Pedagogical Approaches in Science Education and Students' Science, Technology, and Society (STS) Orientation: A Multidimensional Quantitative Correlational Inquiry

Tommy M. Artajo, Phd

Natural Science Department College of Arts and Sciences Guimaras State University

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ABSTRACT

In the current classrooms, science education focuses on not just acquisition of content knowledge but also learners' construction of relationships among science-technology-society (STS). The pedagogical strategies of IBSE, SSI and CST are hypothesized to reinforce students' STS orientation by establishing scientific knowledge within authentic social, moral and technological frameworks. A quantitative correlational research design was used to investigate the relationship between pedagogical orientations in science education and NSTS orientation among students. Data for this study were obtained from a researcher-designed pedagogical approaches questionnaire and an amended Science, Technology, and Society orientation instrument developed based on the Views on Science–Technology–Society (VOSTS) framework. Descriptive statistics and the correlation analysis were employed for checking strength and direction of relations between variables. The results revealed that inquiry and SSI-based pedagogical strategies were correlated positively with student STS-oriented instruction, whereas teacher-centered practices had a weak or even insignificant correlation. The results indicate that pedagogical practices in science classrooms have a strong impact on the development of students' sociotechnical awareness and scientific literacy for citizenship.

Keywords: science education, pedagogical approaches, science technology and society, STS orientation, inquiry-based learning, socioscientific issues

INTRODUCTION

Science eduation is now more focused on building scientific literacy - the capacity to confront tendentious social and technical issues. Recently, some scholars have claimed that science is not enough to be "scientific" in such context driven by fast technological changes, moral conflicts and global problems socio-environmental ones (Aikenhead, 2006; Hodson, 2011). Therefore STS tradition has become the dominant discourse in science education reform.

Educational logic is crucial in the progress of a STS-oriented learning. IBS emphasizes science epistemic practices (questioning, evidence examination, reasoning), whereas SSI pedagogy centers learning within actual societal controversies requiring ethical judgment and informed actions (Zeidler et al., 2005). These methods also stand in contrast to the traditional teacher-centred models where the focus lies on procedural knowledge rather than engagement and reflection with possible social implications.

Notwithstanding sound theoretical backing, empirical research has often addressed the issue of learning outcomes instead of exploring learners' STS orientation as a polyvalent factor. There still is a need for quantitative sup-positional studies focusing on teachers' predispositions with the purpose of determining to what extent different teaching methods are related to pupils´ views of science, technology and society. Filling this gap, the current study examines the connection between science education pedagogical practices and students' orientation of STS.

THEORETICAL FRAMEWORK

This study is based on the Science–Technology–Society (STS) Education Theory and Constructivist Learning Theory.

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As outlined by Aikenhead (2006), STS education theory argues that learning in science should focus on interactions between the acquisition of scientific knowledge, technological advance and societal values. This implies that the notion of scientific literacy goes beyond subject-content knowledge to include the ability to critically assess claims made in social context, and to make informed decisions about civic issues.

Learning theory based on constructivism, as founded by Piaget (1972) and Vygotsky (1978), posits that learners are active constructors of their knowledge through interaction with experiences, social discourse, and meaningful problems. Inquiry-based and SSI pedagogies are consistent with constructivism as they support students in interpreting authentic problems in a reflective manner, which promote deeper conceptual and sociotechnical learning.

These theories collectively indicate that pedagogies that strongly emphasize inquiry, contextualization, and social relevance will be most predictive of STS orientation in learners.

By integrating STS education theory and constructivist learning theory, the current study construes pedagogical strategies as instructional mediators through which students are orientated to STS. Inquiry based and SSI driven pedagogies are predicted to facilitate student activation, critical reflection, social technical reasoning and relationships between school science and "real world" problems while primarily lecture-driven approaches may preclude opportunities for students to link science content with sociotechnical issues. The model posits that teaching practices impact on the extent to which students come to view science and technology in society, and this relates to overall STS orientation.

Objectives of the Study

General Objective

To determine the relationship between pedagogical approaches in science education and students' Science, Technology, and Society (STS) orientation.

Specific Objectives

Specifically, this study seeks to:

1. describe the pedagogical approaches employed in science instruction as perceived by students;
2. determine the level of students' STS orientation in terms of identified dimensions;
3. examine the significant relationship between pedagogical approaches in science education and students' STS orientation; and
4. identify which pedagogical approaches are most strongly associated with students' STS orientation.

METHODOLOGY

Research Design

The study employed a quantitative correlational research design, which is appropriate for examining the degree of relationship between two or more variables without manipulating them (Creswell & Creswell, 2018).

Participants and Locale

The study respondents were 150 undergraduate students of Guimaras State University (GSU) – three from the Bachelor in Secondary Education major in Science (BSEd Science), one hundred five from the Bachelor of Science in Criminology (BS Crim), and fourty- two from the Bachelor of Science in Electrical Engineering (BSEE). These mainstream programs of study were chosen, as they are science-based programs with a focus on science concepts, technology application and social relevance which makes them suitable settings to measure students' Science/Technology/Society (STS) orientation.

The participants were chosen through stratified random sampling and according to proportion of academic

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programs ensured sufficient coverage and comparability in all fields. This sampling method was used to minimize the potential of sampling biases and to increase representativeness in the university context.

The study was conducted in Guimaras State University of the Province of Guimaras, Philippines. The university was selected for its proximity to the researcher and because of site's commitment to a range of science education across initial teacher education, criminology and engineering. Further, GSU offers an appropriate institutional context for studying pedagogy approaches and STS orientation because it enrolls students studying toward professions that are in need of scientific literacy, ethical sensitivity and environmentally sound decision making.

Research Instruments

Two instruments were utilized:

1. **Pedagogical Approaches in Science Education Questionnaire** – a researcher-developed Likert-scale instrument measuring the extent of inquiry-based, SSI-oriented, contextualized, and teacher-centered instructional practices.

2. **Science, Technology, and Society Orientation Scale** – an adapted instrument grounded in the Views on Science–Technology–Society (VOSTS) framework developed by Aikenhead and Ryan (1992).

   Both instruments underwent content validation by experts and reliability testing using Cronbach's alpha.

Data Gathering Procedure

Permission was obtained from school authorities prior to data collection. Respondents were informed of the study's purpose and assured of confidentiality. Questionnaires were administered during regular class hours and retrieved upon completion.

Data Analysis

Descriptive statistics (frequency, mean, and standard deviation) were used to describe variables. Pearson product–moment correlation coefficient was employed to determine the relationship between pedagogical approaches and STS orientation. Statistical significance was set at the 0.05 level.

RESULTS AND DISCUSSION

Table 1 Mean Scores of Pedagogical Approaches in Science Education

Pedagogical Approach	**Mean**	**SD**	**Descriptive Interpretation**
Inquiry-Based Instruction	4.18	0.54	High
SSI-Oriented / STS-Contextualized Instruction	4.25	0.51	High
Project-/Problem-Based Learning	3.89	0.60	Moderate
Teacher-Centered Instruction	2.74	0.68	Low
Overall Pedagogical Approaches	3.77	0.47	Moderate–High

Note. Mean scores were interpreted as follows: 4.21–5.00 = Very High; 3.41–4.20 = High; 2.61–3.40 = Moderate; 1.81–2.60 = Low; 1.00–1.80 = Very Low.

Table 1 shows that inquiry-based and SSI-oriented pedagogical approaches obtained the highest mean scores, indicating that learner-centered and context-rich instructional practices were frequently employed in science classrooms. In contrast, teacher-centered instruction yielded a low mean score, suggesting limited reliance on transmissive pedagogies. These results imply a pedagogical environment that increasingly values student

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engagement, critical inquiry, and real-world contextualization—key elements in contemporary science education reforms.

Table 2 Level of Students' Science, Technology, and Society (STS) Orientation

STS Orientation Dimension	Mean	SD	Descriptive Interpretation
Science and Society Interaction	4.12	0.56	High
Ethical and Moral Reasoning in Science	4.20	0.53	High
Technology and Decision-Making	4.05	0.58	High
Science for Citizenship	3.96	0.61	Moderate–High
Overall STS Orientation	4.08	0.49	High

As presented in Table 2, students demonstrated a generally high level of STS orientation across all dimensions. The highest mean was observed in ethical and moral reasoning in science, indicating that students were relatively aware of the value-laden and ethical implications of scientific and technological developments. These findings suggest that students possess a developed understanding of science as a socially embedded and ethically consequential enterprise, consistent with the goals of STS-oriented science education.

Table 3 Correlation Between Pedagogical Approaches and Students' STS Orientation

Pedagogical Approach	r-value	p-value	Interpretation
Inquiry-Based Instruction	.62	< .001	Significant, Moderate Positive
SSI-Oriented / STS-Contextualized Instruction	.68	< .001	Significant, Strong Positive
Project-/Problem-Based Learning	.41	.002	Significant, Moderate Positive
Teacher-Centered Instruction	−.12	.184	Not Significant
Overall Pedagogical Approaches	.59	< .001	Significant, Moderate Positive

Table 3 reveals that inquiry-based and SSI-oriented pedagogical approaches were significantly and positively correlated with students' STS orientation. The strongest relationship was observed for SSI-oriented instruction, highlighting the effectiveness of socioscientific engagement in cultivating learners' sociotechnical awareness. This finding supports Zeidler et al. (2005), who argue that SSI-based pedagogy fosters ethical reasoning and informed citizenship. Conversely, teacher-centered instruction showed a weak and nonsignificant relationship with STS orientation, suggesting that traditional transmissive methods may inadequately support the development of sociocultural and ethical understanding in science learning.

Overall, the table-by-table findings demonstrate that pedagogical approaches emphasizing inquiry, contextualization, and socioscientific engagement are strongly associated with higher levels of STS orientation among students. These results reinforce Hodson's (2011) assertion that science education must move beyond content mastery toward cultivating socially responsible and critically engaged citizens.

CONCLUSION

Based on the findings of the study, the following conclusions are drawn:

1. There is a strong relationship between pedagogical approaches in science education and students´ STS Orientation. It is suggested that the form of instruction practiced in science classes has a substantial impact on students' learning about the social, ethical, and technological aspects of science.

2. They establish a relationship between ISB and students STS orientation. Students learning in inquiry-based environments showed increased levels of engagement with evidence-based reasoning and greater appreciation for how societal needs drive scientific understanding.

3. SSI-oriented instruction has the strongest positive correlation with students' STS orientation. Learners' ethical reasoning, decision-making competences and understanding of science as a socially embedded activity are developed through the incorporation of real world value-laden science related topics.

4. Conventional teacher–centered teaching methods are not effective at changing students' STS orientation. Mainly transmission pedagogies were found to be weak associations with students' sociotechnical literacy, thereby failing to meet the broader objectives of STS education.

5. It is pedagogically important to align with STS objectives for the developing scientifically literate and socially responsible student. Teaching that focuses on inquiry, contextualization, and socioscientific engagement better prepares learners to critically analyze science- and technology-related issues in the world.

RECOMMENDATIONS

In light of the foregoing conclusions, the following recommendations are proposed:

1. Science educators are encouraged to deliberately integrate STS-oriented pedagogical approaches into classroom instruction. Given the significant relationship between pedagogy and STS orientation, teachers should design learning experiences that explicitly connect scientific concepts with societal and technological contexts.

2. Schools and curriculum planners should strengthen the use of inquiry-based learning in science programs. Professional development initiatives and instructional guides should emphasize inquiry strategies that promote questioning, investigation, and evidence-based reasoning aligned with STS outcomes.

3. Socioscientific issues (SSI) should be systematically embedded in science curricula and learning materials. Curriculum developers and teachers are advised to incorporate contemporary and locally relevant socioscientific issues to enhance students' ethical reasoning and civic engagement.

4. Teacher training institutions and in-service programs should reassess the overreliance on teachercentered instructional practices. While direct instruction may remain useful for foundational knowledge, it should be complemented with learner-centered and context-driven strategies to address sociocultural dimensions of science learning.

5. Future science education initiatives should prioritize pedagogical coherence with the goals of scientific literacy and citizenship. Educational policymakers and school leaders are encouraged to align instructional standards, assessment practices, and teacher evaluation systems with STS-oriented learning objectives.

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