This leads to teacher self-censorship to avoid community friction (Bernardo, 2021; Sohsomboon et.al., 2025).

3.4 Philosophical Alignment Versus Practical Capacity: The Second-Courser Paradox

When synthesizing the quantitative descriptive/inferential trends with qualitative inputs, an overarching pedagogical contradiction becomes apparent. Pre-service biology teachers display an authentic, statistically robust philosophical alignment with the ideals of SSI-based instruction, yet they feel structurally unequipped to enact it in actual classrooms.

This professional gap is nuanced when evaluating the subgroup profiles of the cohort. While second-courser participants demonstrated confidence in explaining hard scientific content during qualitative open-ended evaluations, they simultaneously expressed clear hesitation in facilitating open-ended discourse. For instance, one second courser noted: *"I feel secure explaining the genetics of GMOs, but managing a classroom debate where*

students argue about moral values makes me anxious." This explicitly supports earlier observations that pedagogical skill—rather than content mastery—is the critical limiting factor in SSI implementation (Bernardo et al., 2023).

3.5 Limitations of the Study

It is important to acknowledge that the findings of this study are subject to clear limitations regarding external validity. Because this study utilized convenience sampling and drew its cohort from a small sample size ($N = 24$) within a single teacher education institution, the generalizability of these insights across the wider population of pre-service biology teachers in the Philippines is constrained. Consequently, these outcomes should be treated as a descriptive quantitative baseline rather than an exhaustive nationwide consensus.

4. Conclusion and Implications

This study demonstrates that pre-service biology teachers in the Philippines are philosophically aligned with the goals of SSI-based instruction and recognize its importance for developing scientific literacy. However, their concerns highlight systemic barriers that may hinder classroom implementation. Addressing these barriers requires coordinated efforts from teacher education institutions, curriculum developers, and policy makers. Integrating explicit SSI training into pre-service programs and developing localized instructional resources may help bridge the gap between belief and practice.

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