RMLE Online
Research in Middle Level Education

Micki M. Caskey, Ph.D., Editor
Portland State University
Portland, Oregon

2008 • Volume 31 • Number 7 ISSN 1940-4476

Comparison of Student Learning Outcomes in Middle School Science Classes with an STS Approach and a Typical Textbook Dominated Approach

Robert E. Yager
The University of Iowa
Iowa City, Iowa

Hakan Akcay
Marmara Üniversitesi
Istanbul, Turkey

Abstract

The purpose of this study was to determine whether Science, Technology, and Society (STS) learning increases student concept mastery, general science achievement, use of concepts in new situations, and attitudes toward science in middle school classrooms. The study involved two teachers and fifty-two students in grades 6 through 8. Two sections of middle school science were taught by two longtime teachers where one used an STS approach and the other retained a typical use of the textbook as a class organizer. Each teacher administered the same pre- and post-assessments. Major findings indicated that middle school students experiencing the STS format with constructivist teaching practices: (1) learned basic concepts as well as students who studied them directly from the textbook, (2) achieved as much general concept mastery as students who studied in a textbook dominated way, (3) applied science concepts in new situations better than students who studied science in a more traditional way, (4) developed more positive attitudes about science, (5) exhibited creativity skills that were more individual and occurred more often, and (6) learned and used science at home and in the community more than students in the typical textbook dominated section. Further, the STS approach coincided well with the kind of teaching across the curriculum that is (recommended as) central to teaching in middle schools.

Introduction

Science-Technology-Society (STS) has been an example of needed reform in Science Education for over 25 years (Aikenhead, 1980; Bybee, 1985; Hurd, 1986; Roy, 1985; Solomon & Aikenhead, 1994; Yager, 1996). It has been a major effort in the United States since its formal inclusion as one of Norris Harms' foci for improving science education; he used it as one of the organizers for his National Science Foundation (NSF)-supported Project Synthesis (Harms, 1977). The National Science Teachers Association (NSTA) developed an official paper on STS as the 1980s unfolded in recognition of its promise for improving science learning (NSTA, 2006). *Search for Excellence* monographs reported on several national exemplars of STS in schools in the U.S. (Penick & Meinhard-Pellens, 1984). STS continues as a major reform initiative in the U.S. and around the world during the decades that have followed. It is used most often at the middle school level and exemplifies a coordinated curriculum and constructivist teaching. The recommendations for changes in science teaching elaborated in the National Science Education Standards coincide well with the NSTA list of teaching strategies defined as the STS approach. Further, these changes are indeed advanced in science for the entire educational spectrum, namely K–12, with special attention to the total middle school curriculum. One of the major goals for science in the standards specifies content that includes science that deals with personal and societal issues/problems.

Although STS is advanced at all grade levels, it is especially appropriate for middle schools where teachers prepared for both elementary and high school teaching often find common ground. In the Midwest, middle schools most commonly include grades 6, 7, 8; but sometimes include grades 5 and 9. The National Science Education Standards identify the teaching levels as K–4, 5–8, and 9–12. The middle grades are considered significant for helping students meet science goals because of the importance of the new information, new approaches to doing science in laboratories, and the new focus on science as a discipline instead of a collection of disciplines (often unrelated and at times in conflict). Middle schools often do not employ one teacher for all disciplines as commonly found in elementary schools; nor confine the disciplines to biology, earth science, chemistry, and physics as commonly found in high schools. Further, there is less parental, administrative, and student focus on college entrance and/or possible career choices. In many instances, middle schools attempt to focus on school and community problems where all teachers across the entire curriculum are involved with a focus for a month or a nine-week grading period. Such problems commonly include space travel, insecticide issues, nutrition, disease, ozone, global warming, and other concerns reported in the popular press.

In 1990, the NSTA Board of Directors unanimously adopted its position statement on STS. This statement briefly defined STS as the “teaching and learning of science and technology in the context of human experience” (NSTA, 2006, pp. 229–230). This reveals that STS is primarily an approach for teaching and learning as opposed to a curriculum framework. The full statement indicating the kind of specific teaching advocated and the learning it invokes identifies nine essential features of the STS approach to teaching middle school science used in this study. Those features include:

- Student identification of problems with local interest and impact
- The use of local resources (both human and material) to locate information that can be used in problem resolution
- The active involvement of students in seeking information that can be applied to solve real-life problems
- The extension of learning beyond the class period, the classroom, and the school
- A view that science content is more than concepts that exist for students to master for tests
- An emphasis upon process skills that students can use in their own problem resolution
- An emphasis upon career awareness—especially careers related to science and technology
- Identification of ways that science and technology are likely to impact the future
- Student autonomy in the learning process as individual issues are identified and approached. (pp. 229–230)

These nine features characterize the STS approach to teaching used in the experimental class of this study clearly match the teaching that exemplifies the needed focus for interdisciplinary teaching advocated for middle schools.

The STS effort is based on constructivist learning theory (Brooks & Brooks, 1999; Yager, 1991) that emphasizes learners’ prior knowledge and their own previous interpretations of nature. Constructivist teaching requires a learner-oriented environment where the teacher acts as a guide and co-learner. STS uses the constructivist perspective for learning and knowing; its emphasis is on current issues, local situations, and personal relevance. These features make it a natural for middle school classrooms. Students initiate questions, participate in discussions and research actions, and practice decision making through social interactions (Yager, 1996, 2000). STS is also a major focus in other areas of the curriculum—especially the social studies, mathematics, and the applied fields.

Many STS programs utilize societal issues as course organizers. Some emphasize technology, meaning the inclusion of questions about the human-made world as opposed to only questions about the objects and events encountered in the natural world (i.e., pure science). Many major reform efforts and most new textbooks now include technology as a vital part of science content and often as an entrée to more traditional science concepts—unlike the reforms of the 1960s which focused on pure science—and science as "known to scientists" (Zacharias, 1956). Too many equate technology to the use of computers with instruction; but such views are far from the broad field of technology—a discipline in its own right. Mastery of basic science concepts has been the main outcome and the primary indicator of student achievement. This focus on only concept mastery continues as a problem when implementing the No Child Left Behind Act (2001). Yet, most of these efforts never considered the effects of teaching or the actions of students outside the classroom as forms of evidence that learning had occurred.

Critics of the STS approach to science teaching are concerned that students will learn fewer basic science concepts and that general science achievement will suffer (Kromhout & Good, 1983). After all, much less time is spent with the concept domain per se—at least less time with mastery for the sake of mastery or mastery with the assumption that students first need to know before they can become involved with problem resolution. This remains a problem in many middle schools, especially for teachers previously prepared as "science teachers" in formats like those found in most college courses. Many STS enthusiasts argue that involving students with relevant, student-centered, current, real-world issues is where reform must begin (NSTA, 2006). Engaging students in problem resolution, regarding situations where interests and motivation exist from the start, is believed to be necessary if educators are to be successful with the needed reforms. This is the situation in middle school classrooms that follow the philosophy and recommendations for middle schools (NSTA; Wormeli, 2001, 2003). Hofstein and Yager (1982) and Yager (2004) have argued that organizing classrooms around social issues as organizers provide a better way of guiding more students to an understanding of, an appreciation for, and the use of major science concepts and process skills in their own lives. This position is based on the idea that students must choose to learn on their own in order to learn (Starnes & Paris, 2000). This position is characteristic of middle school philosophy across the entire curriculum.

Inquiry has been a stated goal for science teaching for over a century in U.S. schools. However, Hurd (1978) observed that it has been an elusive goal and one not readily attained. Yet, the kind of teaching defined by the NSTA position paper regarding STS and the teaching advocated in the NSES both encourage direct involvement of students in all five phases of the scientific experience, namely:

(1) Formulating questions about the objects and events found/observed in the natural world
(2) Offering explanations for the objects and events encountered (hypotheses formation)
(3) Testing for the validity of explanations offered
(4) Communicating the results to others
(5) Confirming that the results are compatible with "established" views.

For many, STS has become a broader view of science in education—making it more than a review of the major concepts characterizing the traditional major disciplines (NSTA, 2006). A focus on inquiry as defined in the NSES is not only the process used by scientists, but is also a form of teaching that is advocated and a kind of content that includes the history, philosophy, and sociology of science. Inquiry teaching is basic to STS and illustrates that it is not an add-on to existing courses or curricula. It characterizes a broader view of science content, noting a relationship to technology, and casts science as a human endeavor —as opposed to it being described as an accumulated body of knowledge classified into major disciplines, including biology, chemistry, physics, and earth science (NRC, 1996).

The view of the student in the STS approach is very different from what it is in traditional teaching. In traditional teaching, the teacher decides which topics to include, in what sequence, and in what ways. The teacher is the authority and students are the passive recipients. Conversely, students are central in the STS approach, which is congruent with the philosophy recommended for most middle schools. Students generate their own questions rather than relying purely on the questions provided by others. Based on their own questions, students view their previous understanding of the problem, and suggest possible explanations based upon their initial conceptions and experiences. Student-directed questions further serve to define problems, potential solutions, and other points of view. This enables students to see/do science in the same way that scientists do. This makes science more meaningful, exciting, and appropriate. Yager (and various research teams) has identified features of STS compared with traditional science teaching that are central to this report.

Traditional	STS
Survey of major concepts found in standard textbooks	Identification of problems with local/ personal interest/impact
Use of labs and activities suggested in textbook and accompanying lab manual	Use of local resources (human and material) to locate information and resolve problems/ issues
Students passively construct information provided by teacher and textbook	Students are actively involved in seeking information to use
Learning is contained in a classroom for a series of periods over the school year	Teaching going behind the classroom that was provided as the education structure
Focuses on information proclaimed important for students to master	Focuses upon personal impact, making use of student creativity
Views science content as the information included and explained in textbooks and teacher lectures	Views science content not as something that merely exists for student mastery simply because it is recorded in print
Pays no attention to career awareness other than an occasional reference to a scientist (most of whom are dead) and his/her discoveries	Focuses on career awareness, especially careers that relate to science and technology that students might pursue, emphasizing careers in areas other than medicine, engineering, and scientific research
Students concentrate on problems provided by teachers and textbooks	Students become aware of their citizenship roles as they attempt to resolve issues/ problems that they identified
Science learning occurs only in the classroom as a part of the school curriculum	Students see the role of science in a given institution and in a specific community
Science class focuses on what has been previously known	Science class focuses on what the future might be like
There is little concern for the use of information beyond the classroom and performance on tests	Students are encouraged to enjoy and to experience science

(Composites from Yager's publications over a decade: 1991, 1992, 1993, 2000)

In middle schools, most of the curriculum should exhibit the features used to describe STS. In many middle schools, this kind of teaching coincides with the school philosophy. For example, in Iowa where the NSTA Scope, Sequence, and Coordination (SS&C) project existed as one of the six National Centers for SS&G (supported with over $10 million dollars by the National Science Foundation and various industries), STS was the focus for the 20 participating middle schools. In many instances a given grade level (often seventh or eighth) would choose a local problem and consider it in terms of causes, correctives, and study focus. Such topics include examples such as care and use of a city park, waste management, overuse of insecticides, ozone depletion, fast food consumption, and pedestrian crossings. All teachers and students as well as parents and community leaders become involved. The STS approach characterizes middle school philosophy and student-centered instruction. Science and social problems often become central for real learning in a local situation—where learning is seen as relevant to students and where they respond to social issues that are personally relevant, current, and locally based.

Developing a Research Protocol: One STS Story in One Middle School

The NSTA Searches for Excellence (Yager, 1993) introduced two teachers in a midwestern middle school to STS. The teachers were both involved in searches for exemplars with respect to inquiry. Moreover, both were active professionally and had volunteered for action research projects. Conversations with the authors resulted in an action research effort that involved one section of middle school students for a yearlong study where the STS approach was used. Another section (taught by the second teacher) remained tied to the textbook and the stated science curriculum for the school. The fact that the two teachers were different introduced an uncontrolled variable—but both teachers wanted ownership and neither felt that the added data collection could be accomplished in all sections and with equal numbers experiencing science as STS and/or as a textbook dominated experience involving both teachers with an STS and a textbook section.

The two teachers typically worked closely together and prepared laboratory set-ups, established grading policies, constructed quizzes and unit evaluations (often three per grading period) as well as nine week and semester examinations. Both were committed to the district curriculum—in fact, both were leaders in its development. However, both began to question their standard approaches to teaching science; they were concerned with declining interest on the part of students and the failure to note any indicators that the major goals for science in the National Science Education Standards were being met—while remaining closely and rigidly tied to the course structure. Both were willing to change—but also took seriously the idea of action research and the importance of having evidence for success in a climate of calls nationally for "research-based studies" on which decisions about learning, grading, and teaching changes should be made.

One of the teachers (the one with 21 years of teaching experience) was more interested and involved with local/community issues (even though these were seldom part of her science teaching). Nevertheless, she and her students became concerned with the proposed site for a new sanitary landfill in their town. Initially, this teacher was going to depart from the textbook for one of her class sections for a 3–4 week unit. However, the extent of the problem and the interest of her students resulted in its continued focus on the local project for the better part of a year.

The two teachers kept in close communication regarding their teaching. The teacher not involved with the local issue chose one class, a morning section, which corresponded well to the experimental section in terms of time of day, gender balance of students, socioeconomic status, grade-point range, and class performance means. With the help of the school records neither the teachers, the counseling staff, nor the researchers found any statistically significant differences with respect to socioeconomic levels, diversity, gender, grade averages, interest in science, or scores on standard examinations among the students enrolled in the two class sections comprising the STS and traditional sections. Data from the two sections were collected over one full semester with students in both sections completing the same examinations and providing other types of evaluation data.

Although some data from the two teachers had been collected and used as improvements were sought over a two-year period, the teachers were pleased to be partners in a more carefully planned action research study, each with one of their science sections for one semester with specific data collected from students and parents in the two sections.

Research Questions

The teachers, principal, director of counseling, and the university science education research team agreed that the action research project would focus on the following research questions:

(1) How do middle school students who study science with a textbook dominated approach compare with students who have experienced science with an STS teaching approach in terms of specific mastery of concepts included in the textbook as well as measured by the semester exams of general science achievement?

(2) How do middle school students who study science with a traditional textbook approach compare with students who have experienced science in an STS approach in terms of other important domains of science education, including student ability to apply science concepts in new situations, development of more positive attitudes toward science, and the exhibition of specific creativity skills?
(3) How do the middle school classrooms vary in terms of teaching strategies exhibited and practiced in STS and textbook sections?
(4) What do parents and other community members report about student use of their science learning outside the class? How do these differ for students experiencing the textbook approach when compared with those who experience science with an STS approach?

Methods for Considering the Research Questions

Research Question 1 was approached by identifying basic concepts from the chapters in the textbook. Generally, short quizzes that focused on major constructs from the science curriculum (textbook) were administered almost weekly. Ten such quizzes from a previous year were administered as pre-tests—and again at the end of the semester—and were used as a measure of concept mastery. General achievement was measured by analyzing scores on a semester exam that was given initially to all grade level students as a pre-test and as a post-test at the end of the semester. No attempt was made to classify the items and/or to be concerned with validity, reliability, or the other concerns typically considered for research instruments. The semester examination was one used in previous years and hence was ready to use as a pre-test and again five months later as a post-test to provide an indication of general science achievement.

Research Question 2 focused on application of concepts to new situations, development of positive attitudes, and exhibition of creativity skills. Applications of concepts to new situations were encouraged and collected routinely. Often both teachers reviewed the “big idea” that emerged and requested students to keep records of how these ideas could be used in new contexts. This was easier to justify in the STS section because the students often followed up on activities and designed new ones that were unrelated to the textbook outline. Almost weekly students were asked to respond to teacher inquiries about such use of ideas and skills beyond the activities and ideas considered in class—frequently without applicability beyond the classroom and a given testing period.

Attitude was checked periodically in connection with each module/unit/chapter that resulted in a major examination. The attitude questions were developed from items of the Third Assessment of Science by the National Assessment of Educational Programs (NAEP, 1977). The attitude questions included a listing of favorite classes and the degree students were positive about science courses, teachers, and careers. Torrance (1963) described creativity in his seminal work in this area. The act of questioning is considered a mark of a creative person. Further, questions are considered basic (first step) of science itself. Creativity is also required in proposing possible answers to questions. A third level of creativity is involved with devising tests for the validity of the explanations offered. Again, these all exemplify science itself! Students were confronted routinely with discrepant events about which they were asked to generate questions, explanations, and possible tests for determining the validity of the explanations. In all these instances, the questions, explanations, and tests were analyzed with an indication of the uniqueness of each. This was accepted by noting the frequency of the complex thinking that made the question, explanation, and test viable. It was important to analyze the rationale provided by students to be sure students were thinking as opposed to doing what teachers wanted. Four research assistants were used to collect information concerning the aspects of creativity that could be observed. Information from all students in both sections was combined so that the research assistants were unaware of which section the students experienced.

Questions arose concerning the use of specific teaching strategies that STS purports to require. These strategies were likened to the strategies that Brooks and Brooks (1999) used to define constructivist teaching. Burry-Stock (1995) validated an instrument, *Expert Science Teacher Educational Evaluation Model (ESTEEM)*, which the teachers selected as a means of noting the degree of constructivist approaches in actual use in discussions as well as in laboratory situations.

The teachers agreed to videotape class sessions frequently, ask science education research assistants to be partners in the action research, and provide professional interpretation of the 18 constructivist features comprising the ESTEEM instrument. The teachers selected one discussion period and one laboratory period for each unit/module/chapter for videotaping. For this study four sets of videos were collected at the midpoint for each 3–4 week unit (two in a discussion format and two in a laboratory format) as a way of noting general differences in use of constructivist (and STS) practices by the two teachers in the two instructional situations.

To respond to Research Question 4, help was requested and obtained by administrators and counselors in surveying parents and other staff in the school concerning relative impact and use of science outside the classroom. Surveys were conducted at the end of each nine-week grading period and included all science sections and teachers. For this study, only the parents of students in the two sections are reported for analyzing differences among students in the STS and the textbook sections. Much information was gained from surveys, collected during teacher/parent conferences, PTA meetings, and other meetings concerning school programs.

Following is a list of basic questions directed at parents and community leaders:

Parents:

(1) Is there any evidence that your child enjoys science?
(2) Does he/she use any of the concepts and/or skills in taking actions at home?
(3) What kind of evidence does your child provide concerning the impact of science studied this year in school?

Community:

(1) Do you have any indication of impact and use of school science among middle school students from our local school?
(2) Have there been any community improvement projects about which youth in our local school have contacted you?
(3) Are you aware of any school or local news reports about success with science study in our local school? How do you assess the impact of such extensions of learning outside the classroom and the school?

Findings Pertaining to the Research Questions

Table 1 indicates the changes in student achievement between pre-tests and post-tests on a sampling of quizzes and unit examinations at the end of the nine-week grading period. A semester examination for general achievement was given as a pre-test during the opening week of school in the fall; the post-test was the semester exam given to all students in both the STS and Textbook sections. A significant difference was found between pre- and post-test scores for student concept mastery (t (25) = 42.46, $p < 0.01$) and pre- and post-test for general achievement (t (25) = 39.47, $p < 0.01$) in the STS section. A significant difference was also found between pre- and post-test scores for student concept mastery (t (25) = 31.68, $p < 0.01$), and general achievement scores (t (25) = 26.96, $p < 0.01$) in the Textbook section.

Table 1
Comparisons of Pre- and Post-tests in STS and Textbook Class Sections in Terms of Student Concept Mastery and General Achievement.

Variable	Pre-test		Post-test		T	p
	Mean	(S.D.)	Mean	(S.D.)		
STS approach						
Basic concepts	9.15	(1.0)	17.12	(1.0)	42.36	.000**
General achievement	17.38	(2.5)	31.58	(3.0)	39.47	.000**
Textbook approach						
Basic concepts	8.85	(1.2)	16.96	(1.3)	31.68	.000**
General achievement	17.54	(2.6)	33.08	(4.3)	26.93	.000**

** indicate significance at $p < .01$ level

Table 2 indicates the pre- and post-test results for student application of new concepts and the pre-post changes in student attitudes concerning their science study. There are significant changes for both concept mastery and attitude for STS students. A significant difference was found between pre- and post-test scores for application of new concepts (t (25) = 15.20, $p < 0.01$) and pre- and post-tests for attitude toward science (t (25) = 6.91, $p < 0.01$) in the STS section. A significant difference was also found between pre- and posttest scores for application of new concepts (t (25) = 14.29, $p < 0.01$), and attitude toward science (t (25) = 7.5, $p < 0.01$) in the Textbook section. Interestingly, however, the attitude change for the Textbook students was that it became more negative. The results indicate the advantage of the STS approach over the Textbook approach in terms of the development of more positive attitudes toward science and science study. Students in the STS section were significantly better in terms of developing attitudes that were more positive.

Table 2
Comparisons of Pre- and Post-tests in STS and Textbook Class Sections in Terms of Applications of Concepts and Development of Positive Attitudes toward Science

Variable	Pre-test		Post-test		T	p
	Mean	(S.D.)	Mean	(S.D.)		
STS approach						
Applications of Concepts Considered	11.04	(1.5)	18.38	(1.6)	15.20	.000**
Attitutude toward science	7.65	(1.0)	8.88	(0.8)	6.91	.000**
Textbook approach						
Applications of Concepts Considered	10.35	(1.8)	16.54	(1.7)	14.29	.000**
Attitude toward science	8.15	(1.0)	7.00	(0.9)	7.50	.000**†

** indicate significance at $p < .01$ level
† indicates a decrease in mean score

Table 3 provides information gained from students in Textbook and STS sections regarding student suggestions for use of the concepts studied in new settings. Four major areas of the course structure were used, namely force, motion, structures, and design. The number of uses suggested by students in the STS section was greater than it was for students in the Textbook section. Further, the uses that research assistants selected as unique were far greater for students in the STS section as well. Research assistants scored all evaluations without knowledge of which particular students experienced the approach. The students in the STS section were more successful in providing ideas for use of concepts in new contexts and many more offered unique ideas.

Table 3
Student Generated Uses of Basic Concepts in New Situations for Students Enrolled in STS and Textbook Sections

	STS Approach		Textbook Approach	
	Total Number of Uses	Number of Unique/ Complex Uses	Total Number of Uses	Number of Unique/ Complex Uses
Force	23	6	6	1
Motion	27	9	5	1
Structures	21	8	1	0
Design	33	11	0	0

Table 4 provides information regarding comparison of creativity skills, exhibited by STS and concept mastery students at the end of each nine-week grading period. It is apparent that the STS students asked more questions, offered more explanations, and proposed more tests for the validation of the explanations than did students in the Textbook section. Further, more STS students asked questions, offered explanations, and suggested ways of testing for the validity of the explanations than did students in the Textbook section.

Table 4
Creativity Skills Exhibited by the Students in STS and Textbook Section

Creativity Skill Measure	STS Approach		Textbook Approach	
	Instances*	Students**	Instances*	Students**
Questions raised per class period	31	19	11	8
Unique questions raised per class period	11	8	2	2
Explanations	23	18	3	3
Unique explanations	9	7	1	1
Tests for validity of explanations	10	8	0	0
Unique tests of validity of explanations	3	3	0	0

* number equals total provided during class period
** number equals number of students offering them

Table 5 provides information about the 18 features of constructivist teaching identified by the ESTEEM rubric (Burry-Stock, 1995). It is apparent that students in the STS section provided more evidence that constructivist practices were in use. There were differences observed by a team of research assistants who were asked to evaluate the practices as evidence that the teaching approaches used by the two teachers were different.

Table 5
Comparisons between STS and Textbook Teachers in Terms of Constructivist Teaching Practices Using the ESTEEM Rubric

	STS Approach			Textbook Approach		
Constructivist Trait	Discussion Average	Lab	Average of Both	Discussion Average	Lab	Average of Both
Category I: Facilitating the Learning Process from a Constructivist Perspective						
A. Teacher as a Facilitator	4.50	4.00	4.25	2.50	2.00	2.25
B. Student Engagement in Activities	5.00	5.00	5.00	2.00	1.00	1.50
C. Student Engagement in Experiences	4.00	4.00	4.00	3.50	3.00	3.25
D. Novelty	4.00	4.00	4.00	2.50	2.00	2.25
E. Textbook Dependency	5.00	5.00	5.00	2.00	2.00	2.00
Category II: Pedagogy Related to Student Understanding						
F. Student Conceptual Understanding	4.00	4.00	4.00	3.00	2.00	2.50
G. Student Relevance	5.00	5.00	5.00	2.50	1.00	1.75
H. Variation of Teaching Methods	3.50	3.00	3.25	2.00	2.00	2.00
I. Higher Order Thinking Skills	4.00	4.00	4.00	2.00	2.00	2.00
J. Integration of Content & Process Skills	4.50	5.00	4.75	2.50	1.00	1.75
K. Connection of Concepts & Evidence	5.00	4.00	4.50	1.50	2.00	1.75
Category III: Adjustments in Strategies Based on Interactions with Students						
L. Resolution of Misperceptions	4.50	4.00	4.33	2.50	2.00	2.25
M. Teacher-Student Relationship	5.00	5.00	5.00	3.50	3.00	3.25
N. Modification of Teaching Strategies to Facilitate Student-Understanding	3.50	4.00	3.75	2.00	1.00	1.50
Category IV: Teacher Knowledge of Subject Matter						
O. Use of Exemplars	4.00	3.00	3.50	2.00	2.00	2.00
P. Coherent Lesson	3.50	4.00	3.75	2.00	1.00	1.50
Q. Balance Between Depth &Comprehensiveness	3.50	4.00	3.75	2.50	3.00	2.75
R. Accurate Content	4.00	5.00	4.50	3.00	2.00	2.50

Table 6 indicates a review of videotaped classes for both discussion and laboratory sessions for each teacher. The scale ranging from 1 to 5 was used, with a score of 5 given to greatest number of constructivist practices used. The data indicate that the teacher in the STS section was more constructivist in her approach to teaching
Table 6 indicates a review of videotaped classes for both discussion and laboratory sessions for each teacher. The scale ranging from 1 to 5 was used, with a score of 5 given to greatest number of constructivist practices used. The data indicate that the teacher in the STS section was more constructivist in her approach to teaching.

Table 6
Mean Scores of STS and Textbook Teachers in Terms of Constructivist Teaching Practice

	STS Approach			Textbook Approach		
Constructivist Trait	Discussion	Lab	Average of Both	Discussion	Lab	Average of Both
Facilitating the Learning Process from a Constructivist Perspective	4.50	4.40	4.45	2.50	2.00	2.25
Pedagogy Related to Student Understanding	4.33	4.11	4.22	2.25	1.67	1.96
Adjustments in Strategies Based on Interactions with Students	4.33	4.33	4.33	2.67	2.00	2.34
Teacher Knowledge of Subject Matter	3.75	4.00	3.87	2.37	2.00	2.19
Total	4.23	4.21	4.22	2.44	1.92	2.18

Table 7 provides a summary of the data to respond to Research Question 4. The data arose from surveying parents, other teachers who taught students in the two sections, administrators and counselors, PTA members, and other community leaders. More STS students were identified as providing evidence of the impact of science studies in the following situations:

- Additional activities carried out outside the classroom
- Contacts with experts outside the school for information
- Conversations at home concerning experiences in science classes
- Actions taken in the community at large
- Writing editorials for school and community news
- Working with community organizations
- Participating in public debate.

Table 7
Relative Impact of Science Learning Outside the Class for the Students in STS and Textbook Sections

Learning/Using Science Outside the Class*	STS Approach		Textbook Approach	
	Number of instances	Number of students	Number of instances	Number of students
Science-related activities carried on outside of the classroom	38	21	10	10
Contacts with experts for information	31	22	5	5
Talking about science at home	43	20	10	6
Taking actions in community				
Editorials in local newspapers	13	10	0	0
Appearances at government boards	16	12	1	1
Instances of work in community organizations	17	20	3	2
Times participated in public debates	9	9	2	1

***** Each figure is based on activities during a nine-week span of time as reported to school counselors who distributed surveys to parents and local youth organizations and community leaders.

Discussion

The results from this action research study undertaken by two teachers indicate that students can learn as much about science concepts—while involved with a seemingly unrelated local issue as the course organizer—as do students who focus almost completely on concept mastery and use of typical laboratory activities suggested in a textbook. It should be kept in mind, however, that the STS teacher helped prepare the concept quizzes and exams and tried to prepare her students for success. She strove to relate the ideas and concepts to direct the experiences students had while being detectives at work on the community landfill controversy. After one full semester with non-textbook science for the STS section, the general science achievement of students was not significantly different between those enrolled in the two sections as measured by a semester examination prepared by the two teachers. More important, in the case of the application of concepts, students in the STS section were significantly more adept than were students in the Textbook section. Apparently, the STS approach provides more experiences with the application of concepts as a part of the regular classroom experiences and with the extension of science study and involvement with activities beyond the classroom and the textbook.

Students in the STS section were able to suggest and describe uses of concepts in new contexts. They were also more successful in proposing uses that were judged to be more unusual and more complex. Students in the Textbook section were unsuccessful in suggesting uses for the ideas and skills characterizing their school science experiences.

Another advantage of the issue-oriented STS approach was the significantly more positive student attitudes concerning science. The usual decrease in attitude following school study of science as reported in several studies (Hueftle, Rakow, & Welch, 1983; National Assessment of Educational Progress, 1977; Yager, 1996) did not occur when students were involved with issues, which characterize the STS approach. In fact, the attitudes were significantly more positive than they were initially. Perhaps too few have assumed that school science can result in increasing positive attitudes among students about science. The STS approach seems to offer exciting possibilities for middle schools and teachers interested in the affective domain and the development of more positive attitudes about science. Similar results have been reported by Yager and Tamir (1995) and Yager and Weld (1999).

Students in the issue-oriented section asked more questions, followed up on them, and contributed more unique questions than did students in the standard textbook section. Because these are viewed as features of student creativity, it is argued that the changes in frequency of student questions and the quality of their questions represent other major advantages of the STS approach when the students in the two class sections are compared. Certainly proposing explanations for their own questions and suggesting ways to test their validity illustrate knowledge of the nature of science for students in the STS section.

The observations that STS students in this study exhibited more qualities of good citizenship, that they extended science beyond the classroom and school, and that they were more involved with their studies and continued learning—all provide evidence of the merits of the STS approach in middle schools—at least as evidenced by this one small study. There is evidence that students who study in the STS format are able to meet the four goals for science education as advanced in the National Science Education Standards (NSES). The goals indicate that all students should:

- Experience the richness and excitement of knowing about and understanding the natural world
- Use appropriate scientific processes and principles in making personal decisions
- Engage intelligently in public discourse and debate about matters of scientific and technological concerns
- Increase their economic productivity through the use of the knowledge, understanding, and skills of the scientifically literate person in their careers (NRC, 1996, p. 13).

Students in the STS section provided many examples illustrating that these NSES goals were being met. There was no information provided by students in the Textbook section concerning the use of the four goals; nor was there any evidence that instruction provided evidence of actual attainment.

The results and the statistical analyses permit some generalizations—at least as they pertain to this one situation. Although both teachers had similar backgrounds and had worked together in planning and teaching middle school science, there is still no assurance that it was the skill of the teacher in using the STS approach, which resulted in the differences on the several measures. Further, each teacher practiced her unique teaching style, enthusiasm, and philosophy. It can be assumed that teacher actions and practices are important in determining real learning in both the STS and textbook sections. Perhaps it will take more evidence and more experiences to convince even more teachers and schools concerning the advantages of the STS approach and constructivist teaching. More studies are needed to indicate more convincingly that a real life local context can assist in gaining mind engagement and more involvement among students. It is important to note the features used to characterize the so-called STS approach and effective constructivist practices as well as the changes in teaching advocated by the National Science Education Standards. It certainly will take more evidence before STS will be the megatrend that Roy (1985) saw STS to be for the new millennium.

In this study, STS has been found to assist in student learning of science in four of the six domains as identified by McCormack and Yager (1989) and Yager (1996). The STS approach resulted in significant concept mastery but not more than what was achieved with more traditional methods in a textbook dominated classroom. However, applications, creativity, and more positive attitudes are three domains in which the students studying science with an STS approach displayed significant gains over students experiencing more traditional textbook dominated teaching. No information was collected in this study for the process and worldview domains per se. However, Wilson and Livingston (1996) and Kellerman & Liu (1996) have reported previously significant advantages in these two domains for students studying in STS classrooms.

Interpreting the results of this study suggest caution since only two teachers from one school were involved. Further, the effects of the specific teaching strategies varied and may contribute to some of the results. Perhaps it is important to define even more precisely the different teaching that typically differentiates STS and textbook dominated classrooms. Nonetheless, these strategies are those listed in the National Science Education Standards; they also parallel the NSTA listing defining the STS approach. Other cautions in interpreting the results of the study are the tests in which the assessments in the concept domain were determined. They were all teacher prepared and/or those suggested in the textbook. Many of them simply required duplication of skills taught or remembering definitions and explanations. In many ways they were typical tests that followed closely what the textbook (and the teacher involved) suggested. The general achievement examination was a teacher-prepared semester test. No validity and reliability indicators were available. Certainly, it is important not to generalize too much from this one study involving but two middle school teachers in one school district.

Implications: Use of the Findings

Although this is a report of results with significant use of an STS approach to teaching in one Midwestern school district involving two science teachers, there are wider implications for other middle schools and teachers beyond only science. There is evidence that the NSTA SS&C project which for a two-year period focused only on science in grades 5 through 8 (the middle years defined by the National Science Standards) influenced the entire curriculum. Using social issues as course (or school) organizers invites the problems identified to include a social science perspective, to illustrate the need for mathematics, to focus on careers and practical courses, and to improve many communication skills, including reading, speaking, reporting, and writing. STS and its focus on schools, communities, and regional problems make the learning more personally relevant. Students deal with real problems and focus on current concerns. In many respects, the STS philosophy and teaching approach provide vehicles for accomplishing what middle schools identify as their niche in the total schooling spectrum (NSTA, 2006). Young adolescents learn much more than what typical test scores measure. Parents, teachers, school administrators, and community leaders are all directly involved with the education of the students. Above all else, students help determine problems, questions, suggestions for problem resolution. They enter into debates about the evidence collected to support the validity of the proposed solutions and take actions to resolve the problems. The research results reported were attained from the work of the two teachers involved with this study; they exemplify what an STS approach can generally yield in middle schools.

NSTA has launched an effort to prepare Exemplary Program (ESP) monographs (Yager, 2006), which reported on specific attempts to implement the national standards. They provided further examples of successes across the U.S. in meeting the visions of the National Science Education Standards. The ESP monographs, especially the one concerning science in grades 5 through 8, provide further reason to support the changes that the two teachers involved with this study have stimulated (Yager, 2006). Yager's earlier work provided the information to make the study possible while now validating the earlier research.

Summary and Conclusions

The results of this study provide encouragement for those who want to depart from standard use of science textbooks and course outlines in middle schools. There is evidence that concept mastery is not lost when students explore and act on their own as part of class projects. Most important, STS students can apply the science concepts that they seem to know in new situations. This is impressive evidence that STS students really know; they can use the information and skills on their own in new situations. The development of more positive attitudes suggests that benefits in the affective domain may result which in turn provide strong arguments about the desirability of organizing lessons around ideas and procedures other than basic science concepts and processes, especially in middle schools. The results suggest that teacher experimentation and student involvement with real-world experiences/problems should be encouraged even more. Such efforts promise to add excitement, new trials, new information, and greater mind engagement among students as more seek to improve science education for the middle years for all students.

These efforts also provide examples of the kind of teaching and assessments that characterize the visions central to the National Science Education Standards (NRC, 1996) and more nearly match the goals for science that these standards provide. They also include the collaborative features common to the most successful middle school programs. They de-emphasize going over basic concepts of science and work in laboratories where the focus is on following directions and getting results that verify what the book and teacher said would happen. They also illustrate the advantages of casting the use of science information in ways that question their actions and their attempts to answer the research questions initially outlined.

Students in the STS section of middle school science were notably more successful in:

- Generating ideas for use of science concepts in new situations
- Using creativity skills, including questioning, proposing possible explanations
- Devising tests for the validity of the explanations generated
- Using community resources
- Conversing about science at home
- Taking actions in the community as a result of science study.

The results of this study provide a view of possible advantages of exemplary programs in middle schools. The use of the STS approach can provide a vehicle for involving teachers across the middle school curriculum in projects and special efforts that help students see the relevance of their studying across the curriculum, the school day, the school year. Other research has indicated that whole faculties can change more readily than when one exemplary teacher acts alone (Yager & Weld, 1999).

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