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Students Learning to Use the Skills Used by Practicing Scientists

Hakan Akcay
Yildiz Technical University, TURKEY
Robert E. Yager
University of Iowa, USA

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The purpose of the study was to examine the effectiveness of a Science Technology and Society (STS) approach in terms of student understanding of major processes of science. Participants included twelve teachers who agreed to participate in an experimental study where Science, Technology, and Society (STS) strategies were utilized with one class section and in a school class where the teacher determined the course structure and the form of instruction (textbook-oriented) that is typically used by most science teachers. A total of twenty-four sections of students were in STS sections (199 students) and a similar number in textbook-oriented sections (204 students). The data collected were analyzed using quantitative methods. The results indicate that students in the STS sections achieved significantly better than students in the textbook-oriented sections in terms of understanding and using science process skills. Differences in success by male and female students of varying ability levels were examined as well.

Keywords: science process skills, science technology and society (sts), science teaching and learning, professional development

INTRODUCTION

Scientific literacy is an essential skill that enables people to understand and make decisions based on the analysis of information (Bybee, 1993; NRC, 1996). The National Science Education Standards have emphasized a goal that students should achieve scientific literacy, which is defined as the knowledge and understanding of science concepts that are needed in daily living. The National Science Teacher Association has declared that a scientifically literate person is one who can ask or determine answers to questions derived from their own curiosity about everyday life experiences (NRC, 1996). Rutherford and Ahlgren, authors of Science for Americans, state that " the world has changed in such ways that scientific literacy has become necessary for everyone, not just a privileged few; science education will have to change to make that possible" (AAAS, 1993, p. 11)

Scientific literacy enables people to not only use scientific principles and processes in making personal decisions but also participating in discussions of scientific issues that affect society. Scientific literacy increases many skills that

Correspondence: Hakan Akcay,
Department of Science Education, College of Education, Yildiz Technical University, A-212, 34210, Istanbul, Turkey.
E-mail: hakcay@yildiz.edu.tr
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people also commonly use in everyday life, like being able to solve problems creatively, thinking critically, working cooperatively in teams, and using technology effectively. Understanding scientific knowledge and processes contribute in essential ways to further develop these skills. The economic productivity of society is related to the scientific and technological skills of its people. However, achieving scientific literacy takes time, because the National Science Education Standards call for dramatic changes in what students are taught, in how student performances are assessed, in how teachers are educated and stay current, and the complex relationships that exist between school and community (NRC, 1996). Dealing with the relationships among science, technology, and society is essential for achieving basic science literacy. Students in the next generation need to be able to analyze evidence, to understand the relevance of science-based issues to their everyday lives, and to understand that scientific endeavors are governed by social values (Depettencourt, 2000; NRC, 1996).

The investigative processes require hands-on/minds-on activities, laboratory inquiries, and real investigations which provide the most powerful approaches for helping students understand scientific concepts. These processes are often designated as inquiry skills, and embodied in such terms as "exploring and investigating". Students with experiences with hands-on activities can reliably note their own progress with laboratory activities (Luft, 2001; Shavelson, Baxter & Pine, 1992). More importantly, these inquiry skills are also necessary for dealing with everyday life and in developing an understanding of the natural world (Aikenhead, 1979). Thus, it is perhaps most important that these skills be set in situations in which the students can relate them to their personal experiences so that such inquiry skills are seen as "connected" rather than separate entities. The use of process skills in a variety of contexts is important for developing an understanding of the nature of science (Enger & Yager, 2009).

Scientists use specific process skills! Being familiar with these processes concerning how scientists think and work is an important part of learning science in schools (Chairam, Klahan, & Coll, 2015; Chabalengula, Mumba & Mbewe, 2012 ; Yager & Akcay, 2007). The concept and process domains were identified by AAAS in the development of its elementary school program in the late 60s and called Science: A Process Approach (SAPA, 1965). The thirteen processes identified by AAAS represent a generally accepted set of processes which scientists use as they accomplish their work. These "processes" of science include observing, using space/time relationships, classifying, grouping and organizing, using numbers and quantifying, measuring, communicating, inferring, predicting, controlling and identifying variables, interpreting data, formulating hypotheses, defining operationally and experimenting (Enger & Yager, 2009; Ozgelen, 2012).

State of the literature

- One of the component of science education is to prepare students for a scientific and technological world where students will need to learn and apply their scientific knowledge to solve real-world problems and issues.
- Science process skills are the basis for scientific inquiry which provides the most effective approaches for helping students to understand science concepts.
- Science process skills help students to understand how scientists work and think that is an important part of learning science.

Contribution of this paper to the literature

- Science process skills allows students to learn science by doing science and construct their understanding of science with working and using their ideas
- The study indicate that Science-Technology-Society (STS) approach significantly better than textbook-oriented approach concerning understanding and using science process skills
- Science-Technology-Society (STS) approach creates a classroom environment in which students can find answer to problems by using science process skills in which students learn such skills as observing, asking questions, collecting and analyzing data or information, experimenting, and communicate their ideas to others.

The process skills can be targets for instruction themselves, but the identification of separate and distinct processes does not mean that they always occur in definable and/or in identifiable ways. Scientists and students may use several of the science process skills in concert, and these skills may be employed during scientific investigations in ways not expected or predicted by anyone observing the investigative process.

The idea that observation is theory-laden may not have been overtly discussed or considered by students. "Observation is theory-laden" means that what a person can see depends on what he or she believes (Abimbola, 1983). Personal viewpoints and creativity play roles in any investigation. This can be the way students can start as beginning points for investigations. They should often be based on student ideas and questions. Such ideas come from students' prior scientific knowledge, deduction, or even personal guesses, and creativity. In the hypothetico-deductive model, a hypothesis always precedes any investigation, and a conclusion of an investigation results from the confirmation of any hypothesis in mind, not from the data collected from only first hand observations (Popper, 1991). Accordingly, doing science for students in a laboratory investigation should provide a test of student ideas, not just a way to determine the "right" answers. This also sends a message to teachers to consider moving beyond only confirmation-type laboratory work.

Science teachers do need to play a role as the advocate of current "public concepts" (the current accepted scientific thought) to challenge student "private thought" (Matthews, 1994), or to "persuade" them (Kuhn, 1962) or convince a student to appreciate the current, prevalent interpretation/explanation of natural phenomena. Group discussion for an investigation may produce the same persuading effect (Johnson & Johnson, 1983). Students who understand the role of process skills in scientific investigations may more often see science as a career that is fun and creative. These processes and skills are embedded in the knowing, doing, and thinking in science (Enger & Yager, 2009, p. 5).

The science, technology, and society approach

The National Science Teachers Association (NSTA) has defined Science-Technology-Society (STS) as the teaching and learning science and technology in the context of human experiences (NSTA, 1990; Vazquez-Alonso, Garcia-Carmona, Manassero-Mas, & Bennassar-Roig, 2014)). The purpose of the STS approach is to engage students in problem solving activities that they have identified. STS programs begin with real world issues and concerns. Students focus on problems and questions that relate to their personal lives. STS provides an important direction for achieving scientific and technological literacy for all. The emphasis is on responsible decision-making in the real world of the student where science and technology are components. The specific features of an STS classroom are characterized as places where:

- Students identify problems with local interest and impact;
- Local resources (human and material) are used to locate information that can be used in problem resolution;
- Students are actively involved with seeking information that can be applied to solve real-life problems;
- Learning extends beyond the class period--the classroom, the school;
- The focus is upon the impact of science and technology on individual students;
- Science content is viewed more than concepts which exist for students to master on tests;
- There is an emphasis upon process skills which students can use in their own problem resolution;

Table 1. Contrasts between STS programs and traditional science programs in terms of student ability to utilize science process skills

STS	Traditional
Students see science process as skills they can use	Students see processes as skills scientists possess
Students see processes as skills they need to refine and develop more fully for themselves	Students see processes as something to practice as a course requirement
Students readily see the relationship of science processes to their own actions	Teacher concerns for process are not understood by students, especially since they rarely affect the course grade
Students see process as a vital part of what they do in science class	Students see science processes as abstract, glorified, unattainable skills that are unapproachable

- There is an emphasis upon career awareness, especially careers related to science and technology;
- There are opportunities for students to experience citizenship roles as they attempt to resolve issues they have identified;
- Science and technology are seen as ways to impact the future;
- There is some autonomy in the learning process (as individual issues are identified) (NSTA 2007, p. 242).

Table 1 indicates the differences between students involved in an STS program and those in a traditional science program in terms of the process domain.

The Chautauqua Professional Development Program

The Chautauqua Program was supported by a National Science Foundation (NSF) grant to the National Science Teachers Association (NSTA) in 1983. It was developed to study a teacher education model for stimulating reforms in science classrooms. The program began in Iowa with 30 teachers enrolled in a program in one center and grew to include to 230 teachers enrolled in five centers across the state during the 1980-90 years. Over 4,000 teachers were enrolled during last three decades.

The Chautauqua program is a professional development project designed to help science teachers develop their own learning processes through inquiry teaching and learning (Dass & Yager, 1997). The program was designed for in-service science teachers in grades K-12. However, the participants in this study were working together in cooperative learning groups to perform hands-on science inquiry activities that arose from participants' questions, curiosities, and experiences. The program emphasizes learning science content through use of inquiry activities that are student-centered (actually proposed, planned, and carried out by students). Moreover, it focuses on a model for inquiry-based science instruction with teachers also inquiring into their own teaching. The primary goal of the workshop is to increase the skills of in-service science teachers of science by indicating needed systemic changes in science instruction in the classrooms of all participating teachers. Teachers need to collaborate with each other as well as with school administrators, parents, and community leaders. The program can be described with specific features that include:

1. A two-week leadership conference for same of the most successful teachers from previous years who want to become a part of the instructional team for future workshops
2. A four week summer workshop at each new site for 30 new teachers electing to try inquiry teaching and new learning strategies; the workshop provides experience with inquiry (teachers as students) and time to plan a five-day inquiry unit to be used as a pilot with students in the fall
3. A three day fall short course for 30-50 teachers (including the 30 enrolled during the summer); the focus is upon developing a month long inquiry module and an extensive assessment plan

4. Interim communications with central staff, lead teachers, and fellow participants, including a newsletter, special memoranda, monthly telephone contacts, and school/classroom visits
5. A three day spring short courses for the same 30-50 teachers who participated in the fall; this session focuses upon reports by participants on their inquiry experiences and the results of the assessment program over at least one full month. The emphasis is on sharing successes and failures while also planning more full inquiry courses.

The Chautauqua program identified six important domains for developing instructional goals and assessing successes in meeting them. These include;

1. Concept domain(mastering basic content constructs)
2. Process domain (learning skills scientists use as they seek answers to their questions about the natural world)
3. Application domain (using concepts and processes in new situations)
4. Creativity domain (improving quantity and quality of questions, explanations, and text for the validity of personal generated explanations)
5. Attitude domain (developing more positive feelings concerning the usefulness of science, science study, science teachers and science careers)
6. World View domain (how efforts in schools can assist students in understanding the nature of science and to practice its basic components including questioning, explaining, and testing objects and events in the natural world. It includes how science has changed over time and how scientists debate and interact with each other (Enger & Yager,2001,2009 ;Yager & Akcay, 2007, 2008).

Research questions

"Lead teachers" are experienced and successful STS teachers who become partners and members of the instructional staff for new Chautauqua Professional Development efforts which operate for a given academic year in Iowa. These "lead" teachers agree to participate in annual research efforts involving their own students. Twelve such teachers agreed to provide pretest and posttest data for this study to respond to the following questions in terms of understanding and use of science process skills.

1. Do students who experience their science in an STS format excel in terms of understanding and using science process skills over students who experience science in a more typical textbook-oriented format?
2. After experiencing science in an STS format, are there any differences in understanding and use of science process skills between male and female students?
3. After experiencing science in an STS format, do STS high ability students excel in terms of understanding and use of science process skills over textbook-oriented high ability students?
4. After experiencing science in an STS format, do STS low-ability students excel more in terms of understanding and use science process skills over textbook-oriented low ability students?

INSTRUMENTATION

The Assessment Package (Enger & Yager, 2001, 2009) was used to assess the learning achievements of the students in experimental and the contrast classrooms. In this package instruments for assessing student growth in each of six domains of science teaching are provided. Directions are given for using each instrument. Student response sheets and teacher tabulation sheets are also provided as needed. The reliability coefficients for the assessment items in each of the domains were obtained by using a test-retest method with students in classes taught by all Lead Teachers for a given year. Descriptions of the assessment criteria follow with indications of how reliability and validity were established. The range of the reliability for the process test with respect to individual assessment items is also included. The mean, standard division (SD), and t- values were calculated and used to assess differences between pre- and post-tests scores for the process domain for all students in two class sections. The 5% level of significance ($p \leq 0.05$) was used to indicate statistical differences.

Data collection procedures

Pretest and posttest for the process domain of science teaching were administered to students in both experimental and control classes. The pretests were spread over a two week interval prior to the beginning of the experiment. The posttests were conducted one semester later following the instruction. The process items were arranged as a special section of the same examination. In general, an emphasis upon assessment and student changes as evidenced by pretesting and posttesting were maintained as a normal part of science instruction.

RESULTS OF THE STUDY

Table 2 indicates comparisons of the differences for the development and use of process skills between students who experienced instruction in the STS format and those in textbook-oriented classrooms. The results indicate that the average score on the pretests is not different for the students in the two classrooms. No significant differences were found between two teaching methods on the pretest scores for process skills. However, significant differences were found between the two teaching methods on the post-test scores for the thirteen process skills that include observing, using space/time relationships, classifying, grouping and organizing, using numbers and quantifying, measuring, communicating, inferring, predicting, controlling and identifying variables, interpreting data, formulating hypotheses, defining operationally and experimenting across grade six though grade nine. Students in the STS classes also achieved significantly greater growth in terms of their ability to utilize science process skills.

Table 2. Comparisons between the STS and the textbook-oriented students for ability to utilize science process skills

		STS			Textbook-Oriented				
		n	**Mean**	**SD**	**n**	**Mean**	**SD**	**t**	**p**
Grade 6	Pre test- Process	53	3.59	1.2	55	3.42	1.2	.52	.47
	Post test- Process	53	7.34	2.1	55	3.47	1.1	145.71	.00*
Grade 7	Pre test- Process	50	4.08	1.5	50	3.82	1.4	.80	.38
	Post test- Process	50	8.30	2.4	50	3.90	1.4	123.84	.00*
Grade 8	Pre test- Process	48	4.17	1.5	48	4.17	1.6	.00	1.00
	Post test- Process	48	8.42	2.5	48	4.21	1.6	94.32	.00*
Grade 9	Pre test- Process	48	4.60	1.5	51	4.47	1.5	.19	.66
	Post test- Process	48	9.50	2.3	51	4.22	1.5	179.86	.00*

**indicate significance at p < 0.05 level*

Table 3. Comparisons between the male STS students and their textbook-oriented counterparts on the ability to utilize science process skills

		STS (Males)			Textbook-Oriented (Males)				
		n	**Mean**	**SD**	**n**	**Mean**	**SD**	**t**	**p**
Grade 6	Pre test- Process	25	3.48	1.4	29	3.14	1.1	1.03	.32
	Post test- Process	25	7.20	2.4	55	3.28	1.0	65.64	.00*
Grade 7	Pre test- Process	24	3.75	1.5	25	3.48	1.5	.39	.53
	Post test- Process	24	7.92	2.6	25	3.68	1.3	52.56	.00*
Grade 8	Pre test- Process	24	4.38	1.5	24	4.00	1.7	.66	.42
	Post test- Process	24	8.71	2.6	24	4.17	1.9	48.60	.00*
Grade 9	Pre test- Process	23	4.17	1.3	26	4.00	1.4	.20	.66
	Post test- Process	23	9.00	2.1	26	3.81	1.3	110.43	.00*

**indicate significance at p < 0.05 level*

Table 4. Comparisons between the females STS students and their textbook-oriented counterparts the ability to utilize science process skills

		STS (Females)			Textbook-Oriented (Females)				
		n	**Mean**	**SD**	**n**	**Mean**	**SD**	**t**	**p**
Grade 6	Pre test- Process	28	3.68	1.1	26	3.73	1.2	.03	.87
	Post test- Process	28	7.46	1.9	26	3.70	1.0	78.85	.00*
Grade 7	Pre test- Process	26	4.38	1.5	25	4.46	1.3	.34	.56
	Post test- Process	26	8.65	2.2	25	4.12	1.5	72.72	.00*
Grade 8	Pre test- Process	24	3.96	1.6	24	4.33	1.6	.69	.41
	Post test- Process	24	8.13	2.5	24	4.25	1.4	44.77	.00*
Grade 9	Pre test- Process	25	5.00	1.5	25	4.96	1.6	.01	.93
	Post test- Process	25	9.88	2.5	25	4.64	1.6	79.05	.00*

**indicate significance at p < 0.05 level*

Table 3 indicates comparisons of pre- and post-test average scores for male students concerning the development of process skills in STS oriented classrooms and for those in textbook-oriented classes. No significant differences were found on pretest scores for the two groups. For male students, significant differences were found between the two teaching methods on the post-test scores on all thirteen process skills. Male students in classes taught with an STS approach developed science process skills significantly better compared to students in classes taught with a textbook-oriented approach. The data also indicate that male students posttest scores regarding science process skills are two times greater for students in STS classrooms than it was for those in textbook-oriented classrooms.

Table 4 indicates comparisons of pre- and post-test average scores for female students concerning the development of science process skills in STS-oriented classes and those in textbook-oriented classes. No significant differences were found on pretest scores for the two groups. However, for female students, significant differences were found between the two teaching methods on the post-test scores for science process skills. Female students in classes taught with an STS approach developed science process skills significantly better compared to students in classes taught with a textbook-oriented approach. The data also indicate that female students posttest scores for science process skills are two times greater than they were for students in STS classrooms than they were for those in textbook-oriented classrooms.

Table 5 indicates comparisons between male and female students in classes taught with an STS approach regarding their ability to utilize science process skills. No significant differences were found between male and female students for process skills across grade six through grade nine on both pre- and post-test scores. A significant difference did exist with pretest score between male and female students in grade nine. The results indicate that the STS approach to science teaching works equally well for male and female students regarding their knowledge and use of science process skills.

Table 6 indicates comparisons between male and female students in classes taught with a textbook-oriented approach regarding their abilities to utilize the science process skills in new situations. No significant differences were found between male and female students concerning science process skills across grades six through grade eight for both pre- and post-test scores. Significant differences were found between male and female students in the textbook-oriented sections in grade nine regarding both pre- and posttest scores.

Table 5. Comparisons between male and female students taught using STS approach in terms of the science process skills

		Male			Female				
		n	**Mean**	**SD**	**n**	**Mean**	**SD**	**t**	**p**
Grade 6	Pre test- Process	25	3.48	1.4	28	3.68	1.1	.33	.58
	Post test- Process	25	7.20	2.4	28	7.46	1.9	.20	.65
Grade 7	Pre test- Process	24	3.75	1.5	26	4.39	1.5	2.31	.14
	Post test- Process	24	7.92	2.6	26	8.65	2.2	1.16	.29
Grade 8	Pre test- Process	24	4.38	1.5	24	3.96	1.6	.90	.35
	Post test- Process	24	8.71	2.6	24	8.13	2.5	.64	.43
Grade 9	Pre test- Process	23	4.17	1.3	25	5.00	1.5	4.03	.05*
	Post test- Process	23	9.00	2.1	25	9.88	2.5	1.76	.19

***indicate significance at p < 0.05 level*

Table 6. Comparisons between male and female students taught using the textbook-oriented approach for the ability to utilize science process skills

		Male			Female				
		n	**Mean**	**SD**	**n**	**Mean**	**SD**	**t**	**p**
Grade 6	Pre test- Process	29	3.14	1.1	26	3.73	1.2	3.73	.06
	Post test- Process	29	3.28	1.0	26	3.69	1.1	2.12	.15
Grade 7	Pre test- Process	25	3.48	1.5	25	4.16	1.3	2.96	.09
	Post test- Process	25	3.68	1.3	25	4.12	1.5	1.23	.27
Grade 8	Pre test- Process	24	4.00	1.7	24	4.33	1.6	.50	.48
	Post test- Process	24	4.17	1.9	24	4.25	1.4	.03	.86
Grade 9	Pre test- Process	26	4.00	1.4	25	4.96	1.6	5.38	.02*
	Post test- Process	26	3.81	1.3	25	4.64	1.6	4.09	.05*

**indicate significance at p < 0.05 level*

Table 7. Comparisons between the STS high achieving students and their textbook oriented counterparts on the ability to utilize science process skills

		STS			Textbook-Oriented				
		n	Mean	SD	n	Mean	SD	t	p
Grade 6	Pre test- Process	23	4.65	.9	22	4.46	.9	.58	.45
	Post test- Process	23	9.35	1.2	22	4.23	.9	258.30	.00*
Grade 7	Pre test- Process	22	5.63	.9	21	5.10	1.0	.86	.36
	Post test- Process	22	10.55	1.3	21	5.19	1.1	215.22	.00*
Grade 8	Pre test- Process	20	5.30	1.2	19	5.42	1.5	.08	.78
	Post test- Process	20	10.50	1.2	19	5.36	1.5	84.18	.00*
Grade 9	Pre test- Process	17	5.88	1.2	22	6.86	.9	.00	.96
	Post test- Process	17	11.35	1.7	22	5.41	1.1	181.15	.00*

**indicate significance at p < 0.05 level*

Table 8. Comparisons between the STS low achieving students and their textbook-oriented counterparts on the ability to utilize science process skills

		STS			Textbook-Oriented				
		n	Mean	SD	n	Mean	SD	t	p
Grade 6	Pre test- Process	30	2.77	.8	33	2.73	.8	.04	.84
	Post test- Process	30	5.80	1.1	33	2.97	.9	128.47	.00*
Grade 7	Pre test- Process	28	3.07	1.0	29	2.90	.9	.49	.48
	Post test- Process	28	6.54	1.4	29	2.97	.7	151.48	.00*
Grade 8	Pre test- Process	28	3.36	1.2	29	3.35	1.1	.002	.97
	Post test- Process	28	6.93	1.7	29	3.48	1.3	76.82	.00*
Grade 9	Pre test- Process	31	3.90	1.1	29	3.41	1.0	3.48	.07
	Post test- Process	31	8.42	1.9	29	3.31	1.1	153.52	.00*

**indicate significance at p < 0.05 level*

High achieving students were defined as students who earned grades of either A or B in their coursework in both classes. Table 7 indicates comparisons of pre- and post-test average scores for high achieving students concerning the development of science process skills in STS-oriented classes and those in the textbook-oriented classes. No significant differences were found on pretest scores for the two groups. But, significant differences were found between the two teaching methods on the post-test scores for science process skills across grade six through grade nine. High achieving students in classes taught with an STS approach developed science process skills significantly better compared to students in classes taught with a textbook-oriented approach.

Average scores for low achieving students who earned less than a "B" grade in their coursework were also compared in this study. Table 8 indicates comparisons of pre- and post-test average scores for low achieving students concerning the development of science process skills in STS oriented-classes and textbook-oriented classes. No significant differences were found on pretest scores for the two groups. Significant differences were found between the two teaching methods on the post-test scores for science process skills across grades six through grade nine. Low ability students in classes taught with an STS approach were also able to develop more science process skills when compared to students in classes taught with a textbook-oriented approach.

DISCUSSION AND IMPLICATIONS

Science process skills were taught successfully as content and curriculum organizors in the K-8 grades with Science—A Process Approach (AAAS, 1965) proved to be successful. But this study indicates even more successes result when all the goals for teaching science are considered. The use of concepts and processes in a more unified way also support more student-centered and project based approaches. STS often diverts the instruction from textbook use and specific topics as specific organizers for daily instruction. Some could argue that teaching science process skills without a real world context misses the point of STS and real student learning.

The current NSTA handbook illustrates features which are central to STS teaching (NSTA, 2012-13). From health to climate change and from bioethics to energy, a myriad of personal and societal issues require citizens to make informed decisions based on both science and technology. These issues provide a rich and motivating context in which students can learn the principles and practices of science and technology. Science and technology influence every aspect of our lives, and in turn, humans influence the direction and use of scientific and technological endeavors (Roberts, 2007).

NSTA also promotes the education of a citizenry that is scientifically and technologically literate as defined in the National Science Education Standards (NRC, 1996). This requires that we not only know, understand, and value scientific and technological concepts, processes, and outcomes but that we are able to use and apply science and technology in our personal and social lives (Zeidler, 2003). While both science and technology are human endeavors and involve similar basic procedures, science involves exploration of the natural world seeking explanations—which are based on evidence concerning the objects and events encountered. A focus on Technology is included while focusing on the human-made world.

There is a national consensus about the central role that science and technology play in our society and their connection to competitiveness and future economic prosperity. However, we have yet to ensure all students have the ability to use what they have learned when making decisions about what is appropriate in personal, societal, and global situations involving science and technology.

Regarding what students should be able to know and do in science within the context of societal and personal issues is what STS can accomplish. The NSTA Position Statement recommends that students:

- Know the major concepts, hypotheses, processes, and theories of science and be able to use them;
- Include knowledge of science concepts and practices of science in making responsible everyday decisions;
- Understand that the generation of scientific knowledge depends upon inquiry processes and upon conceptual theories;
- Understand that the invention and improvement of technologies depends on technological design processes;
- Understand that science and technology are products of human creativity and imagination, subject to verification and rigorous tests;
- Recognize that scientific understanding is subject to change as evidence accumulates, or old evidence is re-evaluated;
- Distinguish between scientific evidence and personal opinions;
- Understand how society influences science and technology and how science and technology influence society;

- Understand and weigh both the benefits and burdens of scientific and technological developments;
- Be able to consider the trade-offs among alternative solutions when considering decisions that involve competing priorities;
- Recognize that scientific and technologic advances may have unanticipated consequences, which only become apparent over time as the application or technology becomes more pervasive or more power;
- Recognize that many decisions are global in nature and that people in other parts of the world are affected by decisions and faced with similar decisions and issues themselves;
- Understand how sustainable solutions to societal issues are those that meet the needs of the present without compromising the ability of future generations to meet their own needs;
- Recognize how scientific and technologic advances may affect the environment positively or negatively;
- Appreciate the value and role of research and processes of technological design; and
- Know reliable sources of scientific and technological information, how to access them, and how to use these sources in the process of decision making.(NSTA, 2012-13, p. 238)

A focus on process skills enables greater successes with school science. Scientific issues that are personally and socially relevant, and developmentally appropriate, provide ways to generate student interest in and motivation to engage in relating science to personal lives and societal issues generally. In many ways attention to process skills results in more teacher successes and more student learning. Science classes are best when conducted with a focus on scientific and technological issues that are identified by students. Practices and understanding of scientific inquiry and technological design are the results of STS instruction. Successful STS teachers must provide multiple learning opportunities that encourage the study of science in personal and societal contexts.

The first form of science content that is recommended and defined in the National Science Education Standards (NSES) is the unification of science concepts and processes. Too often when they are not "unified". They both merely become information and skills for students to experience as separate entities and not related to anything else in student lives. And, when both are considered, concepts win-out in terms of use by teachers, textbook-inclusions, and curriculum structure. Most science curricula for K-12 science focus largely on an organization of science concepts. Yet, there are what typically determine textbook inclusions. Most science teachers continue to use textbooks to define what goes on in science classrooms. The results of this study should encourage more to "unify" basic concepts with process skills. The major advance will be what happens when studying all facets of science defined and recommend by the National Science Education Standards. The teachers included for this research were thoroughly familiar with STS and strived hard to not make students in the Non-STS classrooms not to be deprived. However, the difficulty was monitoring the more positive attitudes of students in the textbook sections while also ignoring student questions, input, and actions that characterize STS classrooms.

CONCLUSIONS

Findings of this study indicate that students involved in STS classrooms show significant gains in the use of the science process skills like those identified as AAAS. These are the skills used by practicing scientists and engineers any by student experiences in the STS classrooms compared to those obtained in typical science classrooms. Learning with an STS approach generally results in more successes than those with only recall- type assessments by teachers and/or textbook authors.Using science process skills is significantly better in STS sections then in textbook-oriented ones. Moreover, there is little difference between male and female success with learning process skills in STS classrooms.Both low and high ability students excel in STS classroom over the students in classrooms which were taught largely in a textbook-oriented fashion.

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