

Document Analysis of Teaching Practices and Student Learning in Science, Technology, and Society Course

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ABSTRACT: Science, Technology, and Society (STS) is a General Education course that examines the relationships among scientific knowledge, technological development, and social life. This qualitative document analysis synthesized 20 scholarly books, peer-reviewed articles, and official educational reports concerning STS-related instruction, scientific literacy, socioscientific issues, critical thinking, and student engagement. The analysis identified five interconnected themes: contextualization through real-world issues; dialogue, inquiry, and collaborative learning; scientific literacy and critical thinking; student engagement and meaningful learning; and implementation challenges. The reviewed literature indicates that STS instruction becomes more meaningful when teachers connect concepts to authentic issues, use structured discussion and inquiry, and require students to evaluate evidence and consider ethical and social consequences. The findings also suggest that effective implementation requires careful resource selection, explicit scaffolding, inclusive classroom norms, and assessments that value reasoning rather than recall alone. Because the study relied on documents, it does not claim original classroom outcomes. Instead, it offers literature-grounded instructional recommendations for teachers handling STS as a General Education course.

KEYWORDS: Science, Technology, and Society; General Education; scientific literacy; socioscientific issues; critical thinking; student engagement

I. INTRODUCTION

Science, Technology, and Society (STS) is concerned with the ways scientific knowledge and technological developments interact with human values, institutions, environments, and everyday experiences. In an STS classroom, science is not treated only as a collection of facts. It is examined as a human activity shaped by social needs, historical conditions, economic interests, ethical questions, and public decisions. This orientation makes STS particularly appropriate for General Education because students from different academic programs can connect scientific and technological issues with their own disciplines and communities.

The relevance of STS can be seen in issues such as climate change, public health, artificial intelligence, energy, biotechnology, food security, digital privacy, and environmental sustainability. These concerns require more than technical knowledge. They require citizens to interpret information, assess evidence, recognize uncertainty, understand competing interests, and make responsible decisions. The National Research Council (2012) emphasizes scientific practices, crosscutting concepts, and the application of science to real-world situations, while Osborne (2007) argues that science education should attend to the purposes and forms of scientific literacy needed in contemporary society.

Research on socioscientific issues likewise shows the value of engaging learners with complex questions that connect scientific concepts to social and ethical dimensions. Zeidler et al. (2005) describe socioscientific issues education as a framework that supports reasoning, discourse, and informed decision-making. Sadler (2011) further explains that classroom issues can be used to develop scientific understanding while students examine values, evidence, and competing perspectives. These ideas are directly relevant to STS instruction, where the goal is to help students understand science and technology as part of social life.

However, teaching STS may be challenging. Teachers must select reliable and current resources, explain complex concepts in accessible language, manage diverse viewpoints, and guide discussion without reducing controversial topics to unsupported opinion. A qualitative synthesis of existing literature can help clarify the instructional strategies and conditions that are most frequently emphasized in scholarship.

This study therefore examined literature related to STS and closely connected science-education approaches. It focused on instructional strategies, student engagement, scientific literacy, critical thinking, and challenges in implementation. The study is a document analysis and does not report interviews, observations, or original measurements.

II. RESEARCH QUESTIONS

Specifically, this study sought to synthesize existing literature on the teaching of Science, Technology, and Society as a General Education course, particularly in relation to instructional strategies, student engagement, scientific literacy, and critical thinking. It addressed the following questions:

- What instructional strategies are commonly associated with STS and socioscientific issues instruction?
- How do these strategies support students' understanding of the relationship between science, technology, and society?
- What learning benefits related to scientific literacy, critical thinking, and engagement are described in the literature?
- What challenges are identified in implementing STS-related instruction?
- What practical recommendations can be proposed for teachers handling STS as a General Education course?

III. METHODOLOGY

A. Research Design

The study employed a qualitative document analysis design. Document analysis is appropriate when a researcher aims to interpret written materials, identify recurring concepts, compare scholarly positions, and construct a thematic synthesis. The design was selected because the study intended to develop literature-grounded insights rather than measure the effect of a particular classroom intervention.

B. Sources of Documents

The study reviewed 20 selected documents consisting of scholarly books, peer-reviewed journal articles, and official educational or institutional publications related to Science, Technology, and Society (STS) education, socioscientific issues, scientific literacy, critical thinking, student engagement, inquiry-based learning, and science education.

The documents were selected based on their relevance to the research questions and their contribution to the understanding of STS instruction as a General Education course. Priority was given to established academic and institutional publications with identifiable authors, publication dates, publishers, or journal information. Documents were included when they provided conceptual explanations, research findings, or instructional implications relevant to the study.

Materials were excluded when they were unrelated to STS instruction, lacked identifiable publication information, or did not contribute meaningfully to the research questions. The selected documents served as the basis for identifying recurring concepts, comparing scholarly perspectives, and developing the thematic synthesis presented in the study.

C. Data Analysis

The researcher read the selected documents and recorded statements related to teaching strategies, learning benefits, student participation, scientific reasoning, and implementation concerns. Similar ideas were grouped into categories and subsequently consolidated into broader themes. The final themes were interpreted in relation to the objectives of STS as a General Education course. Since the study was qualitative and document-based, the findings are presented as a thematic synthesis and not as numerical claims about student achievement.

D. Ethical Considerations and Limitations

The study used publicly available scholarly and institutional materials and did not involve human participants. Proper attribution was maintained through in-text citations and a reference list. The study is limited by the availability and scope of the reviewed literature. It cannot establish the actual effectiveness of a strategy in a specific classroom or institution. Classroom-based research may be conducted in the future to examine how the identified practices operate among particular groups of STS students.

IV. RESULTS AND DISCUSSION

Table 1 presents the thematic synthesis of the reviewed literature in relation to the research questions. The analysis generated five interconnected themes: contextualized teaching through real-world issues; dialogue, inquiry, and collaborative learning; scientific literacy and critical thinking; student engagement and meaningful learning; and challenges in implementing STS instruction. The themes overlap because instructional strategies may simultaneously influence students' understanding, engagement, reasoning, and participation.

Table 1. Thematic Synthesis of Science, Technology, and Society Instruction

<i>Research Question/Focus</i>	<i>Major Theme</i>	<i>Main Insight</i>	<i>Instructional Implication</i>
Instructional strategies commonly associated with STS instruction	Contextualized teaching	Real-world issues make STS concepts relevant.	Use current events, local cases, and authentic problems.
Strategies that support students' understanding of STS	Dialogue, inquiry, and collaboration	Discussion exposes students to multiple perspectives.	Use structured debates, case analysis, and inquiry tasks.

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Learning benefits related to scientific literacy, critical thinking, and engagement	Scientific literacy, critical thinking, and meaningful engagement	Students benefit from evaluating evidence, constructing arguments, and reflecting on social issues.	Use source analysis, argumentation, inquiry, and reflective writing.
Challenges in implementing STS-related instruction	Implementation challenges	Resources, content complexity, and learner diversity affect STS teaching.	Provide scaffolds, credible materials, and inclusive classroom norms.
Practical recommendations for STS teachers	Instructional applications	Effective STS teaching requires contextualized, evidence-based, and participatory learning experiences.	Use authentic issues, active learning, and appropriate assessments.

A. Contextualized Teaching Through Real-World Issues

The first theme concerns the use of real-world issues as contexts for learning. STS concepts become more meaningful when students examine questions connected to their daily lives and communities. Examples include the social consequences of artificial intelligence, the ethics of biotechnology, the environmental effects of energy choices, and the public health implications of scientific claims. Such contexts help students recognize that science and technology influence social decisions and are themselves influenced by social priorities.

The literature on socioscientific issues supports the use of authentic and controversial questions to connect scientific knowledge with ethical and civic reasoning (Sadler, 2011; Zeidler et al., 2005). In practice, an instructor may begin with a local or current issue, provide the necessary scientific background, and ask students to identify stakeholders, evaluate evidence, and propose defensible responses. This approach can enhance relevance while preventing STS from becoming a purely abstract discussion.

B. Dialogue, Inquiry, and Collaborative Learning

The second theme is the importance of dialogue and active participation. STS issues commonly involve multiple perspectives; therefore, students benefit from structured discussions, debates, case analyses, role-playing, inquiry tasks, and collaborative problem-solving. These activities provide opportunities for students to explain ideas, listen to alternative views, ask questions, and revise their positions based on evidence.

However, collaboration should be carefully organized. Students need clear roles, guiding questions, credible resources, and criteria for evaluating arguments. Without structure, discussions may become dominated by confident speakers or may remain at the level of personal opinion. Teachers can address this concern by requiring evidence-based claims, individual reflection, and group outputs that make students' reasoning visible.

C. Scientific Literacy and Critical Thinking

The third theme is the development of scientific literacy and critical thinking. Scientific literacy includes understanding scientific ideas, interpreting evidence, recognizing uncertainty, and applying knowledge to personal and public decisions. Osborne (2007) emphasizes that science education should prepare learners to participate meaningfully in a society shaped by science and technology. In STS, this means that students should learn not only what science says but also how claims are produced, communicated, challenged, and used.

Critical-thinking tasks may include comparing media reports with original studies, identifying unsupported claims, analyzing data displays, evaluating the credibility of online sources, and constructing position papers. These tasks are consistent with the socioscientific framework of Zeidler et al. (2005), which highlights reasoning and discourse around complex issues. Teachers should explicitly model how to distinguish evidence from assertion and how to acknowledge limitations in an argument.

D. Student Engagement and Meaningful Learning

The fourth theme concerns student engagement and meaningful learning. Engagement is more likely when students see a clear connection between course content and real-world concerns. STS activities that involve community problems, current events, ethical dilemmas, and decision-making can invite students to contribute their experiences and disciplinary perspectives. This is particularly useful in General Education classes where students may have different academic backgrounds.

Engagement, however, should not be equated with activity alone. Meaningful engagement involves sustained attention, intellectual effort, participation in reasoning, and reflection. Teachers can support this by using questions that do not have immediate answers, allowing students to investigate sources, and requiring them to explain how their views developed.

E. Challenges in Implementing STS Instruction

The literature also points to several challenges in implementing STS instruction. STS topics may require knowledge from the natural sciences, social sciences, ethics, history, economics, and politics. Teachers must therefore balance breadth and depth and avoid

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oversimplifying complex issues. Resource quality is another concern because online information may be inaccurate, biased, or outdated. Teachers need to curate materials and teach students how to evaluate sources.

Classroom diversity and controversial issues present additional challenges. Students may differ in prior knowledge, language proficiency, confidence, and personal beliefs. Clear discussion norms, inclusive participation structures, and evidence-based assessment can help create a respectful learning environment. The goal of STS is not to produce identical opinions but to develop informed, reasoned, and socially responsible judgment.

Overall, the thematic synthesis indicates that effective STS instruction involves more than the presentation of scientific and technological information. It requires contextualized learning experiences, structured dialogue and inquiry, explicit attention to evidence and reasoning, and instructional support responsive to students' diverse backgrounds. The findings further suggest that student engagement is strengthened when learning activities are connected to authentic social concerns and when students are given opportunities to examine issues from multiple perspectives. These themes provide the basis for the conclusions and recommendations presented in the succeeding sections.

V. CONCLUSIONS

Based on the findings of the qualitative document analysis, the following conclusions are drawn:

1. Science, Technology, and Society (STS) is best taught through approaches that connect scientific and technological concepts with authentic social issues. Contextualized instruction helps students recognize the relevance of science and technology in everyday life and encourages them to examine the consequences of decisions affecting communities.
2. Dialogue, inquiry, and collaboration are valuable instructional approaches in STS. Since STS topics involve multiple perspectives and complex judgments, structured discussions and collaborative activities grounded in credible evidence and clear questions can support scientific literacy, critical thinking, and meaningful student engagement.
3. Effective STS instruction requires careful planning and purposeful instructional support. Teachers need to manage complex content, select trustworthy resources, accommodate diverse learners, and establish respectful norms for discussing controversial and socially relevant issues.
4. The use of credible evidence and structured learning activities is essential in developing students' understanding of STS issues. These practices can help learners examine claims, consider alternative perspectives, and make more informed judgments about the social implications of science and technology.
5. The conclusions of this study are limited to literature-grounded guidance. Since the study utilized documentary sources rather than direct classroom observations, interviews, or student performance data, the findings should not be interpreted as empirical proof of effectiveness in a particular educational setting. Further classroom-based research is recommended to validate these conclusions.

VI. RECOMMENDATIONS

Based on the findings of the study, the following recommendations are proposed to strengthen the teaching and learning of Science, Technology, and Society (STS) as a General Education course:

1. Use current, local, and socially relevant science-and-technology issues as lesson contexts.
2. Combine conceptual explanations with case studies, inquiry, debate, role-playing, and reflective writing.
3. Teach students explicit procedures for evaluating evidence, sources, data, and scientific claims.
4. Provide structured group roles, discussion protocols, and rubrics that assess reasoning and evidence use.
5. Use differentiated materials and scaffolds for students with varied academic and scientific backgrounds.
6. Maintain a curated collection of reliable articles, reports, videos, and case materials for STS lessons.
7. Use authentic assessments such as issue briefs, position papers, portfolios, presentations, and reflection journals.
8. Conduct future classroom-based research to examine students' experiences and learning outcomes in STS.

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