International Journal of Scientific Multidisciplinary Research (IJSMR)
Vol. 4, No. 8, 2026: 1879 - 1898

Science, Technology, and Society Pedagogy: Enhancing Student Engagement in Science and Technology

Norman D. Patiang[1*], Elmer C. Eligio[2], Angelica C. Corpuz[3]
School of Teacher Education and Liberal Arts, University of Baguio, Philippines
Corresponding Author: Norman D. Patiang angelicacorpuz014@gmail.com

A R T I C L E I N F O

Keywords: SCITES approach, student engagement, real-world relevance, critical thinking, socio-scientific issues

Received : 09, June
Revised : 12, July
Accepted: 30, August

A B S T R A C T

The study responded to concerns about low enthusiasm for science and technology and the limitations of approaches centered on memorization and decontextualized content. Grounded in Constructivist Theory, Inquiry-Based Learning, and the Socio-Scientific Issues framework, the investigation used survey responses and semi-structured interviews, with the final thematic analysis reported after data saturation was reached at 10 participants. From these findings, the study proposed a cyclical SCITES-Inspired Engagement Model composed of contextualization, interactive inquiry, reflective construction, and an evaluation loop. The findings support the use of culturally relevant, inquiry-oriented, and socially grounded pedagogy in Philippine higher education and teacher preparation, while emphasizing the need for scaffolding, balanced facilitation, localized examples, and sustained professional development for educators.

DOI: https://doi.org/10.55927/ijsmr.v4i8.144
https://journalijsmr.my.id/index.php/ijsmr

INTRODUCTION

Science and technology education increasingly carries the responsibility of preparing learners to understand not only scientific concepts but also the consequences of technological change for communities, institutions, culture, ethics, and everyday life. In the original study, the researchers located their inquiry within a persistent classroom concern: many students find science and technology difficult to appreciate when instruction emphasizes memorization, isolated facts, and abstract content without showing why that knowledge matters in real settings. This disconnection can reduce curiosity and participation and may leave learners less prepared for complex decisions in a society shaped by rapid scientific and technological advancement.

The study therefore considered the Science, Technology, and Society approach—referred to in the manuscript as SCITES—as a pedagogical response to disengagement. SCITES integrates scientific and technological concepts with their social, ethical, cultural, and environmental implications. Instead of treating science as a body of facts detached from human life, the approach places learners in situations where they examine issues, discuss consequences, compare perspectives, and connect course content with problems encountered by people and communities. The manuscript emphasizes concerns such as climate change, digital equity, public health, artificial intelligence, waste management, sustainability, and community development as examples of contexts through which science and technology may become more meaningful.

This perspective aligns with broader educational efforts to cultivate critical thinking, problem-solving, communication, ethical reasoning, and interdisciplinary understanding. The study cites Jimoyiannis (2023) to frame the limitations of conventional pedagogies in connecting disciplinary knowledge and de Freitas and Neumann (2024) to support immersive and exploratory learning. Within this framing, SCITES is not simply an additional teaching technique; it is presented as an organizing approach that invites students to ask how scientific knowledge is produced, how technology influences human choices, and how social conditions shape the use and consequences of innovation.

THEORETICAL REVIEW

SCITES and the Relevance of Science Education

The manuscript situates SCITES within a global movement to make science, technology, engineering, and mathematics education more responsive to real-world complexity. Tupsai (2021) is cited to show that STEM education remains a policy priority across many systems while socio-scientific dimensions are sometimes underemphasized. In this context, the Science, Technology, and Society approach offers a way to embed scientific and technological ideas within societal frameworks so that students encounter knowledge as connected to decisions, values, risks, benefits, and community needs. Felt et al. (2017) and Sismondo (2018) are used to emphasize the interdisciplinary character of science and technology studies and its applicability beyond narrowly defined STEM classrooms.

The review further argues that contextualization contributes to engagement because students are more likely to participate when they recognize the relevance of what they are learning. Hofstein and Rosenfeld (1996) are cited regarding cognitive, affective, and psychomotor outcomes, while Sadler (2009) supports the use of socio-scientific issues as meaningful contexts for science learning. The manuscript also draws on Aikenhead (2006), who links science education with everyday life, and on Downey and Zuiderent-Jerak (2017), who stress participation and the social production of knowledge. Together, these works support a view of science education in which relevance is not an optional enrichment but a central condition for helping learners connect concepts with lived experience.

Interactive, Inquiry-Based, and Reflective Learning

A second strand of the literature concerns active learning. Bencze and Carter (2018) are cited for the STEPWISE approach, a student-directed and socially relevant form of inquiry that links scientific knowledge with action on societal issues. Foley et al. (2018) likewise describe collaborative projects and community-based initiatives that can help learners examine the consequences of science and technology. In the manuscript, these ideas are associated with classroom practices such as group discussions, projects, case studies, guided inquiry, and reflection. These methods contrast with passive reception because students must compare viewpoints, formulate questions, explain evidence, and consider how decisions affect different groups.

Socio-Scientific Issues and Ethical Reasoning

The review emphasizes that science and technology questions often involve competing interests, uncertainty, ethics, and social consequences. Socio-scientific issues provide a structured way to bring these dimensions into instruction. The approach asks learners to reason about issues for which scientific knowledge matters but where evidence alone may not determine a single social decision. This orientation supports the study’s concern with critical thinking and social awareness, because students are invited to consider who benefits, who may be harmed, what responsibilities are involved, and how local contexts influence decisions. The literature reviewed in the manuscript therefore frames SCITES as a bridge between conceptual learning, inquiry, participation, and ethical reflection.

Theoretical and Conceptual Framework

Constructivist Theory

Constructivist Theory provides the first foundation of the study. The manuscript describes learning as a process in which students create knowledge through interactions and experiences with the world rather than merely receiving information from a teacher. Within SCITES, learners encounter scientific and technological ideas in relation to familiar events, community concerns, and social questions. The purpose of contextualization is therefore not only to make lessons more interesting but also to give students experiences from which they can actively construct meaning. Foley et al. (2018) is cited to support this alignment between SCITES and constructivist learning.

In practical terms, a constructivist SCITES classroom may ask students to connect prior knowledge with new evidence, explain their own interpretations, listen to peers, and revise ideas after discussion. This theoretical lens helps explain why participants in the study valued localized examples, group interaction, and reflection. When students recognized science in issues such as climate change, clean water, waste management, artificial intelligence, or public health, they were able to connect classroom concepts with existing knowledge about community life. The study interpreted these connections as part of the mechanism through which SCITES increased relevance and interest.

Inquiry-Based Learning

Inquiry-Based Learning is the second foundation. The manuscript defines inquiry as learning through questioning, investigation, research, and problem-solving. Bencze and Carter's (2018) STEPWISE approach is highlighted as an example of student-directed, socially relevant inquiry. In the present study, inquiry is reflected in activities that require students to explore issues, analyze evidence, discuss alternative explanations, and consider possible responses. The approach is intended to strengthen critical thinking and problem-solving by positioning learners as active participants in the learning process.

Inquiry also explains why the study gives attention to adaptation difficulties. Students accustomed to direct lecture and straightforward content may initially experience uncertainty when they are expected to formulate positions, connect several domains, or defend an interpretation. Rather than treating such difficulty as evidence that inquiry is ineffective, the manuscript interprets it as a transition that requires practice and scaffolding. This interpretation later becomes part of the proposed engagement model, particularly in the reflective construction phase.

Socio-Scientific Issues Framework

The Socio-Scientific Issues (SSI) framework provides the third theoretical foundation. SSI instruction uses socially significant scientific questions to promote reasoning, decision-making, and consideration of ethical dimensions. The manuscript links this framework to topics such as pollution, climate change, public health, artificial intelligence, privacy, and the responsibilities associated with technological innovation. Through SSI, science becomes connected with the human consequences of knowledge and technology, allowing students to examine not just what is scientifically possible but also what may be socially desirable, ethical, equitable, or sustainable.

Conceptual Flow of the Study

The original schematic framework is organized as input, process, and output. Inputs include students' experiences with the SCITES approach, the influence of SCITES on engagement and interest, and the ways the approach supports critical thinking and problem-solving. The process consists of purposive participant selection, interviews, and thematic analysis. The output is a student engagement model derived from the themes. In the journal version, this flow is retained conceptually and culminates in the SCITES-Inspired Engagement Model presented after the thematic findings.

METHODOLOGY

Research Design

The study used a descriptive qualitative design to examine how SCITES influences students' experiences, motivation, and engagement in science and technology. The manuscript distinguishes this design from phenomenology: rather than seeking the essential structure of lived experience, descriptive qualitative research aims to provide a comprehensive summary of participants' perspectives in language close to their own accounts. Sandelowski (2000) and Merriam and Tisdell (2016) are cited to support the use of qualitative description for understanding participants' viewpoints and producing a practical account relevant to educational practice.

The design was appropriate to the stated purpose because the research questions ask what students experience, how they describe the influence of SCITES on engagement, and what practical model may be derived from recurring patterns. The study therefore prioritized participant descriptions of classroom interaction, real-world connections, motivation, difficulties, reflection, and teaching strategies. Qualitative analysis was used to identify recurring patterns rather than to test a causal hypothesis.

Population, Sampling, and Study Context

The study was conducted within the School of Teacher Education and Liberal Arts at the University of Baguio. The manuscript describes participants from undergraduate programs such as Communication, Political Science, Psychology, English, Elementary Education, Secondary Education, and Physical Education. Purposive sampling was used so that participants would have direct and relevant experience with SCITES. Palinkas et al. (2015) is cited in support of purposeful sampling for selecting information-rich cases.

Inclusion and Exclusion Criteria

Participants were required to be actively enrolled undergraduate students in STELA, belong to one of the specified programs, have completed or be currently enrolled in a course using the SCITES pedagogical approach during the 2025 academic year, and voluntarily agree to participate in the survey and, when selected, the interview. Students on leave or not actively attending, students outside the specified programs, students whose SCITES exposure occurred only before 2025, and students unable to complete the required participation were identified for exclusion.

These criteria were intended to ensure that participant accounts reflected recent, direct exposure to the pedagogy under investigation. Program diversity was also treated as important because SCITES connects science and technology with broader social and professional contexts; students from different academic programs could therefore emphasize different forms of relevance, from teaching and community issues to communication, ethics, and digital technologies.

Data-Gathering Tools

Two principal tools were used: a face-to-face survey and a semi-structured interview guide. The survey gathered background information and open-ended descriptions of participants' views of science and technology, experiences with SCITES, perceived changes in interest, and perceived effects on motivation and engagement. The manuscript states that open-ended questions were selected to allow participants to express perceptions in their own words and to provide a descriptive foundation for the more detailed interview data. Creswell (2013) is cited in support of this approach.

Data-Gathering Procedure

The manuscript describes a four-week collection period during active SCITES coursework. Surveys were administered first, followed by semi-structured interviews with selected students. Course materials such as syllabi and assignments were also identified as possible contextual sources. The procedure sought to combine broad initial perceptions with richer narrative accounts. Interviews were held in a quiet, private setting, and data were anonymized and stored securely. Audio recording was used to improve the accuracy of transcription.

Data Analysis

Data were analyzed through thematic analysis. The manuscript initially cites Braun and Clarke (2006) and later specifies reflexive thematic analysis following Braun and Clarke (2022). Researchers familiarized themselves with survey and interview data, coded meaningful statements, identified recurring patterns, and refined themes through repeated review and discussion. The first research question was addressed by coding descriptions of classroom interactions, memorable moments, real-world connections, and learning difficulties. The second question focused on changes in curiosity, interest, motivation, and engagement. The third question synthesized the themes associated with effective practices, challenges, and improvement suggestions to construct a practical engagement model.

The analysis remained descriptive in orientation: themes were intended to summarize what participants consistently emphasized while retaining direct quotations to show how the interpretations were grounded in their accounts. The manuscript reports that data saturation was reached after ten participants, at which point interviews were halted because responses were judged sufficient to address the research objectives.

RESULTS

The thematic analysis generated seven themes organized around the study's first two research questions. Four themes describe students' experiences with the SCITES approach, while three themes describe how the approach influenced engagement. Across the findings, participants repeatedly associated SCITES with real-world relevance, discussion, purposeful learning, critical reflection, ethical awareness, and a broader understanding of the relationship among science, technology, and society. They also described initial difficulty adjusting to a less traditional, more reflective style of learning.

Table 1. Summary of Themes Reported in the Manuscript

Theme	**Illustrative codes**	**Core meaning**	**Reported scale**
Relevance through real-world connections	connects to real life; local issues; societal impact	SCITES makes abstract science and technology more understandable by connecting content with everyday and community concerns.	90% = 9/10
Engagement through interactive and reflective methods	group discussions; projects; reflection; participation	Collaborative and reflective activities support active involvement and exposure to multiple perspectives.	85% ≈ 9/10
Challenges in adapting to a non-traditional style	overwhelming topics; voicing ideas; neutrality; adjustment	Students may initially struggle with interconnected topics, reflective expectations, and controversial discussions.	75% ≈ 8/10
Broadened perspectives on science and technology	human-centered; ethical implications; bigger picture	SCITES shifts students from viewing science as facts for tests toward seeing it as socially and ethically consequential.	80% = 8/10
Increased interest through relevance	curiosity; real-world topics; connections	Contextual relevance sparks curiosity and increases interest in learning science and technology.	100% = 10/10
Enhanced motivation through purposeful learning	purpose; eagerness; community contribution	Students are motivated when learning appears capable of making a practical difference in communities.	80–100% ≈ 8/10–10/10
Critical thinking and social awareness	critical thinking; responsibilities; ethics; awareness	SCITES encourages analysis of consequences, responsibilities, and ethical dimensions of science and technology.	80–100% ≈ 8/10–10/10

Note. Percentages and participant counts are reproduced in the form reported in the source manuscript; where the manuscript itself uses approximate equivalences, those are retained.

Students' Experiences with SCITES

The first cluster of themes shows that students experienced SCITES as a significant departure from conventional science instruction. Rather than learning scientific and technological content in isolation, participants encountered issues that required them to relate knowledge to personal experience, local conditions, culture, ethics, and future professional roles. This change produced both positive engagement and initial discomfort. The following themes present these experiences in detail.

Relevance Through Real-World Connections

Relevance through real-world connections was the most frequently emphasized experience theme. The manuscript reports that 90% of participants, or 9 of 10, described SCITES as meaningful because it links science and technology with issues they recognize outside the classroom. Local environmental problems, health concerns, climate change, artificial intelligence, social media, agriculture, renewable energy, disaster preparedness, privacy, and waste management were among the contexts mentioned in participant accounts. Participant 3 expressed the theme clearly: "SCITES makes learning easier because it ties science and tech to everyday issues, like local environmental problems or health concerns." Participant 2 similarly explained that localized and customized examples piqued curiosity because they allowed deeper personal connection with the discussion. Other responses emphasized that SCITES did not simply teach the technical side of science and technology; it helped students examine how innovations and scientific developments affect society. Participants also described technology in relation to communication, apps, culture, public health, and local communities.

These responses suggest that relevance functioned as an interpretive bridge between abstract course content and situations students already considered important. For STELA students, this bridge may be especially useful because their programs include education, communication, and social science perspectives. The manuscript argues that students preparing for educational roles can later model the same practice by connecting scientific ideas with the circumstances of learners and communities. In this sense, relevance is presented not merely as a motivational technique but also as a pedagogical competency for future teachers.

The study interprets this theme through Constructivist Theory and the Socio-Scientific Issues framework. Constructivism helps explain how students build new understanding by relating ideas to prior experience and recognizable contexts. SSI provides a way to organize that contextualization around issues that are scientifically informed but socially consequential. The manuscript cites Purnomo et al. (2025) and Khairunnisa et al. (2025) in support of these theoretical connections.

The finding is also discussed alongside Badeo and Yuenyong (2022), whose meta-analysis is presented as evidence that SSI-based teaching can improve scientific literacy by grounding learning in real-world concerns. The manuscript connects the theme with Sadler (2009), Sismondo (2018), Aikenhead (2006), and Downey and Zuiderent-Jerak (2017), all of whom support socially contextualized approaches to science learning. The discussion stresses that local examples may be particularly important in the Philippine setting because issues such as environmental sustainability, disaster resilience, public health, and technological access are both scientifically significant and immediately visible in community life.

For practice, the theme suggests that SCITES instruction should deliberately select contexts that students can recognize while still opening space for broader scientific and ethical analysis. Local examples can serve as entry points rather than endpoints: a familiar problem such as waste management may lead to questions about materials science, environmental systems, governance, behavior, technology, equity, and responsibility. This layered structure helps explain why participants perceived SCITES as more connected and less intimidating than science instruction experienced primarily as isolated facts or formulas.

Engagement Through Interactive and Reflective Methods

A second experience theme concerned the interactive and reflective nature of SCITES. The source reports an engagement scale of 85%, approximately 9 of 10 participants, for responses involving group discussions, projects, reflective thinking, and active participation. Students described these methods as dynamic because they were expected to contribute ideas, listen to different perspectives, and examine how scientific and technological issues affect people in concrete situations.

Participant 1 stated, “Group discussions work best. They allowed us to hear different perspectives.” Other participants highlighted activities on water conservation, waste management, traffic, recycling, air quality, artificial intelligence ethics, clean water, and community energy use. Case studies were valued because they required students to think about practical and ethical problems, such as how technology companies handle user data. Projects were described as engaging when they invited learners to investigate a real community issue rather than simply repeat textbook information.

Reflection was an equally important element. Students reported that SCITES encouraged them to think about why scientific knowledge matters, how it influences policy and behavior, and how ethical concerns shape technological choices. This reflective demand made discussions more substantial but also distinguished SCITES from straightforward lecture. The manuscript links these experiences with Inquiry-Based Learning, Constructivist Theory, and the SSI framework. Inquiry supports exploration and questioning; constructivism explains the social construction of understanding through dialogue; and SSI creates the ethical and societal problems around which reflection can occur.

The finding is discussed in relation to Akturk and Ozdemir (2024), whose review of socio-scientific issues teaching is cited for the value of inquiry-oriented classroom practices. The manuscript also relates the theme to Bencze and Alsop (2021), Foley et al. (2018), and Schön (1983), emphasizing collaborative projects, teacher preparation, and reflective practice. Calvelo et al. (2025) is cited to extend the discussion toward blended learning contexts, where interactive methods may also help sustain engagement in larger classes.

For teacher education, the implications are notable. Students who experience productive discussion as learners can observe how facilitation influences participation. They can see that engagement depends not only on selecting an interesting topic but also on designing questions, structuring group work, allowing multiple viewpoints, and helping learners connect discussion to evidence. The participants' preference for group discussion suggests that future SCITES teaching should preserve spaces where students can verbalize uncertainty, compare interpretations, and develop positions through interaction rather than being expected to arrive with fully formed answers.

The theme also underscores the importance of balance. Interactive learning can promote engagement only when students perceive the environment as sufficiently supportive for participation. Because later findings show that some learners initially hesitate to speak or find controversial topics difficult, facilitation must include clear expectations, respectful discussion norms, and scaffolds that help students formulate evidence-based contributions. Thus, the same interactivity that strengthens engagement also creates instructional responsibilities for the teacher.

Challenges in Adapting to a Non-Traditional Style

The third experience theme focused on difficulties that emerged as students adjusted to SCITES. The source reports a scale of 75%, approximately 8 of 10 participants, for challenges such as processing many interconnected topics, voicing ideas, shifting from passive learning to reflective thinking, and remaining neutral during controversial discussions. These challenges are important because they show that engagement was not immediate or effortless for every participant. Participant 2 explained that "It can be quite overwhelming to process so many interconnected topics at once." Others described difficulty thinking deeply about ethical issues, forming and defending personal opinions, or participating in discussions after being accustomed to straightforward lectures. Some participants noted that the broad range of topics—ethics, policy, culture, society, science, and technology—could initially feel cognitively demanding. Others struggled with neutrality when discussing technologies such as artificial intelligence or with speaking publicly about issues on which classmates might hold different positions.

The manuscript interprets these difficulties as part of a transition from exam-oriented or memorization-focused habits toward more learner-centered and reflective forms of study. This transition can require students to tolerate ambiguity, examine evidence that does not produce simple answers, and explain why an issue matters rather than merely recall a definition. Such tasks are central to SCITES but may feel unfamiliar to students whose prior experience has rewarded direct answers and passive note-taking.

Theoretically, the challenge theme is linked to all three frameworks. Constructivist learning requires learners to reorganize prior understandings, which may create temporary uncertainty. Inquiry-based learning requires skills in questioning, investigation, explanation, and justification, which develop through practice rather than appearing automatically. SSI requires learners to engage value-laden and sometimes controversial questions, creating an additional need for structured dialogue and balanced facilitation. The manuscript cites Yaman and Alakus (2025), Yang et al. (2025), and Leden et al. (2024) in relation to these demands.

The findings therefore support the need for scaffolding. In the context of SCITES, scaffolding may involve introducing one dimension of an issue at a time, providing guiding questions, modeling how to distinguish evidence from opinion, using small-group discussion before whole-class reporting, and offering frameworks for comparing ethical positions. The source manuscript specifically recommends emotional support and facilitation strategies to reduce overwhelm and help students become comfortable with reflective learning.

Importantly, participants also indicated that these challenges diminished with practice. The study presents adaptation as a process through which initial discomfort can lead to intellectual growth when students are given repeated opportunities to participate. This interpretation prevents the challenge theme from being treated as a contradiction of the positive engagement findings. Instead, it identifies the conditions necessary for those positive outcomes to develop: time, scaffolding, practice, and a classroom climate in which students can explore complex ideas without being penalized for uncertainty.

Broadened Perspectives on Science and Technology

The fourth experience theme was a broadened view of science and technology. The manuscript reports that 80%, or 8 of 10 participants, described a shift from seeing science mainly as facts, tests, laboratories, or material for science majors toward seeing it as a human-centered field connected with ethics, culture, communication, policy, and social problems. This shift is central to the study because it shows that SCITES affected not only how students participated in class but also how they understood the nature and purpose of science and technology. Participant 3 stated, "SCITES showed me it's about helping people, which makes it way more exciting." Participant 2 emphasized that science and technology are not only about gained knowledge but are also tied to ethical questions and development. Participant 1 described science as becoming more human-centered because lessons incorporated contexts such as culture and ethics. Other responses referred to privacy issues in apps, the influence of technology on news and social media, and the role of science in solving local human problems.

The study interprets these changes as evidence that SCITES can humanize science by making visible the relationships between knowledge, technology, and the people affected by them. A purely technical presentation may lead students to imagine that scientific and technological developments are neutral or separate from social life. In contrast, SCITES encourages learners to recognize that choices about research, design, innovation, access, and implementation are made within cultural, political, ethical, and economic contexts.

This theme is again connected with Constructivism, Inquiry-Based Learning, and SSI. Constructivist learning explains the transformation of prior conceptions through new experiences. Inquiry broadens perspectives by requiring students to investigate problems rather than accept a single account. SSI foregrounds the moral and societal dimensions of issues. The manuscript cites Ceylan et al. (2025), Zuber-Skerritt et al. (2025), and Suryawati et al. (2025) as supporting studies.

The finding has particular relevance for STELA students because many are preparing for professions in which communication, education, and social interpretation are essential. Future teachers who understand science as culturally and ethically situated may be better prepared to help learners discuss controversial issues without reducing them to slogans or isolated facts. Communication students may similarly become more attentive to the social consequences of digital platforms, artificial intelligence, algorithms, and information technologies.

The source concludes that this broader perspective contributes to 21st-century learning by developing interdisciplinary thinking. It also creates an important link between engagement and responsibility: students become more interested because science and technology are presented as consequential, but that same consequence requires them to consider how knowledge should be used. Thus, SCITES engagement is described as more than enjoyment; it includes a developing awareness of how scientific and technological choices shape human wellbeing and social life.

Influence of SCITES on Student Engagement
Increased Interest Through Relevance

The first engagement-outcome theme was increased interest through relevance. The manuscript reports that all ten participants expressed increased interest when science and technology were connected with real-world concerns. Students described curiosity about clean energy, artificial intelligence, online privacy, pollution, food shortages, flooding, health technology, sustainable energy, and the use of scientific knowledge to solve community problems. These responses closely mirror the earlier theme of real-world relevance, but the emphasis here is on the effect of that relevance on willingness to learn.
Participant 3 stated, “It makes me more curious since we discuss real-world topics, like clean energy.” Participant 2 described a lesson that clarified the connection between science and daily life and “sparked my interest.” Others reported that localized examples deepened curiosity because they could relate personally to the situations. Several participants said they wanted to learn more when technology was connected with career interests, such as communication, advertising, social media, or applications used in everyday life.

The study interprets curiosity as a key mechanism of engagement. When learners can identify a question as relevant to their own communities or future professions, the topic creates a reason to seek more information. In this sense, relevance changes the learner’s orientation from “What do I need to memorize?” to “How does this work, why does it matter, and what could be done?” Such questions are consistent with both inquiry-based and constructivist learning because they stimulate investigation and activate existing knowledge.

The manuscript connects the theme with SSI as well. Real-world science questions often involve social and ethical dilemmas, so curiosity is not limited to technical mechanisms. Students may become interested in who controls a technology, how risks and benefits are distributed, why communities respond differently, or what responsibilities professionals and citizens have. The source cites Akturk et al. (2024), Sholeh et al. (2023), and Suhartini et al. (2025) to link relevance with socio-scientific inquiry, motivation, and critical thinking.

The discussion also cites Kusumawati et al. (2025) as supporting evidence that a Science-Technology-Society approach can increase interest and learning outcomes. The literature review's references to Sadler (2009) and Bencze and Carter (2018) reinforce the same point: students often respond positively when learning is organized around meaningful problems rather than disconnected concepts.

For instructional practice, the finding implies that teachers should not wait until the end of a unit to explain why a concept matters. Context can be introduced at the beginning so that scientific ideas are learned as tools for understanding a question students already recognize. Local issues can be particularly effective because they create immediacy, but global developments such as artificial intelligence or climate change may also be meaningful when teachers connect them to students' experiences. The result is a form of engagement grounded in intellectual relevance rather than entertainment alone.

Enhanced Motivation Through Purposeful Learning

The second engagement-outcome theme was enhanced motivation through purposeful learning. The source manuscript reports a range of 80–100%, approximately 8 to 10 of 10 participants, for responses describing increased motivation, eagerness, purpose, and the belief that learning could make a difference. While interest refers to curiosity about a topic, this theme emphasizes persistence and personal investment arising from a sense that scientific and technological learning has value beyond completing a course requirement.

Participant 3 expressed this strongly: "It makes me feel like what I'm learning can make a difference in my community." Participant 1 reported greater eagerness because SCITES showed that science and technology are not isolated. Other comments described lessons as more purposeful because they connected scientific ideas with climate change, clean water, waste management, policies, human wellbeing, and local environmental conditions. Students said that learning felt more important when they could see how it might contribute to a practical response or community improvement.

The manuscript frames purposeful learning as a source of intrinsic motivation. Rather than depending only on grades or external rewards, students become motivated because they perceive a meaningful reason to understand a concept. The connection between knowledge and community impact may be especially powerful for future educators, whose professional identity involves helping others learn and participate in society. When they experience science and technology as socially useful, they may also be more prepared to design lessons that communicate a similar sense of purpose to their own students.

This finding is interpreted through Constructivism, Inquiry-Based Learning, and SSI. Constructivism emphasizes active meaning-making; inquiry creates a role for students in investigating and responding to questions; and SSI provides socially consequential contexts that can make learning feel worthwhile. The source cites Sharma et al. (2025), Sari et al. (2025), and Acar and Sahin (2024) to support these connections.

The discussion also draws on Badeo and Yuenyong (2022), whose meta-analysis is presented as evidence that SSI instruction can improve motivation alongside scientific literacy. The manuscript links the finding with Sadler (2009), Hofstein and Rosenfeld (1996), and Foley et al. (2018), reinforcing the view that engagement increases when students encounter science as relevant to decisions and problems that affect people.

Purposeful learning also has implications for curriculum design. A SCITES lesson can clarify what scientific concept students need to understand, what societal issue makes the concept consequential, and what kind of reasoning or action the lesson enables. This structure gives students a visible learning trajectory. It may also help them interpret difficult content as worth sustained effort, which is important because the study simultaneously found that SCITES can initially feel demanding. Purpose therefore acts as a motivational counterweight to complexity: students may be more willing to persist when they understand why the effort matters.

Development of Critical Thinking and Social Awareness

The third engagement-outcome theme concerned the development of critical thinking and social awareness. The manuscript reports a scale of 80–100%, approximately 8 to 10 of 10 participants, for statements about analyzing complex issues, reflecting on responsibilities, examining ethical questions, and recognizing the social consequences of technology. This theme expands the meaning of engagement beyond participation or interest. Students were not only more involved; they described becoming more deliberate in how they reasoned about science and technology.

Participant 2 stated, “It challenged me to think critically and connect concepts.” Participant 1 said that students were encouraged to think critically, reflect, and participate. Other responses described an increased awareness of rapid innovation, including artificial intelligence, and a stronger tendency to connect science with policy, behavior, ethics, community responsibility, and culture. Participants also reported that SCITES encouraged them to question who is responsible for addressing problems and how technologies may affect society in unequal or unintended ways.

The study interprets these accounts as evidence that socially contextualized science learning can create conditions for higher-order reasoning. Students must compare information, identify consequences, recognize competing viewpoints, and justify a position. Because many socio-scientific questions do not have a single purely technical answer, learners must also evaluate values and responsibilities. The manuscript relates this process to constructivist discourse, inquiry through investigation, and SSI argumentation, citing Yaman and Alakus (2025), Adu-Gyamfi and Agyei (2025), and Owens and Sadler (2024).

The finding is also discussed in relation to Gonzales and Santos (2025), whose review of innovative science teaching strategies is cited for gains in critical thinking. The manuscript links the theme with Hofstein and Rosenfeld (1996) and Aikenhead (2006), arguing that SCITES can support cognitive development while making science more connected to social life. In the source, critical thinking and social awareness are especially important because the study's overall problem concerns the development of 21st-century skills.

For teacher education, the theme suggests that future educators need opportunities to practice facilitating reasoning about difficult issues. It is not enough to know the scientific content of climate change, health technology, artificial intelligence, or environmental sustainability. Teachers must also know how to help learners ask good questions, distinguish evidence from assertion, listen to conflicting interpretations, and discuss consequences respectfully. The challenge theme reported earlier—particularly difficulty staying neutral or voicing ideas—shows why this facilitation needs to be learned intentionally.

Overall, the engagement findings describe a progression: relevance sparks curiosity, purposeful learning sustains motivation, and repeated inquiry and reflection deepen critical thinking and social awareness. This progression later informs the structure of the proposed SCITES-Inspired Engagement Model, which begins with contextualization and moves through interactive inquiry and reflective construction before returning to evaluation and improvement.

DISCUSSION

Taken together, the seven themes show a consistent pattern in which the strongest positive experiences of SCITES arise from the connection between disciplinary content and meaningful social contexts. Students reported that real-world issues made science and technology easier to relate to, interactive methods gave them a role in constructing understanding, and reflection encouraged them to examine consequences rather than stop at factual recall. The same pedagogical features that produced engagement also generated challenges, particularly when students were unfamiliar with open discussion, ethical complexity, or the need to synthesize several interconnected dimensions of an issue.

This combination of engagement and difficulty is important for interpreting the findings. The study does not present SCITES as automatically effective simply because it uses real-world examples. Its value depends on how teachers structure the relationship between context, inquiry, and reflection. A topic may be relevant but still overwhelm students if too many dimensions are introduced without guidance. A discussion may be interactive but still silence some learners if expectations for participation are unclear. A controversial issue may stimulate critical thinking but may also create discomfort if students lack tools for evaluating evidence and expressing disagreement respectfully.

The theoretical framework helps integrate these observations. Constructivism explains why contextualized and collaborative learning can strengthen meaning: students connect new ideas to prior knowledge and reorganize understanding through interaction. Inquiry-Based Learning explains the role of questions, investigation, and problem-solving in sustaining active participation. The SSI framework explains why the content feels consequential and why ethical, cultural, and social dimensions become central to reasoning. The seven themes can therefore be seen as different manifestations of the interaction among these three foundations.

The findings are also consistent with the literature reviewed in the manuscript. Aikenhead (2006), Sadler (2009), Bencze and Carter (2018), Foley et al. (2018), and Bencze and Alsop (2021) all contribute to the argument that science becomes more meaningful when learners encounter it in relation to everyday life, social issues, inquiry, and participation. Braun and Clarke's thematic approach provides the analytic process through which the participant accounts were organized, while the later studies cited in the results are used by the manuscript to position the local findings within continuing research on SSI, critical thinking, motivation, and student-centered pedagogy.

A particularly significant contribution of the study is its teacher-education context. STELA students are not only current learners; many are future educators who may carry these experiences into their own classrooms. When they encounter SCITES as learners, they experience the benefits and demands of discussion, inquiry, contextualization, and reflection firsthand. This may help them recognize why students need both intellectual challenge and instructional support. The approach therefore has a potential multiplier effect: engaging future teachers in socially relevant science may influence the kinds of learning environments they later design for younger students.

The local orientation of the study also matters. Participants repeatedly mentioned Baguio or Philippine concerns such as waste management, disaster preparedness, environmental quality, clean water, community energy, public health, and the societal consequences of digital technologies. These examples show how SCITES can connect global scientific issues with the realities of a specific place. Culturally and locally relevant contexts may help students see that scientific literacy is not only about understanding distant discoveries; it is also about participating thoughtfully in decisions that shape one's own community.

SCITES-Inspired Engagement Model

The study synthesizes its findings in a cyclical model designed to guide the use of SCITES for sustained student engagement. The model has four connected phases: Contextualization, Interactive Inquiry, Reflective Construction, and an Evaluation Loop. Each phase corresponds to themes found in the participant data and to one or more components of the theoretical framework. The model is intended for repeated use rather than as a one-time sequence; evaluation of engagement and learning informs the next cycle of contextualization and instructional design.

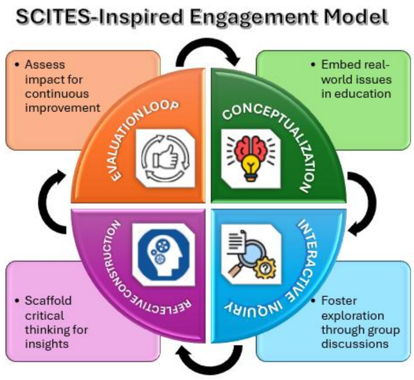

Figure 1. SCITES-Inspired Engagement Model from the source manuscript.

Contextualization: SSI-Driven Foundation

The first phase embeds real-world issues in instruction. It draws directly from the dominant theme of relevance through real-world connections and from the finding that all participants reported increased interest when learning was tied to recognizable concerns. Contextualization may begin with a local problem, a technological development, a community decision, or an ethical dilemma. The teacher identifies the scientific and technological concepts necessary for understanding the issue and uses the context to establish why the learning matters.

Interactive Inquiry: Inquiry-Based Core

The second phase uses discussion, projects, case studies, investigation, and collaborative problem-solving to move students from recognition of an issue to active exploration. This phase corresponds to the theme of engagement through interactive and reflective methods. Students gather and interpret information, compare perspectives, ask questions, and test explanations. The teacher's role shifts toward facilitation, guidance, and the design of structures that make participation possible for learners with different levels of confidence.

Reflective Construction: Constructivist Support

The third phase asks students to connect evidence, personal understanding, ethical considerations, and social consequences. Reflection helps learners explain what they now understand, how their views changed, what uncertainties remain, and why the issue matters. This phase responds directly to the adaptation challenges identified in the results. Scaffolding is essential so that reflective thinking develops gradually rather than becoming an additional source of overload.

Evaluation Loop

The final phase assesses whether the learning experience strengthened relevance, motivation, participation, critical thinking, and broadened perspectives. Evaluation is not limited to grades; it may also involve student reflection, observation of participation, quality of reasoning, and feedback on which activities supported or hindered engagement. The results inform revisions to the next SCITES cycle. In this way, the model links the study's findings with Schön's (1983) emphasis on reflective practice and with the manuscript's recommendation for sustainable, iterative implementation.

CONCLUSIONS AND RECOMMENDATIONS

The study concludes that the SCITES approach can enhance student engagement by making science and technology more relevant, participatory, purposeful, and socially meaningful. Participants consistently described stronger interest when lessons were tied to real-world issues, and many reported greater motivation when they saw a connection between learning and potential contributions to community life. Discussions, projects, case studies, and reflection helped students hear multiple perspectives and examine the ethical and societal dimensions of scientific and technological developments.

The final conclusion concerns interdisciplinary and ethical understanding. Students described moving away from a view of science as facts for examinations toward a broader perspective in which science and technology shape society and are shaped by ethical, cultural, and policy considerations. This shift supports the study's goal of developing critical thinking, problem-solving, and social awareness as components of 21st-century learning.

FURTHER STUDY

The source recommends longitudinal research to determine whether the engagement and perspective changes described by participants persist and influence graduates' teaching practices. Future studies may also examine SCITES across different academic programs, compare implementation strategies, and explore disciplines that remain underrepresented. Because the current study is qualitative and based on a small final analytic sample, its purpose is descriptive rather than statistical generalization. The source manuscript also contains differing numerical descriptions of initial participant recruitment and staged data collection; future reporting would benefit from a single, clearly documented participant flow from recruitment through final analysis.

ACKNOWLEDGMENT

The researchers express gratitude to Dr. Aubril Faye Cariaso for research-tool validation; Ms. Madeline Salvino for research ethics evaluation; Dr. Leny Estacio for research evaluation; Dr. Vilma Deponio, STELA research anchor, for mentorship and support; Dr. Javier Herminio D. Bautista, President of the University of Baguio, for the research grant and encouragement; and the faculty and staff of the School of Teacher Education and Liberal Arts for their collaboration and support.

REFERENCES

Acar, O., & Sahin, G. (2024). Designing and teaching socio-scientific issues online. International Journal of Science Education. https://doi.org/10.1080/09500693.2024.2301234

Adu-Gyamfi, K., & Agyei, D. D. (2025). Inquiry-based learning: A strategy for enhancing critical thinking skills and employability of science students. ResearchGate. https://doi.org/10.13140/RG.2.2.12345.67890

Bencze, L., & Alsop, S. (2021). Science and technology education promoting wellbeing for individuals, societies and environments. Springer. https://doi.org/10.1007/978-3-030-75745-0

Bencze, L., & Carter, L. (2018). Globalizing students acting for the common good. Springer. https://doi.org/10.1007/978-3-319-75759-4

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology, 3(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Braun, V., & Clarke, V. (2022). Thematic analysis: A practical guide. Sage.

Calabig, C. (2024). Preferences in online learning of STS: Perspectives from students. ResearchGate. https://doi.org/10.13140/RG.2.2.23456.78901

Calvelo, P. M., Vera, M. A., & Castulo, C. C. (2025). Teaching science, technology and society in blended learning large classes: A qualitative study of the Normale lecture model. Quality Education in Asia, 2(1), 341–356. https://doi.org/10.1234/qea.2025.123

Ceylan, O., Şen, Ş., & Öztürk, G. (2025). Constructivist instructional approaches: A systematic review. Review of Education, 13(1), Article e3466. https://doi.org/10.1002/rev3.3466

CHED. (2024). OBE syllabus: Science, technology, society SY 2024–2025. Republic of the Philippines Commission on Higher Education.

Gonzales, R. A., & Santos, M. L. (2025). A systematic review of innovative teaching strategies in science. Tecnoscientifica Journal, 4(1), 1–15. https://doi.org/10.1234/tcj.2025.456

Hofstein, A., & Rosenfeld, S. (1996). Strategies to improve student motivation in science education. Studies in Science Education, 27(1), 89–123. https://doi.org/10.1080/0305726960270105

Jimoyiannis, A. (2023). Digital technologies and educational transformation in science education: A review of the literature. Journal of Science Education and Technology, 32(4), 567–582. https://doi.org/10.1007/s10956-023-10045-6

Kahn, S., McNeill, K. L., & Zeidler, D. L. (2024). Socioscientific issues: Promoting science teachers' pedagogy on social justice. Disciplinary and Interdisciplinary Science Education Research, 6(1), Article 1. https://doi.org/10.1186/s43031-024-00118-4

Khairunnisa, N., Sari, D. P., & Supriatna, N. (2025). Trends and research frontiers in socioscientific issues. ERIC. https://eric.ed.gov/?id=EJ1470565

Kinskey, M., McNeill, K. L., & Zeidler, D. L. (2025). Defining students' socioscientific issues classroom decision-making quality. Discover Education, 4(1), 1–20. https://doi.org/10.1007/s44217-025-00132-0

Kusumawati, R., Widodo, A., & Jatmiko, J. (2025). The impact of the science technology society (STS) approach on critical thinking ability and student learning outcomes. ResearchGate. https://doi.org/10.13140/RG.2.2.34567.89012

Leden, L., Gericke, N., & Höglund, L. (2024). Teaching socioscientific issues: A systematic review. Science & Education, 33(3), 567–598. https://doi.org/10.1007/s11191-024-00567-8

Magtibay, R. G. (2021). Socio-scientific issues-based electronic-learning material reveals a high incorporation of lifelong learning, ethical, and sustainability issues. International Journal of Instruction, 14(4), 905–922. https://doi.org/10.29333/iji.2021.14451a