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Socio-Scientific Issues (SSI)-Based Learning Material and the Scientific Literacy of Grade 10 Students

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A B S T R A C T

Socio-Scientific Issues (SSIs) are essential to today's education because they provide students with a means to address problems that intersect society and science in the real world. This study focuses on designing and developing socio-scientific issues (SSI)-based learning material to improve and enhance the scientific literacy of Grade 10 students. It also attempted to determine the students' perception of core aspects and the quality assessment of socio-scientific issues (SSI)-based learning materials, and to find out if there is a significant relationship between those perceptions and the students' scientific literacy performance level. Additionally, it sought to determine the significant difference between the pre-assessment and post-assessment level of scientific literacy of the respondents after the use of socio-scientific issues (SSI)-based learning material. Using an experimental-developmental research design, sixty (60) Grade 10 students at San Antonio National High School during the academic year 2023-2024 were chosen as the respondents of the study. Teacher-made SSI-based learning material and pre-assessment and post-assessment tests which were validated by the panel of experts were used to measure the scientific literacy performance level of the students. In line with the study's findings, there is no significant relationship between students' perception of the core aspects of SSI-based learning materials and their scientific literacy performance level, except for the design elements and the investigative nature of science. Aside from this, there is also no significant relationship between the students' perception of the quality assessment of SSI-based learning material and their scientific literacy performance level, except for the practicality and knowledge of science. Moreover, there is a significant difference in the scientific literacy performance level of the respondents between pre-assessment and post-assessment, after the use of socio-scientific issues (SSI)-based learning materials. In conclusion, educators may consider incorporating socio-scientific issues into the teaching and learning process to enhance students' scientific literacy further.

Keywords: *Learning Material, Scientific Literacy, Socio-Scientific Issues*

Introduction

Education is a key pillar of society, providing a window into comprehending the diverse difficulties and opportunities of the modern world. In today's rapidly changing global landscape, characterized by technological advancements, social transformations, and environmental concerns, education plays a crucial role in shaping people's knowledge and understanding of current societal challenges. The development of critical thinking skills is crucial to this function, as it enables individuals to examine, analyze, and evaluate information effectively.

In this regard, Bailin and Battersby (2020) emphasize the importance of education in cultivating critical thinking characteristics, such as open-mindedness, skepticism, and intellectual humility, which are necessary for determining the core causes of social problems. Furthermore, education not only enhances individual cognitive capacities but also cultivates social awareness and empathy, instilling a sense of responsibility to address societal disparities and injustices. Andreotti et al. (2015) emphasize the transformative ability of education to build global citizenship and social justice perspectives, helping people identify and challenge institutional barriers to equality and human rights.

In today's education, the integration of Socio-Scientific Issues (SSIs) is crucial because it enables students to address real-world challenges that intersect science and society. Beyond the classroom, Socio-Scientific Issues (SSIs) help students become knowledgeable and engaged citizens in an increasingly complex and interconnected world. SSIs enable students to explore the social, political, and ethical aspects of scientific challenges, allowing them to participate in democratic decision-making processes (Simon, 2020). Given this, SSIs encourage the development of socio-scientific reasoning abilities, such as the ability to perceive the interplay between scientific facts, societal values, and ethical issues (Zeidler, 2014). Students who participate in SSI-based learning become active members of democratic societies, capable of engaging in informed conversation, advocating for evidence-based policy, and addressing complex societal concerns (Simon, 2020). Thus, incorporating SSIs into the scientific curriculum is crucial for equipping students with the skills, knowledge, and dispositions necessary to navigate the challenges of the twenty-first century.

Considering this, the Organization for Economic Cooperation and Development's (OECD) Program for International Student Assessment (PISA) evaluates the scientific literacy of 15-year-old students in participating nations, including the Philippines. The assessment evaluates students' ability to apply scientific knowledge in real-world contexts, encompassing domains such as Reading Literacy, Mathematical Literacy, and Science Literacy. In the Philippines, students' average scientific literacy is lower than the OECD average, with the majority classified as Skill Level 1a, showing a basic comprehension of scientific ideas and the capacity to recognize explanations for scientific phenomena. Specifically, nearly 77.97% of Filipino students have competency levels lower than Level 2, indicating that they lack sufficient skills in applying scientific information. Furthermore, 35% of Filipino students are classed as Skill Level 1a, with another 35% classified as Skill Level 1b, indicating that the majority have basic competency levels. Gender disparities in scientific literacy are negligible, with male and female students scoring similarly at Fluency Level 1a. However, more male students are classed as having greater and lower competency levels than female students. Notably, in Level 3, students can apply complex knowledge content to identify or develop explanations for familiar phenomena, demonstrating a deeper understanding of scientific concepts (Cordon & Polong, 2020).

Aside from this, there is also a large difference in scientific literacy between pupils in public and private schools in the Philippines. Private school pupils outperform their public-school peers, with fewer students falling below competency levels and higher mean scores. Despite this, both groups' mean scores are within Skill Level 1a, suggesting a fundamental comprehension of scientific principles. Senior high school students often exhibit greater levels of scientific literacy than junior high school students, indicating that scientific literacy improves as students' progress through their schooling. Specifically, 27.14% of Senior High School students are classed as Skill Level 2, compared to 15.28% of Junior High School students.

Furthermore, there are differences in scientific literacy levels across urban and rural areas, with the National Capital Region (NCR) having the highest results. The PISA 2018 results show the critical need to enhance the quality of basic education in the Philippines. The Department of Education aims to address this issue with the "Sulong EduKalidad" program, which focuses on teacher training, curriculum updates, improving the learning environment, and fostering multi-stakeholder collaboration (Cordon & Poling, 2020).

Given the inherent challenges in teaching Socio-Scientific Issues (SSIs) to students, this study endeavors to elevate and enrich the scientific literacy of Grade 10 students by implementing a socio-scientific issues (SSI)-based learning tool. SSIs present complex intersections between science, society, and ethics, requiring students to navigate nuanced concepts and engage critically with real-world issues. By incorporating SSIs into the curriculum, educators aim to cultivate not only scientific knowledge but also essential skills such as critical thinking, ethical reasoning, and decision-making.

Methodology

1.1 Research Design

This study employed experimental-developmental research design. Experimental-developmental is a systematic work, drawing on knowledge gained from research and practical experience and producing additional knowledge, which is directed to producing new products or processes or to improving existing products or processes. According to Sirsilla (2023), an experimental research design helps researchers achieve their research objectives with increased clarity and transparency. An experimental research design comprises protocols and procedures designed for conducting scientific experiments with two sets of variables. Experimental research enables researchers to collect essential data that informs better research decisions and establishes the facts of a study. Whereas developmental research presents a focused approach to answering fundamental questions regarding the reasons behind and methods for teaching specific content to audiences. It entails a cyclical procedure of conducting detailed development and evaluation of teaching-learning sequences on a small scale, tailored to specific content areas. The goal is to generate an empirically validated rationale for the effectiveness of such sequences, thereby making a significant contribution to the knowledge base of educators, curriculum developers, and educational researchers (Klaassen & Kortland, 2015). The study aimed to develop supplementary learning material based on socio-scientific issues (SSI) and to observe the differences between groups before and after using the learning material. The participants were selected randomly from the population of Grade 10 students. They were given the same set of lessons, activities, and tasks included in the learning material to attain comparable results. The participants were evaluated based on the results of their pre-assessment and post-assessment to determine if there was a significant difference in their scientific literacy performance level.

1.2 Respondents of the Study

The respondents of the study were sixty (60) students from two (2) heterogeneous classes of Grade 10 during the academic year 2023-2024 at San Antonio National High School, San Antonio, Quezon. A random sampling technique was used to choose the appropriate respondents for the study. In a simple random sample, a subset of a population is chosen entirely at random. This sampling approach ensures that every member of the population has an equal opportunity to be selected (Thomas, 2023). The respondents were almost all the same age and at the same level in terms of prior knowledge of the topics included in science 10. They were subjected to and exposed to socio-scientific issues (SSI)-based learning material.

1.3 Research Instruments

The researcher used several instruments to improve and enhance the scientific literacy of Grade 10 students such as an adapted survey questionnaire about core aspects of socio-scientific issues (SSI), researcher-made survey questionnaire about quality assessment of SSI-based learning material, a teacher-made lesson exemplar about the topic incorporating socio-scientific issues (SSI), researcher-made SSI-based learning material that includes introduction, discussion, activities, performance tasks, and assessments centered on socio-scientific issues (SSI), and pre-assessment and post-assessment for evaluating scientific literacy performance level that is adjacent to the competency for the third quarter of K-12 science curriculum guidelines. These instruments underwent checking and validation by several external experts in the field to ensure that the content of the research instruments was crafted in alignment with the objectives required, ensuring their validity and relevance for use in the study. Comments and suggestions from experts were also taken into consideration to improve the research further. Additionally, the survey questionnaires were administered to a small group of 20 students for a pilot test to assess its reliability. Based on the results, the researcher made necessary adjustments and revisions to enhance consistency. The variables tested yielded good results, suggesting that the research could proceed with full implementation.

1.4 Research Procedure

This study employed the ADDIE (Analysis, Design, Development, Implementation, Evaluation) Instructional Model to develop and evaluate socio-scientific issues (SSI)-based learning material to improve and enhance the scientific literacy of Grade 10 students. The first phase involved an in-depth needs analysis, which included observing science 10 class to identify gaps in learning, assessing student performance to determine areas for improvement in scientific literacy through pre-assessment, reviewing student's readiness and willingness to engage with SSI-based learning material and analyzing the content of core aspects such as design elements, learner experiences, and teacher attributes, necessary for effective SSI-based learning implementation.

The second phase involved planning instructional materials, including lesson exemplars, survey questionnaires, and SSI-based learning materials anchored on the Most Essential Learning Competencies (MELCs) in the K-12 science curriculum guide for Grade 10. The lesson covered the concept of biodiversity for the third quarter of the 2023-2024 academic year. This phase ensured that the learning materials not only adhered to the core aspects of SSI but also possessed validity, practicality, and effectiveness as key quality features to address the perceived needs of the students.

During the third phase, relevant materials and sources were collected and integrated to develop SSI-based learning materials and assessments according to the specifications outlined in the previous phases. A panel of experts validated these to ensure effectiveness. At this phase, the concepts were translated into actual learning materials in teaching science 10.

During the implementation phase, pilot testing was conducted with a small group of students to assess the reliability and feasibility of the materials. The researcher facilitated learning using the developed SSI-based material in this phase. Various activities, tasks, and assessments aligned with socio-scientific issues were incorporated to expose students to SSI, thereby promoting their critical thinking, problem-solving, and scientific literacy skills.

Finally, the evaluation phase assessed the effectiveness of the SSI-based learning material through post-assessment, analyzed the data to determine the impact of SSI-based learning material on students' understanding of socio-scientific issues (SSI) and their scientific literacy performance level, and gathered feedback for future improvements and research endeavors. The evaluation findings were then utilized to refine the learning material, informing future potential implementations. All the gathered data were subjected to statistical analysis and interpretation.

1.5 Data Analysis

After the implementation of the study, the questionnaires and the pre-assessment and post-assessment scores were collected and tallied immediately and were given to the statistician for treatment. The data was statistically computed, interpreted, and verbally analyzed.

1.6 Ethical Consideration

With utmost confidentiality, the respondents' information and results were assured to be limited and accessible only to the researcher and to the researcher adviser.

1.7 Statistical Treatment of Data

Appropriate statistical treatments were employed to analyze the data and provide evidence that addressed the study's objectives. The following statistical treatments were used in this research:

Descriptive statistics, including frequency, percentage, mean, and standard deviation, were used to interpret and determine the scores of the respondents' scientific literacy performance levels in the experimental groups.

Paired sample t-tests were used to determine whether there is a significant difference in the pre-assessment and post-assessment results before and after the utilization of socio-scientific issues (SSI)-based learning material.

Pearson's Product Moment Correlation was used to analyze the possible presence of a significant relationship between the core aspects and the quality assessment of socio-scientific issues (SSI)-based learning materials and the scientific literacy performance level of the respondents.

2. Results and Discussion

Table 1. Assessment of the Core Aspects of Socio-Scientific Issues (SSI)-based Learning Material in terms of Design Elements

Indicators	Mean	SD	VI
1. Presents the issue first.	3.53	0.50	HO
2. Provides scaffolding for higher-order practices.	3.43	0.50	O
3. Uses media to connect classroom activities to representations of the issue beyond the classroom.	3.47	0.50	O
4. Uses technology to facilitate student learning experiences.	3.40	0.49	O
Overall Mean	**3.46**	**0.22**	**O**

Legend: *3.50–4.00 = Highly Observed (HO); 2.50–3.49 = Observed (O); 1.50–2.49 = Moderately Observed (MO); 1.00–1.49 = Slightly Observed (SO)*

Table 1 presents the students' assessment of the core aspects of the socio-scientific issues (SSI)-based learning material in terms of design elements. Indicator 1 obtained the highest mean score of 3.53, indicating a highly observed level. In contrast, Indicator 4 had the lowest mean score of 3.40, which is interpreted as observed, yielding an overall mean score of 3.46, which is also verbally interpreted as observed.

The results imply that during the students' utilization of the SSI-based learning material, they perceive it to successfully capture their attention through the material's way of introducing real-world issues upfront, particularly issues related to Philippine biodiversity such as climate change, deforestation and habitat loss, illegal wildlife trading, threats to marine biodiversity, and challenges faced by indigenous tribes. Additionally, the learning material addresses contemporary problems in various regions of the Philippines, including the *Kaliwa* Dam project in Luzon, large-scale mining operations in Visayas, and threats to the Philippine Monkey-eating Eagle in Mindanao. These concerns may foster engagement and relevance among students as they go through each lesson in the SSI-based learning material. Similarly, as mentioned in the study by Lee and Witz (2016), engaging with real-world problems that are personally relevant and socially meaningful allows students to develop a deeper understanding of scientific concepts, ethical principles, and societal issues.

However, technology plays a crucial role in the teaching and learning process, offering interactive and meaningful learning experiences to students. Although the material contains links to videos about several places in the Philippines facing relevant socio-scientific issues, it is suggested to explore more opportunities for other technological components supporting the study of Rudolph & Horibe (2016) that leveraging technology can enhance SSI-based instruction by providing access to multimedia resources, interactive online simulations, or other immersive and collaborative platforms to further engage students in the topic. As such, the results indicate that incorporating and maximizing technology more seamlessly in creating activities and tasks in the SSI-based material can deepen students' understanding, critical thinking, and interest in socio-scientific issues.

Table 2. Assessment of the Core Aspects of Socio-Scientific Issues (SSI)-based Learning Material in terms of Learner Experiences

Indicators	Mean	SD	VI
1. Confronting scientific ideas, theories, and ethical dimensions related to the issue.	3.68	0.47	HO
2. Collecting and/or analyzing scientific data related to the issue.	3.55	0.50	HO
3. Negotiating social dimensions of the issue.	3.08	0.28	O
4. Considering nature of science themes associated with the issue.	3.42	0.50	O
Overall Mean	**3.43**	**0.20**	**O**

Legend: *3.50–4.00 = Highly Observed (HO); 2.50–3.49 = Observed (O); 1.50–2.49 = Moderately Observed (MO); 1.00–1.49 = Slightly Observed (SO)*

Table 2 presents the students' assessment of the core aspects of socio-scientific issues (SSI)-based learning material in terms of learner experiences. The results show that Indicator 1 had the highest mean score of 3.68, indicating it was highly observed, whereas Indicator 3 had the lowest mean score of 3.08, interpreted as observed. Overall, the indicators achieved a mean score of 3.43, verbally interpreted as observed.

The results indicate that students perceive the SSI-based learning material as clearly integrating scientific concepts and theories related to each socio-scientific issue. In a lesson on biodiversity, students engaged in a role-playing and debate activity, focusing on the importance of biodiversity conservation in addressing pressing challenges such as climate change, food security, disease prevention, cultural preservation, and economic development within the Philippines. Each group was assigned a specific key reason to focus on why biodiversity needs to be protected. Initially, students were uncertain about how to approach discussing their assigned reason within their groups, leading them to ask questions among themselves and the teacher to clarify their doubts. As they progressed through the learning material, they began to seek answers by analyzing the scientific concepts underlying each key reason. Through this process, they gathered compelling information and developed well-supported arguments, demonstrating a comprehensive understanding and providing meaningful insights into their assigned topics. This result is supported by Grace (2018), which shows that students formulate questions, design investigations, collect data, analyze findings, and draw evidence-based conclusions through inquiry-based learning. This hands-on approach not only allows students to develop critical thinking skills but also cultivates a deep understanding of scientific concepts. Nevertheless, the results also underscore the importance of social aspects in SSI-based learning. As Rudolph & Horibe (2016) suggest, integrating diverse perspectives from fields such as science, technology, ethics, economics, and politics enables students to develop a comprehensive understanding of the interconnected nature of real-world problems. To build on this, incorporating supplementary activities and tasks that raise awareness about various social factors and their impact on the socio-scientific issues could further enhance the learning experience of the students.

Table 3. Assessment of the Core Aspects of Socio-Scientific Issues (SSI)-Based Learning Material in terms of Teacher Attributes

Indicators	**Mean**	**SD**	**VI**
1. Knowledgeable about the science content related to the issues.	3.68	0.47	HO
2. Aware of social considerations associated with the issue.	3.68	0.47	HO
3. Honest about his/her knowledge limitations.	3.72	0.45	HO
4. Willing to position himself/herself as knowledge contributor about the issue.	3.55	0.50	HO
5. The facilitator of a learner-centered classroom.	3.58	0.50	HO
Overall Mean	**3.64**	**0.26**	**HO**

Legend: *3.50–4.00 = Highly Observed (HO); 2.50–3.49 = Observed (O); 1.50–2.49 = Moderately Observed (MO); 1.00–1.49 = Slightly Observed (SO)*

Table 3 presents the students' assessment of the core aspects of socio-scientific issues (SSI)-based learning material in terms of teacher attributes, which garnered an overall mean score of 3.64, verbally interpreted as highly observed. Specifically, Indicator 3 obtained the highest mean score of 3.72, while Indicator 4 recorded the lowest mean score of 3.55, both of which are interpreted as highly observed.

The data suggest that the students perceived the teacher as effective in demonstrating characteristics that support SSI-based learning, which may be attributed to the teacher's evident enthusiasm and preparedness in discussing the scientific and social aspects of the issues. During the study, the teacher demonstrated transparency and intellectual humility by openly acknowledging her knowledge, including the specifics of wildlife laws and regulations. Rather than pretending to have all the answers, she shared her perspectives and encouraged the students to learn alongside her, fostering open communication and trust. This attribute aligns with the study of Hou et al. (2018), which emphasizes the importance of teachers creating inclusive spaces where students feel comfortable expressing their perspectives and engaging in challenging but respectful discourse. Moreover, the findings suggest opportunities to empower teachers through targeted support and training focused on relevant socio-scientific issues. By equipping teachers with the necessary knowledge and skills, they can facilitate collaborative learning more effectively, confidently guide student discussions, and encourage active participation in exploring complex societal issues. Additionally, as noted by Kaya et al. (2021), effective facilitation and mediation skills are crucial for fostering open dialogue and collaborative inquiry in SSI-based learning environments.

Table 4. Assessment of the Quality of the Socio-Scientific Issues (SSI)-Based Learning Material in terms of Validity

Indicators	**Mean**	**SD**	**VI**
1. The learning material aligns with specific learning objectives related to SSI.	3.48	0.50	E
2. The content included in the learning material adequately covers the range of socio-scientific issues intended for exploration.	3.60	0.49	HE
3. The learning material enhances students' understanding, critical thinking, decision-making skills, and ethical reasoning related to socio-scientific issues.	3.62	0.49	HE
4. The socio-scientific issues presented within the learning material are authentic and relevant.	3.68	0.47	HE
5. The learning material regarding socio-scientific issues addresses ethical considerations associated with these topics.	3.42	0.50	E
Overall Mean	**3.56**	**0.21**	**HE**

Legend: *3.50–4.00 = Highly Evident (HE); 2.50–3.49 = Evident (E); 1.50–2.49 = Slightly Evident (SE); 1.00–1.49 = Not Evident (NE)*

Table 4 presents the students' assessment of the quality of the socio-scientific (SSI)-based learning material in terms of validity. Based on the gathered data, Indicator 4 obtained the highest mean score of 3.68, indicating a highly evident level, in contrast to Indicator 5, which garnered the lowest mean score of 3.42, indicating an evident level. Overall, the indicators yielded a mean score of 3.56, verbally interpreted as highly evident.

Based on the results, it implies that the SSI-based learning material incorporates adequate real-world issues that resonate with the students' lives. This is likely due to the contextualization of the content, which suits their interests and reflects current issues relevant to the Philippines, such as illegal logging, agricultural expansion, urbanization, infrastructure development, illegal fishing, coral reef degradation, and mangrove loss. During the discussion, students engage well with these topics because they are familiar with the issues, motivating them to learn more about the effects of these activities. The learning material also includes activities that encourage students to create advocacy campaigns, promoting solutions to current issues and empowering them to take action to mitigate the impact on their future lives. This finding is supported by a study conducted by Schecker et al. (2019), which highlighted the importance of ensuring that SSI-based learning materials adequately cover relevant content areas and address key dimensions of the SSIs under investigation. Aside from relevant issues, addressing ethical principles and ideas is also crucial when dealing with SSIs. According to Sadler & Zeidler (2019), addressing ethical considerations is essential for developing critical thinking and moral reasoning skills, which are integral components of scientific literacy. While the learning material includes a lesson on indigenous community rights that targets ethical aspects, it would be beneficial to incorporate more topics that emphasize ethical considerations.

Table 5. Assessment of the Quality of the Socio-Scientific Issues (SSI)-based Learning Material in terms of Practicality

Indicators	**Mean**	**SD**	**VI**
1. The SSI- based learning material is user-friendly and accessible to educators and students.	3.55	0.50	HE
2. The learning material is adaptable to different educational settings, accommodating various teaching styles, classroom sizes, and student populations.	3.43	0.50	E
3. The learning material is cost-effective and affordable.	3.42	0.59	E
4. The SSI-based instructional learning material aligns with established curriculum standards.	3.43	0.50	E
5. The implementation of the learning material in the classroom does not require excessive preparation time.	3.52	0.50	HE
Overall Mean	**3.47**	**0.22**	**E**

Legend: *3.50–4.00 = Highly Evident (HE); 2.50–3.49 = Evident (E); 1.50–2.49 = Slightly Evident (SE); 1.00–1.49 = Not Evident (NE)*

Table 5 presents the students' assessment of the quality of the socio-scientific (SSI)-based learning material in terms of practicality. Indicator 1 had the highest mean score of 3.55, interpreted as highly evident, while Indicator 3 gained the lowest mean score of 3.42, interpreted as evident. Overall, the indicators obtained a mean score of 3.47, verbally interpreted as evident.

The results show that students found the SSI-based learning material to be easy to use and readily available. The material's coherent structure, direct language, and clear instructions on each activity, along with specified desired outcomes and rubrics, enabled students to navigate and utilize it independently, both in class and at home. The inclusion of engaging visuals supported the context of the issues presented, enhancing the learning experience. Additionally, the teacher perceived the material as efficient and effective for preparing and implementing, thereby streamlining the teaching-learning process. These findings align with Lawless & Pellegrino's (2021) study, which highlights the importance of user-friendly materials that require minimal preparation, particularly in contexts with limited time and resources. However, as part of the public schools with the most students on a limited budget, the cost of learning materials may be a barrier to their widespread adoption. The material's extensive length and inclusion of visuals, which enhance its effectiveness, contribute to higher reproduction costs. This implies that the cost may be unsustainable for some students, thereby limiting their access to the material. To address this, it would be beneficial if learning institutions could provide financial support for reproducing the material or offer alternative options for the students who struggle with the cost, ensuring equal access to this valuable learning resource. Recent research has explored innovative approaches to designing SSI-based learning material that can be tailored to specific learning environments, such as mobile applications, online platforms, and modular learning resources. (Ferguson & Daniel, 2021).

Table 6. Assessment of the Quality of the Socio-Scientific Issues (SSI)-based Learning Material in terms of Effectiveness

Indicators	**Mean**	**SD**	**VI**
1. The SSI-based learning material increases students' understanding of scientific concepts, societal issues, ethical considerations.	3.72	0.45	HE
2. The learning material develops students' critical thinking skills, such as analysis, evaluation, inference, and argumentation.	3.77	0.46	HE
3. The learning material improves students' abilities to identify, analyze, and propose solutions to real-world problems.	3.58	0.50	HE
4. The learning material develops collaborative and teamwork skills as students engage in discussions, debates, or group projects related to socio-scientific issues.	3.50	0.50	HE
5. The learning material creates a long-term impact on students' continued interest in science and societal issues.	3.40	0.49	E
Overall Mean	**3.59**	**0.23**	**HE**

Legend: *3.50–4.00 = Highly Evident (HE); 2.50–3.49 = Evident (E); 1.50–2.49 = Slightly Evident (SE); 1.00–1.49 = Not Evident (NE)*

Table 6 presents the students' assessment of the quality of the socio-scientific (SSI)-based learning material in terms of effectiveness, which garnered an overall mean score of 3.59, verbally interpreted as highly evident. Indicator 2 recorded the highest mean score of 3.77, interpreted as highly evident, while the lowest mean score of 3.40 was from Indicator 5, interpreted as evident.

The results suggest that the learning material may be instrumental in developing students' critical thinking skills. As students' progress through the material, they engage in individual and group activities that facilitate information processing after each discussion. These activities cater to both lower-order and higher-order thinking skills, preparing students to tackle complex socio-scientific issues. Examples of such activities include unscrambling letters, multiple-choice questions, explanation-type problems, role-playing and debating, simulations, and case studies. Real-world applications are also integrated, requiring students to break down information, evaluate evidence, weigh arguments, and make informed decisions, as seen in debates on topics such as illegal wildlife trade and case studies on the rights of indigenous tribal communities. Students found the learning material to be meaningful and helpful in developing their critical thinking and scientific literacy skills. This finding is consistent with the study of Bennett et al. (2021), which emphasizes the importance of effective materials in enabling students to connect scientific concepts to their everyday lives, explore diverse perspectives on complex issues, and develop a deeper understanding of the interplay between science and society.

While the material effectively engages students' interest during its use, sustaining this interest over a longer period may be a challenge. To address this, incorporating reinforcement activities or follow-up lessons could be useful in maintaining students' grasp of the issues beyond their initial learning experience. However, given the structured lesson plan aligned with DepEd's quarterly standards, continuously exploring socio-scientific issues might be challenging due to the varied topics and branches of science covered each quarter, not all of which apply to the exploration of socio-scientific issues. Therefore, as noted by Barton et al. (2021), sustaining SSI-based learning initiatives requires careful planning and collaboration among stakeholders, including educators, administrators, policymakers, and community members.

Table 7. Pre-Assessment and Post-Assessment of Scientific Literacy Performance Level in terms of Knowledge of Science

Knowledge of Science	**Pre-Assessment**		**VI**	**Post-Assessment**		**VI**
Scores	**f**	**%**		**f**	**%**	
5.00	0	0.0	O	44	73.3	O
4.00	1	1.7	G	11	18.3	G
3.00	6	10.0	S	5	8.3	S
2.00	22	36.7	FS	0	0.0	FS
1.00	26	43.3	P	0	0.0	P
0.00	5	8.3	VP	0	0.0	VP

Legend: *5.00 = Outstanding (O); 4.00 = Good (G); 3.00 = Satisfactory (S); 2.00 = Fairly Satisfactory (FS); 1.00 = Poor (P); 0.00 = Very Poor (VP)*

Table 7 presents the students' pre-assessment and post-assessment scientific literacy performance level in terms of knowledge of science. In the pre-assessment, the majority of students (43.3%) scored 1 out of 5, categorizing them as being at the poor level. However, the post-assessment results indicated that the majority of the students (73.3%) achieved a perfect score, placing them at the outstanding level.

Before using the SSI-based learning material, students may tend to focus on memorizing terms rather than engaging in deeper learning, leading to struggles in recalling and understanding fundamental science facts, concepts, and principles. This was evident in their incorrect answers to questions about the definition of biodiversity and related concepts. To address this, the SSI-based learning material was designed to introduce key facts and concepts with clear definitions, relevant examples, and a connection to societal issues. It contains parts and activities that require students to answer and explain the topic in their own words and understanding. This helped students build on previously learned concepts and move beyond rote memorization. During implementation, students thoroughly read the material and provided correct answers to the teacher's questions, demonstrating a comprehensive understanding of the biodiversity concepts. They were able to describe the components of biodiversity, correctly identify ecosystem types, and determine whether a statement is a threat or a benefit to biodiversity. This suggests that exposure to SSI-based learning enables students to develop effective strategies for understanding and retaining science concepts. Kolong et al. (2023) also emphasized that the development of SSI-based curricular resources may improve the teaching and learning processes in science, potentially enhancing students' deeper understanding, engagement in scientific practices, and argumentation skills.

Table 8. Pre-Assessment and Post-Assessment of Scientific Literacy Performance Level in terms of Investigative Nature of Science

Investigative Nature of Science	**Pre-Assessment**		**VI**	**Post-Assessment**		**VI**
Scores	**f**	**%**		**f**	**%**	
5.00	0	0.0	O	33	55.0	O
4.00	1	1.7	G	23	38.3	G
3.00	3	5.0	S	3	5.0	S
2.00	11	18.3	FS	0	0.0	FS
1.00	32	53.3	P	0	0.0	P
0.00	13	21.7	VP	1	1.7	VP

Legend: *5.00 = Outstanding (O); 4.00 = Good (G); 3.00 = Satisfactory (S); 2.00 = Fairly Satisfactory (FS); 1.00 = Poor (P); 0.00 = Very Poor (VP)*

Table 8 presents the students' pre-assessment and post-assessment scientific literacy performance level in terms of the investigative nature of science. Initially, 53.3% of students who scored 1 out of 5 are at the poor level. In contrast, the post-assessment results showed that 55.0% of the students obtained a perfect score and reached the outstanding level.

Before the implementation of SSI-based learning, students were often used to traditional lecturing and textbook-based learning, which limited their exposure to hands-on practices and engaging activities. They also lacked opportunities for collaboration, discussion, and exploration, which limited their development of systematic approaches to scientific processes. Through SSI-based learning, students were given the chance to process and analyze real-world issues. They worked in groups to research and present endangered wildlife species, strategizing how to organize information on habitat, threats, conservation status and efforts. This collaborative approach might have allowed them to gain a deeper understanding of the topic, drawing on diverse perspectives and ideas from their peers. Another activity, the marine biodiversity simulation, involved students creating stations representing coral reefs, mangroves, and fisheries, where they investigated the species and the ecosystem's role, gathered information, and worked in groups to develop possible sustainable conservation methods. By incorporating engaging elements such as infographics and games, students immersed themselves in the experience, moving beyond passive learning. This suggests that SSI-based learning aids in scaffolding abstract concepts, such as inferring and analyzing data gathered, by enabling students to explore, question, and critically evaluate real-world phenomena. Furthermore, Fita et al. (2021) also noted that SSI-based learning can enhance students' learning outcomes and conceptual understanding by developing their critical thinking skills, problem-solving abilities, scientific literacy, and capacity to construct knowledge through scientific inquiry and discussion.

Table 9. Pre-Assessment and Post-Assessment of Scientific Literacy Performance Level in terms of Science as a Way of Knowing

Science as a Way of Knowing	**Pre-Assessment**		**VI**	**Post-Assessment**		**VI**
Scores	**f**	**%**		**f**	**%**	
5.00	0	0.0	O	24	40.0	O
4.00	0	0.0	G	33	55.0	G
3.00	2	3.3	S	3	5.0	S
2.00	11	18.3	FS	0	0.0	FS
1.00	32	53.3	P	0	0.0	P
0.00	15	25.0	VP	0	0.0	VP

Legend: *5.00 = Outstanding (O); 4.00 = Good (G); 3.00 = Satisfactory (S); 2.00 = Fairly Satisfactory (FS); 1.00 = Poor (P); 0.00 = Very Poor (VP)*

Table 9 presents the students' pre-assessment and post-assessment scientific literacy performance level in terms of science as a way of knowing. In the pre-assessment, most students (53.3%) scored 1 out of 5, indicating a poor level of understanding. On the other hand, the post-assessment results showed that most students (55.0%) achieved a score of 4 out of 5, indicating they were at the good level.

Before introducing SSI-based learning to the class, students rarely participated actively in class discussions and seldom expressed their thoughts, feelings, or opinions on topics. This limited engagement may have stemmed from the nature of the discussions, which often lack depth or controversy, resulting in few opportunities for students to express their various perspectives. Consequently, students struggled to provide logical explanations and rarely explored broader connections beyond scientific concepts. To address these cases, the learning material provided various controversial issues for discussion, allowing students to explore their stances and opinions. Activities were also designed to encourage students to share possible reasons behind current events and phenomena, as well as explore the effects of these events and their potential long-term consequences, enabling them to understand the implications for future societies. Through this process, students were able to reflect and make informed decisions about their actions and choices in the present. Anwar and Ali (2020) emphasized the importance of delivering content through learner-centered teaching approaches. They also highlighted that the use of diverse socio-scientific case studies and regular argumentation practice had a positive impact on students' argumentation skills and reasoning.

Table 10. Pre-Assessment and Post-Assessment of Scientific Literacy Performance Level in terms of Interaction with Science, Technology, and Society

Interaction with Science, Technology, and Society	**Pre-Assessment**		**VI**	**Post-Assessment**		**VI**
Scores	**f**	**%**		**f**	**%**	
5.00	0	0.0	O	33	55.0	O
4.00	0	0.0	G	23	38.3	G
3.00	3	5.0	S	4	6.7	S
2.00	9	15.0	FS	0	0.0	FS
1.00	29	48.3	P	0	0.0	P
0.00	19	31.7	VP	0	0.0	VP

Legend: *5.00 = Outstanding (O); 4.00 = Good (G); 3.00 = Satisfactory (S); 2.00 = Fairly Satisfactory (FS); 1.00 = Poor (P); 0.00 = Very Poor (VP)*

Table 10 presents the students' pre-assessment and post-assessment performance levels in scientific literacy, specifically in terms of interaction with science, technology, and society. Pre-assessment results showed that nearly half (48.3%) of the students scored 1 out of 5 and were classified as poor level, while post-assessment results revealed that 55.0% of the students secured a perfect score and attained the outstanding level.

The results suggest that before implementing SSI-based learning, students focused primarily on scientific concepts and knowledge, often overlooking their connections to technology and society. This limited their understanding of the interrelationships between the three. The SSI-based learning material bridged this gap by incorporating discussions and activities that linked scientific knowledge to the impact of technology on society. Notably, discussions around advancements in mining equipment and modern fishing methods illustrated how scientific knowledge drives practical applications. Students recognized both the benefits and potential harms of these technologies when misused. Through this approach, students came to appreciate the interconnected roles of science, technology, and society in shaping our lives.

Contextualizing science education through socio-scientific issues (SSI) can help address challenges in science, technology, and ethical and moral domains by introducing real-world problems that are socio-culturally and emotionally relevant to students. SSI can positively influence students' conceptual understanding, as well as the development of skills such as perspective-taking, argumentation, and moral reasoning. Furthermore, SSI helps students engage with new ideas, interests, and values that not only enhance scientific literacy but also foster a sense of global citizenship (Mang et al. 2021).

Table 11. Significant Relationship between the Perception of the Core Aspects of Socio-Scientific Issues (SSI) and the Scientific Literacy Performance Level of the Respondents

	Knowledge of Science *(r)*	**Investigative Nature of Science** *(r)*	**Science as a Way of Knowing** *(r)*	**Interaction of Science, Technology, and Society** *(r)*
Design Elements	-0.027	-0.283*	-0.087	0.189
Learner Experiences	-0.161	0.001	-0.123	-0.173
Teacher's Attribute	-0.015	0.163	-0.118	-0.109

** Correlation is significant at .05 level (2-tailed)*

Table 11 reveals important insights into how students' perceptions of core aspects of socio-scientific issues (SSI) relate to their scientific literacy performance. Among the variables examined, the only meaningful relationship appears between design elements and the investigative nature of science, showing a moderate negative correlation of r = -0.283. This suggests that when science lessons are overly structured or focused on rigid instructional design, students may engage less in investigative processes that are essential to scientific thinking. Instead of fostering curiosity and exploration, heavily designed activities may restrict opportunities for students to ask questions, design experiments, and investigate real-world scientific problems.

The implications of these findings suggest that educators should reevaluate how science is taught. Teachers should be supported in shifting from content-heavy, design-driven instruction to more inquiry-based and student-centered approaches. Incorporating real-world socio-scientific issues into lessons, allowing students to discuss, debate, and investigate them, can enhance scientific literacy and prepare learners to engage with science meaningfully in society. As the world becomes increasingly influenced by complex scientific challenges, fostering these competencies in students is more crucial than ever. A study by Evagorou & Dillon (2020) emphasizes that effective socio-scientific issues (SSI) instruction demands flexible and dialogic learning environments where students are encouraged to explore multiple perspectives, engage in argumentation, and reflect on the social implications of science.

Table 12. Significant Relationship between the Perception of the Quality Assessment of Socio-Scientific Issues (SSI) and the Scientific Literacy Performance Level of the Respondents

	Knowledge of Science *(r)*	**Investigative Nature of Science** *(r)*	**Science as a Way of Knowing** *(r)*	**Interaction of Science, Technology, and Society** *(r)*
Validity	-0.019	0.047	-0.101	0.065
Practicality	-0.263*	-0.052	0.229	-0.085
Effectiveness	0.056	0.114	0.000	-0.019

** Correlation is significant at .05 level (2-tailed)*

Table 12 reveals how students' perceptions of the quality assessment of socio-scientific issues (SSI) relate to their performance in various domains of scientific literacy. Among the reported correlations, the only meaningful relationship appears between practicality and knowledge of science, showing a moderate negative correlation of r = -0.263. This suggests that when students perceive the practical application of SSI-based learning material as high, their demonstrated knowledge of scientific concepts may be lower. One possible interpretation is that while SSI-based learning's practical appeal can boost student engagement with science's societal context, it may potentially shift focus away from grasping core scientific concepts. Additionally, as the lessons are engaging and practical, students may become emotionally and socially invested; however, this investment can lead to selective learning, where they grasp the narrative and societal impact without fully absorbing the underlying science. These imply that while integrating practical, real-world elements into SSI-based learning is valuable, educators must ensure that these tasks are also designed to reinforce core scientific concepts, thereby promoting the development of scientific literacy in learners. This finding is similar to a meta-analysis by Badeo and Duque (2023), which shows that SSI-based education boosts scientific literacy; however, its impact on specific areas, such as knowledge and reasoning skills, varies, suggesting that hands-on engagement doesn't automatically lead to stronger content understanding.

Table 13. Significant Difference between the Pre-Assessment and Post-Assessment Scientific Literacy Performance Level of the respondents after the use of Socio-Scientific Issues (SSI)-based Learning Material

	Pretest		**Posttest**		**Mean Difference**	**t**	**df**	**p-value**
	Mean	**SD**	**Mean**	**SD**				
Knowledge of Science	1.53	0.85	4.65	0.63	-3.12	-24.310	59	0.000
Investigative Nature of Science	1.12	0.87	4.43	0.83	-3.31	-24.865	59	0.000
Science as a Way of Knowing	1.00	0.76	4.35	0.58	-3.35	-32.484	59	0.000
Interaction of Science, Technology, and Society	0.93	0.82	4.48	0.62	-3.55	-27.077	59	0.000

Legend: *p-value <0.05–Significant*

Table 13 highlights the improvement in the scientific literacy performance of respondents following the implementation of socio-scientific issues (SSI)-based learning materials. The results clearly indicate that across all four domains of scientific literacy, students' post-assessment scores increased compared to their pre-assessment scores.

These results suggest that the use of SSI-based learning materials effectively enhances students' overall scientific literacy. The most pronounced improvements were in the domains associated with critical thinking and application, such as understanding science as a way of knowing and its interaction with technology and society. This implies that engaging with real-world issues in science education not only deepens factual understanding but also promotes higher-order thinking and contextual awareness. A review of Viehmann et al (2023) analyzed the use of socio-scientific issues in science lessons. It was found that incorporating real-world problems into science education enhances critical thinking, fosters interdisciplinary learning, and equips students to tackle complex societal issues through scientific inquiry, thereby strengthening their grasp of scientific facts and motivating deeper, more meaningful engagement with science.

These imply that adopting SSI-based learning approaches and material can transform science education by making it more relevant, inquiry-driven, and connected to societal concerns. This not only boosts student performance but also fosters a deeper appreciation for science as a dynamic and socially embedded field of study. This finding is consistent with the research of Kinslow et al. (2019), who found that integrating socio-scientific issues into science curricula significantly improves students' reasoning, content understanding, and ability to connect science with real-life issues. They argue that

SSI frameworks encourage students to engage in meaningful dialogue, evaluate evidence, and consider ethical dimensions—skills that are critical for functional scientific literacy in today's society.

4. Conclusion

The findings of the study showed that there is no significant relationship between the respondents' perception of the core aspects of socio-scientific issues (SSI)-based learning material and their scientific literacy performance level, except for the design elements and investigative nature of science. Thus, the null hypothesis is partially supported. Similarly, it also showed that there is no significant relationship between the respondents' perception of the quality assessment of SSI-based learning material and their scientific literacy performance level, except for the practicality and knowledge of science. Thus, the null hypothesis is partially supported. Moreover, the findings revealed a significant difference between the pre-assessment scientific literacy performance levels of the respondents after using socio-scientific issues (SSI)-based learning materials. Therefore, the null hypothesis is not supported. Through the results of this study, educators may consider incorporating socio-scientific issues (SSI) as part of the teaching-learning process or may opt to use the researcher-made socio-scientific (SSI)-based Learning Material or to develop their version of the learning material to aid in the improvement and enhancement of students' scientific literacy.

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