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ABSTRACT

The science-technology-society (STS) movement represents an attempt to "liberate the student from narrow utilities" (Dewey) through an interdisciplinary approach to the three content areas (science, technology, and society) providing a coherent conceptual scheme for integrating classroom instruction. This action research study sought to identify the challenges and obstacles to preparing students to create lessons within an STS framework. An STS project was selected and assigned as a requirement for the undergraduate elementary education students enrolled in elementary social studies methods and elementary science methods courses. The science and social studies methods instructors developed an integrated STS experience for their preservice teachers. This STS project included five phases: identification and definition of an issue, exploration of the issue, proposal for action, development of lessons, and reflection on the process. The study also required that the STS topic the students developed focus around a health care issue. This paper follows the development of those lessons. (Contains 54 references.) (MVL)

Integrated Instruction in University Methods Courses: Applying Science Technology Society

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Despite the diversity of opinion regarding the value of integrated instruction (Czerniak, Weber, Sandmann & Ahern, 1999), the desire to create more efficient and authentic learning experiences in the science classroom continues. The challenges of preparing students to become effective science teachers have contributed to generously to the teacher education literature. In particular, the desire to have students instruct science from an integrated and interdisciplinary (Abruscato, 1996; Carin, 1997; Howe and Jones, 1998; National Research Council, 1996) perspective provides challenges to a methods course instructor offering instruction in a standard content-specific format. Science education curriculum and program documents also support these initiatives (American Association for the Advancement of Science, 1989; National Council for Social Studies, 1994; National Council of Teachers of Mathematics, 1989; National Research Council, 1996). These academic and organizational efforts have been buttressed by a proliferation of instructional packages, such as the AIMS and GEMS programs, which promote integrated instruction. Modeling the desired instructional strategy is difficult due to the perceived barriers of the content disciplines, knowledge of pedagogy, and lack of existing models (Huntley, 1999).

The purpose of integrated, interdisciplinary approaches is to provide students with a unified view and opportunities to connect learnings that are related to each other (Czerniak, Weber, Sandmann & Ahern, 1999; Knapp, 1996; Sealy, 1995; & Wasley, 1994). For example, when experiencing an integrated curriculum the learner develops

skills in language arts and the skills can be used to learn about social studies, science, and other subjects (Tanner, 1997). Educational experts believe that integrated curriculum has a natural home when a teacher wishes to be more student centered and problem based (Gardner, 1993).

The benefits of an integrated, interdisciplinary approach to teacher education are not clearly delineated. Critics of the integrated approach believe that students should reach "deep understandings across disciplines by first reaching deep knowledge within the discipline (Gardner, 1993). Many of those same critics believe that when teachers use an integrated approach one discipline may overshadow others, there is not time to explore powerful subject-based ideas, less content is learned and subject matter depth is lost (Knapp, 1996). Advocates of the approach believe that integrated instruction improves retention, focuses on problem based learning and is more student centered. It is particularly appealing to the middle school movement and team teaching (James, Lamb, Householder, & Bailey, 2000; Willis, 1994).

The issues are even more complex when considering the benefits of an integrated curriculum in teacher education programs. Are integrated methods courses the most helpful approach to help future teachers acquire the pedagogical skills necessary to teach science and other subjects? Teacher educators who attempt to model integrated curriculum during methodology courses have "little empirical evidence" that integrated, interdisciplinary teaching improves learning (Czerniak, Weber, Sandmann & Ahern, 1999; Hough & St. Clair, 1995; Meir, Cobbs, & Nicol, 1998), though much "testimonial" evidence makes strong claims for its value. However, many new standards advocate and recommend that curriculum reflect some aspects of integrated, interdisciplinary

approaches (AAAS, 1989; Knapp, 1996; NCSS, 1994; NCTM, 1989; NRC, 1996; Willis, 1994).

Logistical issues related to time and subject matter coverage also serve as challenges to teacher educators. Integrated teaching requires far more teacher preparation and time to collaborate than traditional approaches (Louisell & Descamps, 1997). Materials, lessons plans, and classroom management plans must be closely coordinated and connected. Planning and teaching together as a team requires coordinated effort and blocks of common time. Few learners have been exposed to a truly integrated approach. New teachers who were raised in a system designed to encourage specialization must be exposed to integrated curriculum to gain expertise, especially in math and science (Pang & Good, 2000; Wasley, 1994). When implementing integrated curriculum, new teachers must be taught a see how to guide their students to use group work and engage in collaborative tasks.

Science Technology Society as Integrated Instruction

John Dewey wrote of "liberating the student from narrow utilities." The science-technology-society (STS) movement represents an attempt to accomplish that goal through an interdisciplinary approach to those three content areas, providing a coherent conceptual scheme for integrating classroom instruction. The beginnings of the STS movement can be traced to efforts in several European countries, as well as some domestic attempts during the early 1960s (Yager, 1990). According to Yager, the effort in the United States was finally given an added emphasis in the early 1980s as educators sought to create a science program that would involve all students--not just the one or two percent who would study science in college. Among the goals of the STS program is

to provide real-world connections for students between science content and societal issues, providing students with an authentic means of integrating instruction between and among the disciplines (Lumpe, Haney, and Czerniak, 1998). The process would give the student practice in identifying potential problems, collecting data with regard to the problem, considering alternative solutions, and considering the consequences based on a particular decisions (Yager, 1990). This social action outcome of instruction finds support in contemporary definitions of scientific literacy (American Association for the Advancement of Science, 1989; Kumar & Berlin, 1996; Ramsey, 1993)

Aikenhead (1992) provided a conceptualization of the STS program. Technology is conceived as the interface between science and society. As citizens are called upon to make decisions, they typically utilize technology as a means of securing information, as well as a tool for the implementation of solutions. The pivotal role served by technology can provide a means of action and of investigation in the STS curriculum. This conceptualization also implies the nature of science as a field within all of society.

Both social studies educators and science educators have discussed the benefits of the STS curriculum approach to their respective fields. From the social studies perspective, Remy (1990) argued that STS curriculum can contribute to the goal of promoting civic competence by providing an understanding of the social issues generated by science and technology and by offering students the opportunity to practice decision-making related to these issues. Furthermore, he recommended STS as a means of promoting interdisciplinary connections, developing students' appreciation for the role of science and technology in shaping our democratic heritage, and resisting anti-scientific

and pseudo-scientific rhetoric from "antagonists of modern science and technology."

Remy (1990) concludes:

> We need to find ways to devote some attention in the curriculum to the concepts of science and technology as symbiotic enterprises, their origins and development in Western civilization, their functions in contemporary American life, their power and limitations in solving problems, and the benefits and risks associated with their applications to society (p.205).

The National Council for the Social Studies (NCSS) adopted STS as one of the ten thematic strands of its curriculum standards (NCSS, 1994). The description of STS provided in the NCSS standards document notes that STS involves questions that are key to the social studies curriculum, such as

> Is new technology always better than that which it will replace? What can we learn from the past about how new technologies result in broader social change, some of which is unanticipated? How can we cope with the ever-increasing pace of change, perhaps even with the feeling that technology has gotten out of control? How can we manage technology so that the greatest number of people benefit from it? How can we preserve our fundamental values and beliefs in a world that is rapidly becoming one technologically-linked village? (NCSS, 1994. P. 28).

Although the STS approach is typically described in the secondary school context, the NCSS recommended the STS curriculum as appropriate and relevant to social studies education at all grade levels. For example, the performance expectations for this standard indicate that elementary students should be able to:

- Identify and describe examples in which science and technology have changed the lives of people.
- Identify and describe examples in which science and technology have led to changes in the physical environment.

- Describe instances in which changes in values, beliefs and attitudes have resulted from new scientific and technological knowledge.
- Identify examples of laws and policies that govern scientific and technological applications.
- Suggest ways to monitor science and technology in order to protect the physical environment, individual rights, and the common good (p. 43).

The social studies education literature tends to emphasize STS as an approach to the study of how science and technology impact society. Science educators, however, tend to focus on how STS can achieve the goal of promoting scientific literacy – using science to achieve social good. The purpose of school science in an STS framework then is much broader than the typical discipline-centered, textbook-driven science course. Zoller (1992), for example, described the need for all students to be informed as to the content and process of science, but with the understanding that science and society impact each other. Brunkhorst and Yager (1990) found that exemplary science programs that use an STS framework tend to:

- Emphasize science for all students
- Emphasize higher order thinking skills across content areas
- Be interdisciplinary in nature
- Be hands-on, student-centered, minds-on programs
- Include student action plans, projects, field experiences, and field research
- Utilize many outside resources
- Tie STS issues to the traditional content of the course

- Structure evaluation to assess a variety of domains and include awareness and reasoning components
- Produce students who do as well (if not better) than students in typical science courses when standardized tests and/or textbooks are used (p. 63).

These characteristics clearly match the current notions of what constitutes scientific literacy. The American Association for the Advancement of Science (1993) offered a similar description of scientific literacy:

> Science literacy enhances the ability of a person to observe events perceptively, reflect on them thoughtfully, and comprehend explanations offered for them. In addition, those internal perceptions and reflections can provide the person with a basis for making decisions and taking action. (AAAS, 1993, p. 322)

More recently, Leslie (1999) addressed the need for reestablishing a conversation regarding the role of STS in education. He argued that the need to connect all students with the role of science and technology within a broader societal framework is essential. This theme resonates with the purpose behind the title of the American Association for the Advancement of Science's *Science for all Americans*.

Further underscoring the need to make education available to all Americans, the STS approach has value beyond the disciplines of social studies and science in terms of meeting the needs of urban youth (Waks, 1991), African-American youth (Jegende, 1994; Solomon, 1994), women (Rose, 1994), and other marginalized ethnic groups (Rampal, 1994). Caseu & Norman (1996) suggest that STS may have untapped possibilites for engaging diverse learners in science. May (1992) suggested that, when implementing the STS curriculum, one must seriously consider the "whats and whys" of this approach. In her view, the STS approach can, if unleashed irresponsibly, represent an expression of a

westernized, secular, science-driven culture. Thus, some degree of sensitivity is needed with respect to the belief systems of the students who will participate in the program. In our view, the potential dichotomies between western and nonwestern, secular and sacred, represent an area for consideration within the STS framework.

Teacher Preparation for STS

As with any curriculum initiative at the K-12 level, it is essential that the STS approach be implemented with a degree of caution; lest it be considered this week's fad by a cynical cadre of teachers (Bragaw, 1992). Rutherford (1988) argued that, while some may consider STS to be another trend in education, it actually has a great degree of staying power given the increasing volume of information in society and the importance of scientific and technological developments in the daily lives of citizens. If the STS approach is to be implemented appropriately, the preparation of teachers for this task is of paramount importance.

Several researchers have explored the issue of teachers' perceptions of STS. Mitchener and Anderson (1989) examined teachers' perceptions regarding the creation and implementation of an STS curriculum and identified barriers such as, concerns over content, discomfort with grouping, uncertainties about evaluation, frustrations about student population, and confusion over the teacher's role. Rhoton (1990) also investigated teachers' perceptions and found that teachers had a high degree of perceived need in terms of both adequate information and preparation. Interestingly, Rubba's (1989) study suggested that while teachers were confidant in their own ability to understand STS content and to teach it effectively, their students' abilities to understand the content was

not confirmed by the data. The author suggests that teachers' perceptions of high interest activities are not consistent with what students perceive as high interest activities.

Further support for the application of an STS approach comes from the work of Wiesenmayer and Rubba (1999), who found evidence demonstrating a strong link between student participation in an STS curriculum and significant (positive) changes in student citizenship behaviors. Clearly the participation of students in high interest activities has a positive influence on their citizenship behaviors. This connects strongly with Rubba's (1989) earlier assertion that the activities must be meaningful to students for the benefits of STS instruction be acquired.

Rubba (1990) also examined the dynamics of teacher-teacher interactions and suggested that there is a strong need for interdisciplinary cooperation between teachers if STS is to be successful. Similarly, Yager, Mackinnu, and Blunck (1992) found that teachers need more training in terms of their exposure to and implementation of an STS program if it is to be effective. Schibeci (1990) echoed these findings as he determined that adults display very little in the way of basic scientific and technological literacy.

Among elementary students, Thirunarayana (1998) determined that elementary students can develop meaningful conceptions among science, technology, and society related topics that offer a personal relevance to themselves. However, in terms of environmental issues, they still evidenced some difficulty expressing clear conceptions of the relationships among the issues. Thirumarayana suggested therefore that before STS instruction be implemented, teachers must first build upon their interests and use that to develop the conceptual understanding. One can see that this remains a challenge if

Schibeci's (1990) earlier assertion that adults lack adequate knowledge in terms of scientific and technological literacy is assumed.

Implementation of an STS Project for Preservice Elementary Teachers

In an effort to address the need to prepare preservice elementary teachers for integrated instruction, the investigators elected to use STS as a means of developing student experiences. An STS project was selected and assigned as a requirement for the undergraduate elementary education students enrolled in our elementary social studies methods and elementary science methods courses. The project involved a total of some 120 elementary education students across three sections of each course. These students were enrolled in a "block" of methods courses that typically includes science, social studies, language arts, reading, and assessment during the semester prior to their student teaching experience. During this semester, these preservice teachers also complete a full-time, three-week internship in an elementary or middle school.

Each of the instructors taught three sections of their respective undergraduate methods courses. There were approximately 30 students in each class. The instructors taught two groups of students in common. The STS assignment was available to all students in the courses they taught, but among the two groups of students whom the instructors shared the STS assignment could be used for credit in both the science and social studies methods courses. Students in both classes, furthermore, could select the STS assignment as one option out of three (other options in the courses included software evaluations, constructing discipline-based instructional unit, constructing a WebQuest, or a reading/seminar experience), making participation in the STS project optional. In all, some 70 STS assignments were completed.

The science and social studies methods instructors developed the STS experience for their preservice teachers. These individuals shared students in two of the methods course blocks. The first STS project included five phases: identification and definition of an issue, exploration of the issue, proposal for action, development of lessons, and reflection on the process.

An additional component of the experience was making use of resources from the School of Nursing at the university, in support of their efforts to promote awareness of health care careers, particularly among nurses. The authors of the study required that the STS topic the students developed be focused around a health care issue. To support this, the School of Nursing made resources available to assist students in their development of the topic. These resources included a web site, a presentation by members of the faculty, and a commitment to being available to students as they pursued the development of the STS project.

In an attempt to meet the needs of students in the teacher preparation program, the authors of the paper designed a flexible approach for students to use while developing an STS investigation. The students were offered three approaches to meet the course requirements in terms of learning about STS as an instructional approach. One of the approaches required the students to actually engage in an STS investigation of their own. Students were asked to abide by the following steps to investigate and report back what they learned from the investigation. The phases of the project were as follows:

- *Identification*--Students identified an issue for investigation.

- *Exploration*--Students conducted research through library work, Internet searches, and personal interviews. Students examined multiple perspectives of the issue and the potential consequences of each of the possible solutions.
- *Proposal for action*--Based on the exploration, students proposed some action be taken to respond to the findings from the exploration phase.
- *Implementation of action*--This component of the experience could be accomplished in either one of two strategies:
  - Construct a display board and brochure, alerting the public at large as to the issues examined and their proposal for reasonable action in response to the issues. The displays were to be shared by posting them in a public location within the college of education.
  - Compose a letter to a person of influence (legislator, government official, newspaper editor) explaining the issues developed and the proposal for action. It was expected that the students submit the letter to the identified person of influence, and share a reply with the instructors, if one was received.
- *Reflection on the process*--the student was asked to compose a brief essay describing their interaction with the process and how they foresee this experience as having prepared them to teach in an STS framework.

The third option offered to students was based on an approach profiled by Varella, Monhardt & Monhardt (2001). Students were asked, in this option, to produce a unit outline for an instructional unit supporting an STS investigation. The student selecting this option was required to develop the following:

- *Description of the problem*--Compose a paragraph that defines exactly what this "problem," issue, or topic is, taking into consideration the grade level for which the unit was developed.
- *Establishing relevance*--Write a paragraph that might get your students interested in this topic.
- *Possible student questions*--Generate a list of ten credible questions that students might ask about this topic.
- *Possible resources*--Considering your student questions and the developmental/age level of your students, generate a list of possible resources that your students could utilize to find answers to their questions. These were to include both written and human resources.
- *Learning activities*--Submit a lesson plan in each of the following areas:
  - A guided discovery science lesson
  - A social studies lesson
  - A lesson to examine health careers that relate to the topic under investigation
- *Social action*--Write a paragraph that explains clearly what action could be taken by your students to address this issue. The action was to a task that could be completed by children at the age/developmental level for which they designed the unit.
- *Concepts*--List specific concepts within science and social studies that would be encountered in this unit.
- *Evaluation*--List possible means for assessing and evaluating students on the outcomes of this project.

Students submitted one of these assignments to receive course credit in both their science methods course and their social studies methods course. In each case, the assignment was worth approximately 10 percent of the entire course grade. Other assignments included traditional activities such as examinations, microteaching experiences, and class participation.

Methodology

Methodology for this investigation followed an action research approach. Given the role of action research as a means of reflecting upon and improving classroom experiences, the authors of this study, as university methods educators, sought to identify the challenges and obstacles to preparing students to create lessons within an STS framework.

The authors were guided by the principles of action research in our attempt to understand both the development of prospective teachers' knowledge and skills related to STS instruction and our own practice in facilitating these outcomes. Glanz (1998) defines action research as, "a type of applied research … that is conducted by practitioners to improve practices in educational settings." The primary difference between action research and other forms of research is that, "action researchers study their own practice, not the practice of others" (Wade, 1999, p. 75). An action researcher must adhere to the same guidelines for rigor in data collection and analysis standard in all forms of inquiry. The action research approach, however, allowed us to add an additional layer to the investigation.

Action research has traditionally been conducted in K-12 settings by teachers and administrators as a means of examining school practices, promoting staff development,

and encouraging school reform (Corey, 1953; Glickman, 1993; Sagor, 1992). Recently, the notion of teacher educators as self-reflective practitioners has led to studies making use of the action research design in university settings (i.e., Wade, 1999). As relatively novice teacher educators, the authors both engage in a great deal of critical reflection regarding course assignments, teaching methods, assessment practices, and a host of other teaching issues. By engaging in action research, we were able to formalize and collaborate in this self-reflective process, as well as examine the student outcomes of our STS project (Milson & King, in press).

In addition to the instructional changes under examination by the methods course instructors, members of the university's nursing faculty were interested in the influence of conducting developing elements of the students instruction around issues related to nursing as a career. To this end, a pretest-posttest measure of student responses to a nursing survey was administered at the beginning and at the end of the semester. In this way, the nursing faculty sought to determine the extent of knowledge gains regarding nursing acquired during the research for the STS investigation.

Outcomes and Discussion

A number of outcomes were observed from the experience of actually engaging in a Science-Technology-Society investigation. The results provided the authors with some insights into the process of developing STS-themed instruction in their respective methods courses.

Support for the use of STS as an element of the elementary science and social studies methods courses came initially through comparing student knowledge gains from one semester to the next. Objective measures made from course examinations indicated that students obtained a better understanding of STS as an instructional approach in both the science and the social studies methods courses. The elements of STS were discussed by both methods instructors previously, but only so far as a classroom discussion and assessing their understanding through a written examination/multiple choice examination. To this extent, engaging students in an actual STS investigation demonstrated increased knowledge among students of the elements of STS instruction.

Greater awareness of STS as a theme for instruction was also observed through improved scores on course assessments. Students recognized STS as a means to implement interdisciplinary instruction. As with the first point above, student knowledge of STS, in general, increased as measured through course assessments. Understanding of purpose for STS was also evident during classroom discussions and responses to specific questions.

Students also better recognized the application of STS in content areas, promoting a coherent means of developing interdisciplinary instruction. Put succinctly, students obtained an improved understanding of the role that STS can serve as a means of developing interdisciplinary instruction.

The challenges experienced by the instructors were observed in three areas, devoted primarily to the project itself and the perception of how it was evaluated. One of the key points noted was the issue of motivation: students in the shared methods courses were more likely to carry out the STS-related assignment for the sake of efficiency—it

gave them credit for two courses. Comments from students underscoring this point included the following:

> I thought it was interesting and I wanted a good grade.
> Because it counted for 2 classes.

Other students did indicate that carrying out the project themselves did, in fact, give them deeper insights into the nature of inquiry and STS-themed instruction, which was consistent with scores on examinations. Reflecting this position:

> I felt the project was very helpful in understanding STS development projects...
> I liked doing the assignment.
> I think STS projects are very useful. It gives students and teachers a *real* life purpose to learn science and technology skills and content. Not all students will be scientists, but for everyday living, STS shows how science applies. I LIKE IT A LOT!

For students who elected not to select the STS option, the primary reason given was that they did not want to have their choice of topics limited to issues that had a health care component included.

A perspective that emerged numerous times among the preservice teachers was the belief that the STS assignment was too much of a burden for students to complete during the semester or that the assignment was not perceived to be directly applicable to their career goals. A sample of students representing this point of view:

> The level of difficulty was too great.
> I thought it was not for an education class. It did not teach me anything about how to teach.

Some students rather stridently voiced their objection to the entire assignment:

> It was a waste of time. It was just a research project. It wouldn't help me in my classroom other than giving me another way to assign the same thing to my kids.
> I don't see how this project relates to teaching science.

Specific to the assignments, the authors noted a pattern emerging from the assignments submitted for course credit. In many cases, students struggled with the important skills of developing a position on a topic and developing coherent arguments to support their point of view. Given that the skill of collecting evidence and arguing for a position is a key component of inquiry-based science and with all major reform initiatives, this was most troubling.

These issues were underscored first by student reluctance to consider multiple perspectives for the issue they were examining. During the initial project development, considerable time and effort were expended to make this point clear. With one exception, no student stated that their position had changed during the course of their investigation. Student narratives sometime took on an element of self-parody: "I believe X, some people believe Y, but they're wrong/stupid/ignorant" does not depart significantly from several of the projects submitted.

Students also exhibited a disinclination to take a position. Frequently, after presenting arguments collected on either side of an issue, several students closed with a statement such as "as I have shown here, there are several issues to consider." Frequently, after presenting arguments collected on both sides of an issue, several students closed with a statement such as "as I have shown here, there are several issues to consider. As our state representative, what do *you* believe we should do on this matter?" This reluctance to use the data to make an informed decision was disconcerting, as considerable class time was devoted to the challenges of making decisions based on the data collected; perhaps the desire to not be perceived as wrong prevented these students from presenting their position.

Other students demonstrated a lack of understanding as to how the government functioned. In these cases, students would compose a letter to a legislator seeking legislative remediation, but contacting a member of the national congress to deal with a state or local issue, such as recycling in a school district. A significant number of students attempted to solve all of the challenges created by asking for legislation; other strategies such as economic boycotts, direct action by organized individuals to correct their identified problem, or contacting executive officers of corporations were never attempted.

In terms of developing science instruction in concert with their identified STS issues, students were challenged to implement science beyond a discipline-specific approach. The global approach to identifying science issues within the domain of an STS investigation proved problematic, as students were consistently unable to identify what science content/inquiry skills would be profitably engaged. The broader definitions of scientific literacy, with science representing, in part, argument and explanation, were not well addressed in most of the projects submitted.

The previously noted science and social studies instructional issues exacerbated instructional issues. The project was worth approximately 10% of the course grade in both the science and social studies methods courses. Students, however, demonstrated frustration that the grades were to count for credit in both courses--this occurred after multiple course credit was previously considered to be an advantage. It seems that the challenges they encountered carrying out the assignment--and arguing their points of view effectively--became a serious disincentive when they perceived the assignment as

awarding them a B/C grade in two course assignments, rather than what they had anticipated would be an A/B letter grade.

Students also were frustrated by their belief that "all opinions are valid." While the emphasis by the instructors was on the quality of the argument, students received feedback on the quality of the arguments they offered in a very personal way.

From the experiences here, the instructors are still convinced as to the value of STS as a means of developing effective integrated instruction. To move beyond the challenges experienced during this investigation, several areas of improvement are suggested:

> Develop more experiences to help students learn to develop support positions via the use of data.
> Create more class experiences that demonstrate the means to develop interdisciplinary instruction through the use of real world problems.
> Proceed with caution when implementing interdisciplinary instruction. The high conceptual level of understanding required to effectively implement curriculum of this nature might better be reserved for students who have already taken an initial methods course.

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