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ABSTRACT

The current agenda in science education calls for science instruction that enhances student understanding of the nature of scientific enterprise, enables students to critically analyze scientific information as well as apply it in real-life situations, and sets them on a path of lifelong learning in science. In order to prepare teachers who can facilitate this kind of science instruction, substantial reform of both preservice and inservice science teacher education must occur. This paper describes an attempt to organize a secondary preservice science methods course around a science-technology-society (STS) approach. Student feedback suggests that preservice teachers' predispositions influence their views on the effectiveness of the STS approach. (WRM)

An STS Approach to Organizing a Secondary Science Methods Course: Preliminary Findings

by

Pradeep M. Dass

AN STS APPROACH TO ORGANIZING A SECONDARY SCIENCE METHODS COURSE: PRELIMINARY FINDINGS

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Science Methods Course: The Need for Reform

The current science education reform agenda represented by documents such as the National Science Education Standards (National Research Council, 1996) and Science for All Americans (American Association for the Advancement of Science, 1994) is focused on the teaching and learning of science which goes far beyond the simple transmittal of scientific facts, figures, and processes. The appeal is for science instruction which enhances student understandings of the nature of the scientific enterprise, enables them to critically analyze scientific information as well as apply it in real-life situations, and sets them on a path of life-long learning in science. In order to prepare teachers who can facilitate this kind of science instruction, substantial reform of both preservice and inservice science teacher education must occur. This paper describes an attempt to organize a secondary preservice science methods course around a science-technology-society (STS) approach.

Typically, a critical component of preservice science teacher (PST) education is the science teaching methods course. The intent of this course usually is to help PSTs develop an understanding of various aspects of science instruction such as pedagogical approaches, management strategies, and assessment techniques. Traditionally, PSTs have learned about these aspects in a somewhat isolated manner in the sense that these are taught as separate instructional units. Since the methods course is taken prior to student-teaching and not all methods courses have a field component attached to them, PSTs rarely get an opportunity to see how these different aspects interrelate in the actual classroom context. Also, due to the fragmented approach, methods courses often fail to help PSTs develop a concept of science instruction which can successfully implement current reform proposals (such as relating science to the daily lives and interests of students, accurately portraying the nature of the scientific enterprise, and generating life-long learning habits). In order to alleviate these drawbacks, I tried an STS approach in my secondary science teaching methods course. This approach is defined by the National Science Teachers Association as the teaching and learning of science in the context of human experiences (National Science Teachers Association, 1990-91). The overarching goal of the course was to have PSTs experience the type of science instruction promoted by the current reform agenda as characterized above.

Science for Life: The Course Organizing Module

The module, 'Science for Life' was used as an organizer for the secondary science methods course in the sense that most topics included in a science teaching methods course (such as assessment, cooperative learning, etc.) were experienced by the PSTs within the context of this module throughout the course of the semester. This module was developed with the assumption that the most desirable instruction in the sciences during current times is that which relates science to the lives of students in ways that enables students to see the relevance of science outside the classroom and apply scientific knowledge, principles, and processes to deal with real-life issues, problems, and concerns at both personal and societal levels. To this end, 'Science for Life' engaged PSTs in exploring and experiencing science during a methods course in much the same ways as they should engage their students in secondary science classes. Elements of the Constructivist Learning Model (CLM; Yager, 1991) were employed in engaging in scientific explorations aimed at dealing with a real-life issue, concern, question, or problem selected by the PSTs. Several major aspects of science instruction such as assessment and classroom management were addressed during the course within the context of the module. The module also involved extensive use of modern communication and information technology, thus providing PSTs with experience in integrating technology to enhance science instruction. At the end of the course, PSTs developed an instructional module, based on their own explorations, for use in secondary science classes so as to engage secondary students in science learning which has direct relevance to their lives. They are expected to use their instructional module during student teaching.

Goals of the Module

The goals for school science that underlie the National Science Education Standards (National Research Council, 1996) "define a scientifically literate society" (p. 13). The challenge for preservice science teacher education is to train PSTs in instructional approaches which they can effectively use for the furtherance of these goals in secondary science classrooms. Drawing from NSTA's definition of the STS approach, this module aims to engage PSTs in experiencing science explorations based on real-life issues, concerns, questions, or problems. It is designed to accomplish the following goals with regard to preservice science teacher preparation, which in turn are expected to enable PSTs to further the goals of scientific literacy in secondary science classes.

1. PSTs will learn to engage their students in scientific exploration and inquiry in the natural environment, stimulated by real-life situations, concerns, issues, and questions.

2. PSTs will learn to relate science to the daily lives and interests of their students.

3. PSTs will learn to create effective learning opportunities for students in a community of diverse learners, enabling them to construct meaning from specific science learning experiences.

4. PSTs will develop an understanding of the national, state, and local science standards and will be able to organize science instruction that meets these standards.

5. PSTs will learn to use a variety of authentic and equitable assessment strategies to evaluate and ensure student learning in multiple domains of science.

Resources for the Module

Several resources are important for this module. They can be divided into the following categories on the basis of the nature of resource.

Technology-Related Resources: The module requires availability of computers with internet connection so that PSTs can (a) communicate electronically with the instructor, their peers, and resource persons/organizations around the world and (b) access the world wide web for locating information and other resources. PSTs should have active e-mail accounts. They should also have access to word-processing, graphics, and presentation software.

Human Resources: The module involves communicating with scientists, experts, and organizations involved in work related to the specific problem, issue, or question selected by the PSTs. The purpose of this communication is to get first-hand expert information, learn about actions being taken, and get feedback from these experts on PSTs proposals of solutions and actions. PSTs are expected to locate appropriate human resources themselves.

Literature Resources: Research-based literature related to STS and the CLM in various forms (journal articles, books, monographs, electronic journals, etc.) would be used. Some would be referred to or provided by the instructor and some located by the PSTs.

Major Learning Activities

PSTs work in self-selected pairs throughout this module. Since the module design is based on the constructivist learning model, learning activities can be classified into the following phases.

Invitation: During this phase, PSTs are invited to brainstorm, search, and select one issue, question, or problem (henceforth referred to as TOPIC) based on real-life situations which will form the basis of the rest of their explorations. Each pair of PSTs may select a different topic. The topic may be based on either a global or a local situation but should be such as would arouse the interest and curiosity of high school students. PSTs must provide a rationale for their topic selection. Ideas for some current topics may be found at the following internet web sites: *http://www.whyfiles.news.wisc.edu;* and *http://www. sigmaxi.org.*

Exploration: PSTs explore their topics in terms of the following two components:

1. Identifying critical questions that need to be addressed in order to explore the topic.

2. Gathering and analyzing scientific information and/or data needed to address the questions identified in 1 above.

This phase involves the use of internet and the world wide web as well as traditional print resources to locate and collect relevant information. PSTs identify several agencies, groups, or scientists who are studying issues and questions relevant to their topic and communicate with them electronically to gather latest information as well as to share their own findings, positions, and action proposals with them.

PSTs design hands-on/minds on investigations to conduct original research into questions that emerge. These can be in the form of laboratory experiments, computer analyses, model building, etc. The exploration phase provides the basis for formulating hypothesis, designing explanations, and proposing solutions.

Proposing Explanations and Solutions: During this phase, PSTs synthesize information to formulate hypothesis, design explanations, and propose solutions. This phase involves communicating information and ideas to peers and to the external experts they communicated with during the exploration phase. Feedback from peers and external experts is used to refine hypothesis, explanations, and solutions. Finally, these are assembled in an electronic presentation format.

Taking Action: Based on the synthesis in phase 3 above, PSTs make informed decisions, take specific positions, and suggest appropriate actions. In essence, this is the application phase in which the knowledge gained is applied in terms of actions. Proposed actions may be at the local level such as starting a new recycling program in the school or at a more global level such as communicating with policy-makers to influence decisions regarding environmental issues. PSTs present these action proposals to their peers in the methods class; however, in the secondary classroom setting, they would actually involve their students in carrying out these action proposals.

The learning activities described above are designed to have PSTs experience the constructivist learning model for teaching science. During each of the phases described above, issues such as assessment of student learning, managing cooperative learning groups, and effective use of modern technology, would be discussed and analyzed within the context of the module. These discussions too ought to model the constructivist approach in that the said issues should be discussed at appropriate time as the need to discuss them emerges during the progress of the module and the discussions should be facilitated rather than controlled by the methods instructor. During the course of the module, PSTs maintain a journal to record the learning activities and to write reflective analyses of their own learning experiences. Based on their own explorations within this module, PSTs eventually create an STS instructional module for a secondary science class, which they can use during student teaching.

Assessment

The assessment within this module is designed to gather information on PSTs understanding of reform-oriented science instruction with regard to the following: Constructivist teaching and learning principles; STS principles; nature of the scientific enterprise; and effective use of technology to enhance science instruction.

Both quantitative and qualitative approaches are used to collect assessment data. Quantitative approach includes the use of questionnaires with Likert-type rating scales. These are administered as pre-tests at the beginning of the semester and post-tests at the end of the semester. The following questionnaires found in *The Iowa Assessment Handbook* (Enger & Yager, 1998) were used: Perceptions of Science Teachers about Science; NAEP Questionnaire for Student Views about Scientific Theories and Scientists; What you think about the Nature of Science; Science, Technology & Society Attitude Scale.

Additionally, a questionnaire regarding technology use was administered to collect data on PSTs understanding of effective use of technology to enhance science instruction. This questionnaire was developed by the *Learning with Technology in Higher Education* project of the Northcentral Regional Educational Laboratory (NCREL).

Qualitative approaches include data collection through PSTs presentations of their STS instructional modules at the end of the semester, reflective journals during the semester, and in-depth interviews at the end of the semester.

Preliminary Findings

The quantitative data from the Fall 1998 group have not been analyzed as of this writing. Only preliminary analysis of qualitative data, which involved looking for trends in PSTs thinking about the use of the STS approach, has been conducted. This analysis indicates that PSTs predisposition influenced the quality of their modules as well as their views on the usefulness and effectiveness of this approach in science teaching and learning in the secondary classrooms.

The Fall 1998 group consisted of 8 members. One of them was a practicing middle school teacher taking this course to complete the high school certification requirements. He had already been doing some STS type projects in his middle school classroom. He created an elaborate STS module on the *quality of drinking water* in his town. He found the process very useful in terms of being able to understand what students would experience in an STS approach. The following comments summarize his views.

> As a student (of this methods course), I feel that understanding the process that the student would go through helps design how the teacher should be thinking when designing what he/she expects of the students. Understanding this process of research and development of the topic from invitation to taking action has forced me to take the student's role. I can now say that I do understand what they would encounter.

Another member, who conducted an investigation of the Asian Longhorned Beetle infestation in the Chicago area for his module titled, *Beetlemania,* said that he had been thinking and feeling the same ideas (STS, Constructivism, etc.) for several years. Now he has a name for them. He found it reassuring to discover that other people (the course instructor and authors of literature used in the course, such as P. D. Hurd and R. E. Yager) think the same way. His previous work experiences taught him that you learn by doing things yourself and remember that which you are interested in and apply. So the STS approach and module "clicked" in his own mind. Here is what he said about the STS approach.

> Having completed the STS module, I now have a tremendous appreciation for STS; an appreciation based on experience. The STS approach offers several important benefits including real world experience and relevance to the student's life, but most importantly, STS creates a context in which students find themselves with a need to learn and a use for what is learned.

To include an example of PSTs who did not feel very comfortable with the STS approach and the module, I mention one who, at the end of semester, claimed to be "more confused". He said that he entered the course with a particular style (of science teaching and learning) that "worked for me". This particular style happens to be the didactic, lecture-oriented approach. He has been a research scientist in the field of medical pharmacology, has a Masters degree in Chemistry and was frustrated till the end of semester about adopting the more student-centered, constructivist approaches promoted through the use of the STS module. He claimed he saw the utility in the STS approach but was unable to adapt it within his own personal mind-set perhaps developed through his years of graduate education and research work. His comments in the reflective journal after the completion of his module titled, *Death: An inquiry into man's mortal weakness*, betray his feelings of apprehension.

> Overall, our module had potential. However, the topic itself was too broad and did not lend itself immediately to projects outside of the classroom. Projects inside the classroom required materials that may or may not be accessible to the high school student.

Another pair of students conducted an investigation regarding human nutrition, titled *Tell me what you eat and I'll tell you who you are: A journey in nutrition.*

Once the quantitative data have been analyzed and the qualitative data have been analyzed more thoroughly, a complete picture of the effectiveness of this STS approach in the science methods course will emerge. Further investigation of the quality and extent of the use of the constructivist principles by PSTs during student teaching this spring will indicate the extent to which they have really learned these principles, for real learning connotes use (Reinsmith, 1993).

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