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ABSTRACT

Science-Technology-Society (STS) can be defined in various ways. For this study, STS is defined as a curricular tool that teachers can use to focus on the interactions between science, technology, and society to make learning more relevant to students' everyday lives. A small qualitative study was conducted with students in a secondary science methods course to see if the positive experience they had with STS in the course carried over into their classrooms as practicing teachers. Three findings stood out: (1) teachers believed they have to work with a social studies teacher to implement STS in their classroom; (2) teachers got more out of the group work component of the project rather than the STS component; and (3) time was a crucial factor in implementing STS for the students. (Contains 15 references.) (MVL)

STS for Pre-Service Teachers: Does it Translate in the Classroom?

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Introduction

Science-Technology-Society (STS) can be defined in various ways. One definition is "an interdisciplinary approach which reflects the widespread realization that in order to meet the increasing demands of a technical society education must integrate across disciplines. Understanding the relationships among political systems, social traditions, and human values, and learning how those relationships are influenced by science and technology, is an essential part of contemporary education" (Penn State, 2001). Others have defined STS as "the teaching and learning of science in the context of human experience, including the technological applications of science (Sweeney, 2001)." For this paper, Science-Technology-Society is defined as a curricular tool that teachers can use to focus on the interactions among science, technology, and society to make learning more relevant to students' everyday lives. No matter how one defines Science-Technology-Society, concern for the learner and their relationship to society is at the foundation of an STS program (Sweeny, 2001).

The first use of STS was in the 1960s in an effort by school and college educators to respond to new problems facing the world (Waks, 1991). John Zinman (In Yager, 1990) first applied the term Science-Technology-Society to this concept in 1980 in his book *Teaching and Learning About Science and* Society. In his book, Zinman identified STS as a curriculum approach created to make concepts and processes found in science and social studies classes more relevant to students (Yager, 1990). Since that time, the use of STS as a curriculum tool in the United States has increased. Several National Science Foundation grants have been awarded in the field of STS and the concept is now included in most science textbooks (Yager, 1993). STS is considered such an important aspect of science education that the *National Science*

Education Standards (National Research Council, 1996), the *Benchmarks for Scientific Literacy* (AAAS, 1993) and the National Science Teachers Association (1990) have stated that STS is an essential component of our science programs. In addition many states have included STS in their science and social studies standards. The major science education organizations feel that Science-Technology-Society is important for us to use in our schools but why? What does a curriculum with STS provide students that a traditional curriculum does not? Why should a teacher jump on the STS bandwagon?

Why should STS be used?

National policy initiatives provide several reasons why STS should be included in the science curriculum of the 21st century. One reason is that science does not stand alone or happen in a "vacuum" but interacts with technology and society (Lumpe, Haney, and Czerniak, 1998). It is not difficult at all to see how the three ideas play on each other. Concepts such as vaccines, space exploration, pollution and genetic cloning are all examples of science concepts that can be taught using an STS approach. Technology can be the bridge between science and social studies (Yager, 1993). This relationship between science, technology and society is described in *Benchmarks for Scientific Literacy* (AAAS, 1993). The *Benchmarks* state "Technology usually affects society more directly than science because it solves practical problems and serves human needs. Science affects society mainly by stimulating and satisfying people's curiosity and occasionally by enlarging or changing their views of what the world is like" (p.45). The *National Science Education Standards* (NSES) also describe the relationship between science and technology. "Science and technology are closely related. A single problem often has both scientific and technological aspects" (National Research Council, 1996, p. 24). What would society be like today without the advancement of computer technology and medical treatments?

In many of the other articles on STS (e.g. Waks, 1991, Howe, 1989 & Zimmerman, 1990), the relationship between the three areas is assumed. Instead of discussing the relationship between science, technology, and society, these articles discuss how STS can be used in the classroom with children.

Another reason that STS should be used in the science classroom of the 21st century is that it provides opportunities for children to link learning to the real world. Students ask teachers the question "How does this relate to my life?" frequently. Teachers constantly try to provide students with experiences to help make those real world applications. Using a STS curriculum can be a tool that teachers can use to make those real world applications that students crave.

Support for the use of STS curriculum to make real world applications is found throughout the STS literature. STS makes science part of the real world (Yager, 1993). Lumpe, et.al (1998) advocate using STS to make real world connections.

> *Including STS in the classroom can develop decision-making skills in students, foster science learning, and provide meaningful application of science to real life. Students should learn ...the interactions of STS as they apply their knowledge to real-life concerns. (p. 17)*

The National Science Teachers Association promotes using STS in the classroom to help students make real world connections. In their July 1990 Position Statement regarding STS, NSTA states that STS focuses on real-world problems. which have science and technology components from the students' perspectives. Zimmerman, in his 1990 article, also supports using STS to make real world applications. He says that STS programs go beyond exposure to aesthetic or cultural artifacts and invite students to engage in solving problems related to their local community. Pedretti (1996) goes as far as to state, that a student needs to understand the impact of science and technology on their lives to fully participate in society. Classroom teachers know the importance of making the real world connections for their students. STS is one of a few research supported curriculum programs that teachers can use to provide real world connections for their students and help them take action in solving problems.

Along with real-world application, STS is a way to involve diverse learners in science. The goal of multicultural education is to create equal educational opportunities for students from diverse backgrounds (Sweeney, 2001). Because an STS approach to teaching science incorporates learning science in the context of the individual learner and involves the student in the learning process, STS is a natural fit for a diverse classroom (Sweeny, 2001). Urban educators also agree that an STS approach to science is a way to reach urban students. Waks (1991) states, "The problem is not really how to teach urban schoolchildren but rather how to win their hearts and minds. This can only be done on terms that are believable and appealing to them" (p. 197). Making science believable and appealing to students means making it relevant to their everyday life. An STS approach does that and therefore is considered the most promising framework for urban science education (Waks, 1991).

Teaching children how to take action is the last reason to use STS in science classrooms. Educators have been charged by the public to prepare citizens who are aware of issues around them and to provide students with the skills necessary to solve these issues. A central tenet of STS education is the promotion of the development of informed and responsible citizens (Pedritti. 1996). Students who have experienced a STS approach to learning take action on issues more often and longer than students who are taught by traditional methods (Rubba, 1990). Why does this approach work in creating action-taking citizens? It goes back to the basic core of the STS concept. "STS is committed without apology to promoting democratic values and the wide distribution of necessary knowledge and skills for full participation in the democratic process of social regulation" (Waks, 1991, p. 196). Because STS promotes these values, it produces an informed citizen capable of making crucial decisions about current problems and issues and taking personal actions as a result of these decisions (National Science Teachers Association, 1990). STS provides the foundation for students' eventual understandings and actions as citizens (National Research Council, 1996 and Wiesenmayer & Rubba, 1999). STS advocates socially responsible public choices and is only science education program that empowers urban youth (Zimmerman, 1990 & Waks, 1991). Supplying students with opportunities to take action and the attitude that they are making a difference provide lifelong gains attributable to an STS program. The National Research Council, the American Association for the Advancement of Science, the National Science Teacher Association and numerous multicultural and urban education programs promote STS as a curricular tool that benefits ALL learners. If STS, like any other concept, is taught to teachers in their methods courses, do they transfer this knowledge into their classroom instruction to enhance learning for ALL students?

Teachers and STS implementation: Does it happen?

Lumpe et. al (1998) have observed there are three basic types of teachers in regard to STS implementation: (1) teachers who realize a STS curriculum provides real-world applications to students, (2) teachers who do not like the idea of integrating of social studies with science, and (3) teachers who are concerned about the time it takes to implement STS in their classroom. The first type of teacher is one who is willing to embrace and use the STS concept. The second type of teacher is one who believes science and only science should be taught in the science classroom. The third type of teacher is one who will find just about any excuse not to try something new in their classroom and time is the easiest excuse for them to give. Sweeny (2001) states that teachers under 25 are usually a type 1 STS teacher, while teachers over 25 are typically type 2 or type 3. All three kinds of STS teachers can be found in any science department or science methods course and science educators must know how to address the needs of all three types for STS implementation to take place in classrooms.

Teachers must believe in or have ownership in the concept before implementation of any concept can occur. Many programs in schools have failed due to the lack of teacher ownership in the concept. In order to determine teacher beliefs about STS, several researchers have created instruments to assess teachers' views on STS (Lumpe et.al. 1998). According to research (Sweeny, 2001, Lumpe, et.al, 1998, Yager, 1991), teachers who understand STS do buy into the STS concept.

The downside to these assessment instruments is that most of them do not address the teacher's actual intent to implement STS in the classroom. In a study conducted by Lumpe, et. al (1998) to address this issue, the researchers asked teachers what would discourage them from implementing STS in their classroom. The teachers who responded reported that lack of materials, lack of money, time, and lack of support from others (such as administration) as reasons they would not implement STS in their classrooms. Sweeny (2001) reported that prospective elementary teachers were more resistant to implementing STS in their classrooms than secondary teachers because of their concern of using controversial issues, such as HIV, in their classrooms. Lumpe et.al (1998) also reported the use of controversial issues in STS is seen as a disadvantage of using STS in the classroom by teachers.

It is obvious that using STS in a science classroom has many benefits to the student. It is not the students who are resistant to learning science through STS, but the teachers. If Sweeny's three levels are correct, where do we begin? Obviously it makes sense to begin with the teachers who appear to be the most open to new ideas -- the ones just entering the profession. Can we provide pre-service science teachers with the kind of experiences that will help them develop a positive attitude toward STS and at the same time help them sustain that commitment until they have their own classrooms?

Context for the Study

A small qualitative study on STS was conducted with students in a secondary science methods course to see if the positive experience they had with STS in the methods course carried over into their classrooms as practicing teachers. The following describes the findings from this study. Pre-service teachers in a secondary science methods class were introduced to the STS concept as part of the requirements for the class. The science methods students were teamed with students enrolled in the secondary social studies methods class for the purpose of creating an STS resource unit. Two three hour class periods were spent with the methods students discussing the philosophy behind Science-Technology-Society, group work, the purpose the project and how the resource unit should be structured. Students were given some class time throughout the semester to work in their STS groups and were asked to turn in frequent progress reports. The staff expected that some out-of-class group meeting time would be necessary, but that was up to each group. Draft copies of the paper outline and a rough draft of the final paper were required in order to keep the students moving ahead. The methods students also sought assistance outside of the class from the science methods professor, the social studies methods professor and the graduate student for the science methods class via office visits, phone calls, or emails. At appropriate points during their project work, the importance of cooperative efforts by all group members was stressed. All were told that being a good group member was an assignment, and that peer assessment within each group would become a part of each individual's grade. On a few occasions, it was necessary for faculty/staff to intervene to help groups be more effective. In addition to preparing a written resource unit paper, students were asked to make a verbal presentation and a visual presentation of their group project. At the end of the assignment, students presented their resource units at a STS fair that was open to the faculty and staff. The methods students were also asked to write a reaction/reflection paper to the experience of creating an STS unit as part of their final assessment.

Three years later, contact was made with those science methods students who were teaching. Similar contact is currently being made with the social studies students and will be reported in further research. Questions about how they have implemented STS in their classrooms were asked. Below is a description of the students' reactions to STS at the end of the science methods course and how they have implemented STS in the current classrooms, as practicing teachers.

Initial Student Impact

As part of the assessment for the STS resource unit, the methods students were asked to reflect on the STS assignment. The students were specifically asked, "What have you learned from this experience?", "What would you do differently for next semester?", and "What have you learned about learning?" For most of the students, the STS experience was positive. Besides learning what STS meant, there were two concepts that appeared in a majority of the students' reflections. Students learned about working in groups and integrating subject matter.

The first concept that the methods students felt they learned from this experience was how to work successfully in a group. Many of the students commented on how this was the first time they had participated in a cooperative group that worked. One student stated, "Great, this is my senior year and group projects just do not seem to fair very well with me. I will never do this to my students once I become a teacher. They just do not work. When we were assigned this project, I had a negative outlook (what a pessimist) from the very beginning." The student then goes on to comment about what she learned from the STS project. "What have I learned about STS as a result of doing this project? Working in a group does work! What a relief to be part of a group that actually gets everything done on time. That is the greatest feeling in the World when one is done with a project a week before it is due." This student's attitude before beginning the project and after completing the project was shared by many of her classmates. The positive experience working in a group was powerful for these students and they now realized that group work can be successful if constructed properly.

In addition to having a positive experience with cooperative groups, many students expressed that they learned how important communication skills are when working in a group. One student wrote in her reflection, "I also learned that communication plays a very vital part in group projects. Without communication, our group would have never gotten anything accomplished, but because we did communicate we worked well with one another and did an excellent project." Another student discussed how she learned to listen to her other group members. "I learned to get over my ego. Every member has a valid and usable opinion or idea. It is important to let everyone talk and share thoughts and ideas." Another aspect of communication that several of the methods students mentioned in their reflections was learning to work with people outside of their teaching field. In the beginning of the assignment, some had the attitude of "us" vs. "them", the "science students" vs. the "social studies" students. In the end, they felt they learned how to respect others and interpersonal skills that would be valuable when working with coworkers in other disciplines.

According to the reactions papers, integration of science with social studies was the other concept that all of the science methods students said they learned as part of the STS project. The methods students learned that science and social studies concepts could be easily integrated with one another and they were able to practice creating STS integrated units through this experience. For many, it was the first time they had looked at science or social studies from this viewpoint. One student wrote, "At first I was very narrow minded (sic), I could see no correlation between science and social studies." By the end of the project, this student saw the correlation between science and social studies and how important that can be in student learning. Another student commented, "I realized that science, technology, and society are very important in today's world. I have realized that subjects can be related to one another much easier (sic) than I thought." A third student stated, "Once my group began brainstorming about topics I realized how closely the components are related. Then I started seeing relationships between most topics discussed. Science, Society and Technology cannot truly be separated!" These are just a sample of how the students began to think outside of their subject area to grasp the concept of integration.

In addition to learning how science and social studies were intertwined, the methods students also discussed how important the integration of the two content areas is in regards to real life application and learning. "STS units can be very beneficial by providing students with real-world problems." In addition to making the content relevant, the methods students felt that it was important for the teacher to take the time and create STS units. One student wrote, "If we do not attempt to show the relevance of each discipline to each other, then students will not make the connections they should be making and will not see the relevance of these disciplines in their lives." Another student commented, "Through interdisciplinary teaching, the teacher is able to provide for a greater understanding in (sic) the students. They will be able to see all sides of each topic and use these new bits of information to become much more fully rounded individuals." They agreed that the units were time consuming to create but in the end, worth the effort because of the gains students would make in overall learning.

Impact of STS in the Classroom

A set of seven open-ended questions was sent to the former science methods students who were currently teaching. The questions were based on the reactions of the students after completing the resource unit. We wanted to know if the students were using STS directly or indirectly in their classrooms, how they felt about using groups in their classroom, if they are using group work in their classrooms, what place content integration had in their classroom and if they think the STS project should be continued in the science methods course. The number of teachers responding was low but their answers give some insight into the use of STS in the classroom.

All of the teachers who responded to the questionnaire placed value on the integration of other content areas into science. They all felt that integration of content material was something that should be done in science classrooms. Comments such as, "I really think it is important for students to make interdisciplinary connections so that what they are learning is more meaningful to them" and "I think it is very valuable to students to see how science is related to other content areas. It makes learning more meaningful to students when they see how different things are related" was a common response. If these teachers see integration of content areas as important, are they using STS in their classrooms as practicing teachers as a way to integrate content areas? Of the teachers that responded to our contact, only one has created an STS unit for use in her classroom. This teacher created a unit on earthquakes. In her unit, "students have to come up with ideas for buildings that can withstand earthquakes, while keeping cost and other factors in mind." Another teacher responded that she has not created a formal STS unit but "includes facts and ideas from other content areas whenever I can." A third teacher reported that she has her students research historical facts dealing with science. Overall, the rate using STS in the classroom is extremely low considering the value the teachers place on subject area integration. This is in direct conflict with Sweeny's earlier findings that teachers under the age of 25 are more likely to implement new ideas in the classroom as compared to older teachers.

The respondents who have not implemented STS in their classrooms cited time, both instructional and planning, as the reason for not using STS. One teacher responded, "I don't have specific STS concepts integrated. I have been so extremely busy (all year around) (sic) trying to put together a decent physics curriculum for the students in my classes. I just don't have the time in my day, before or after school, to put it in." Another teacher reported a similar situation. "I have not been able to implement the STS concept. I have been put in charge of writing the curriculum, and I feel that I am doing well just to make sure I include all of the concepts required to be taught in my own discipline. In the future, it would be nice to do more." A different teacher stated, "There is simply not enough time nor energy for a science teacher to pull in or research ideas from other areas unless they are given the time to do it." Practicing teachers know that time is a barrier to developing and creating curriculum. These pre-service teachers became aware of this fact very quickly when they began teaching.

Although the former methods students are not using formal STS units in their classrooms, they have been engaged in dialog with other teachers about the STS concept. All of the respondents have discussed creating an STS unit or the idea with their coworkers. One teacher commented, "I have discussed the STS concept with one of my coworkers (a social studies teacher). She and I both agree that integrating our subjects would be a good idea, especially since we have many of the same students. However, since we do not utilize teaming at our school I do not know how likely we would be able to develop units together." Another teacher also reported the lack of teaming at her school as a barrier to implementing an STS unit. One teacher reported that her knowledge of integrating content areas assisted her in writing a TIF grant for her school. There is more success in the dialog about STS than in the actual implementation of the concept. But clearly, crossing the line between the science and social studies class in the typical high school is very difficult--not the kind of activity that a single teacher can easily accomplish--especially a new teacher.

Since the teachers who were surveyed were science teachers, they all responded that they use group work on a regular basis. Science is a subject that lends itself to cooperative or group work. What did the methods students learn about group work as a result of the STS project and how is this knowledge used in their classroom? One teacher reported that she saw the importance of using rubrics with group work based on her experience with the STS project. Another teacher responded that the STS experience assisted her in learning how to work with other types of teachers, "It enabled me to get others' perspectives, not just from those in your own discipline, but from people outside as well." A third teacher reported they incorporate an individual accountability section as part of the rubric for a group project. "Having individuals in a group rate each other's performance is a strategy I implement with my own students to encourage them to be responsible for their part of the group's effort." Many of the teachers responded that because of the positive group work experience with the STS project, they are able to create better group projects for their students.

The last question asked in the questionnaire was "Should the STS project be continued in the methods course? Why or why not?" All but one of the respondents agrees that the STS project should be continued. The teacher who did not feel the project should be continued felt this way because she did not feel she gained anything from the project. She had a difficult time communicating with her group and felt there was not enough incentive for group cooperation.

To make the project more valuable, she states, "If the students were required to gather a unit and teach it in a school, that would be much more incentive to be prepared."

The reasons that the teachers felt the STS project should be continued in the secondary science methods course are varied. One teacher feels that the entire methods course should be restructured to be based on projects and presentations similar to the STS project. A second teacher said that the STS project should be continued because "it causes the college students to have a structured group experience. It allows them to see the importance of roles and rubrics." Another teacher claimed the experience prepares the students to work well with teachers in other areas. A different teacher reported that the project allows students to become familiar with the required content in a field outside of their own. Although the former methods students are not using STS in their classroom, they feel that it was a worthwhile endeavor that should be continued.

Findings

From the study of the use of STS in the classroom, there were three findings that stood out. The most surprising discovery was that the teachers believed they have to work with a social studies teacher to implement STS in their classroom. The group structure in the methods course was created to begin dialog between teachers who normally do not discuss how their subjects are related. In schools where cross disciplinary teaming is implemented, it is common practice to pair teachers of Science and Math and teachers of English and Social Studies to create lessons. The methods students were told that the lessons they were creating were lessons that could stand alone in a science or social studies class, you did not have to have both for the lesson to work. From the responses of the teachers, they did not understand that you could implement STS in your science class without working with a social studies teacher. Did we, as instructors, not emphasize this fact? Where did we go wrong in our instructions and how can we correct this in future classes?

The second finding from the study is that the teachers got more out of the group work component of the project rather than the STS component. Having teachers or students work together is considered an essential component to any successful program (Barufaldi & Reinhartz, 2001). Three years later, instead of reporting how useful the Science-Technology-Society aspect has been in their teaching of science, the students reported the skills they gained by working in the groups has been more valuable to them. This finding was initially discouraging for the authors. The goal of the assignment was to open the methods students up the relationship between science and social studies, to show them how the two subject areas are highly integrated. The students became more aware of the relationship between science and social studies due to the project but they are not using that knowledge in their classroom like they are using collaborative groups. This finding cannot be viewed as a failure because the instructors successfully modeled how to create an effective group structure. The STS project, for many of the students, was their first positive experience working in a collaborative group and they have been able to take the group structure created in the methods class and use in their own classrooms. Without this experience, these teachers may be struggling with how to create successful groups in their classrooms.

The third finding from the study is that time is a crucial factor in implementing STS for our students. This was the only finding that was consistent with the research (Lumpe et.al, 1998). Suggestions on how to incorporate STS and deal with the time issue will be made to the students who reported time as a barrier. Time management is something that all teachers struggle with during their induction years. It would be interesting to follow up with the teachers in another three years, after that crucial five-year mark, to see if they are using STS in their classroom and if time is still a barrier.

STS is a curricular reform movement that is not being taken advantage of in many classrooms. STS is considered by the top organizations in science education as a way to teach science to ALL students. STS has been introduced to thousands of teachers, but are they using it? This study brought to light some instructional issues for the methods course instructors that would not have been recognized if the follow-up with the former methods students did not occur. The implication this has to professional development workshops is great. Follow-up with teachers after they have attended the workshop is critical to make sure that the teachers understood and are using the information from the workshop as intended by the instructors. The methods instructors would never had known the misunderstandings with STS if we did not conduct this study.

STS as a curriculum tool can be beneficial to all involved. STS provides opportunities that K-16 students do not get in a traditional science curriculum. It is an integrated concept that provides those crucial links to everyday life that students crave. Science educators must be aware of how useful STS is as an instructional method and how important follow-up with workshop participants or methods students is in using STS. Robert E. Yager (1993) sums up the use of STS nicely with the quote "This is science".

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