INQUIRY TEACHING: IT IS EASIER THAN YOU THINK!

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Abstract

This article is a survey of the literature on inquiry teaching. Many teachers do not participate in inquiry teaching for various reasons. The following are the main reasons: it takes too much time; students do not learn what they need for the state test; and, the teachers do not know how to grade projects and presentations. These reasons sound like rhetoric from long ago, but it is very current. In this article, research is used to show that students who participate in inquiry learning or any type of problem-based education do much better than students who do not have that opportunity. The student participants not only have better grades, but they think on a higher level, become more civic minded, and are better problem solvers.

Included in the article are four models which can be used to teach inquiry science, and two lesson plans with rubrics to help grade the inquiry STS lesson. The major point being made throughout is that there is an advantage to teaching students using inquiry. The only disadvantage is not giving the students the opportunity to use inquiry and to grow.

Introduction

What is inquiry? When one is asked this question, it can be properly explained that, "It is the process of questioning, asking, and interrogating." Thus, inquiry in science thus would be the process of asking a question or seeking the solutions to science questions. Some teachers will say it is that method which takes too much time. However, there are more definitive and descriptive definitions of inquiry: "Inquiry is the process by which scientists pose questions about the natural world and seek answers and deeper understanding, rather than knowing by authority or other processes" [1]. This should encourage teachers to "yearn" for inquiry and not fear it.

Inquiry is found as a major component of scientific literacy. As a means of the methods of science, it focuses on the basic skills of observing, inferring, predicting, measuring, and experimenting [2]. To many teachers, it is the act of asking students questions, and then directing them on how to answer the questions. There are others who will let students suggest their own questions and design experiments to answer them. In short, there are many interpretations of the

meaning of inquiry, but there really is a definition with special characteristics that make an activity or practice an inquiry one.

Definitions of Inquiry

Science as inquiry is one of the *content standards* of the National Science Education Standards [3]. It is a basic in curriculum organization and in students' science education experience. This standard highlights the ability to do inquiry and the fundamental concepts about scientific inquiry that should develop. The emphasis on inquiry moves, "beyond the processes of science and emphasizes the students' cognitive development based on critical thinking and scientific reasoning required in the use of evidence and information to construct scientific explanations [4].

As one of the science *teaching standards*, it is recommended that effective science teachers plan an inquiry-based science program for their students. This means that the teachers would develop a framework of yearlong short-term goals for students, select science content, and adapt and design curricula to meet the interests and experiences of students. They would also select teaching and assessment strategies that support the development of students' understanding and would nurture a community of science learners. Inquiry-supporting teachers work together as colleagues within and across disciplines and grade levels for the benefit of the students [4].

The National Science Education Standards (NSES) also have *professional development standards* concerning inquiry. It calls for teachers to learn the essential science content through the perspectives and methods of inquiry. It emphasizes that teachers are taught as they will teach their students by stating that science teaching experiences or professional development for teachers must include being a participant in inquiry. This means taking the following actions: actively investigating phenomena that can be studied scientifically, interpreting results, and making sense of findings consistent with currently accepted scientific understanding; addressing issues, events, problems, or topics significant in science and of interest to participants; and, incorporating ongoing reflection on the process and outcomes of understanding science through inquiry [4].

Inquiry teaching goes back to Dewey when he noted that developing thinking and reasoning, formulating habits of mind, learning science subjects, and understanding the process of science were the objectives of teaching science through inquiry [5]. Through the idea of hands-

on science, inquiry was promoted in the 1960s with the goal of engaging students in the kind of science practiced by scientists using hands-on activities, ultimately helping students develop scientific concepts and process skills [6-8].

Inquiry has its beginning in constructivism which included hands-on activities as a way to motivate and engage students while trying to solidify science concepts. Constructivist approaches emphasize that knowledge is constructed by an individual through active thinking, defined as selective attention, and organization of information and integration with or replacement of existing knowledge. In addition, social interaction is necessary to create shared meaning; therefore, an individual needs to be actively engaged both behaviorally and mentally in the learning process for learning to take place. As constructivist approaches permeated much of the educational practices in the 1970s, it became particularly prominent in science education through the focus on inquiry [9].

The NSES extends the definition and differentiates the terms "scientific inquiry," "inquiry learning," and "inquiry teaching." DeBoer stressed that science was both process and product whether it is practiced by scientists or studied in classrooms [10]. Trowbridge, et al. state, "It is important to note, however, inquiry teaching does not require students to behave exactly as scientists do. Science inquiry is simply a metaphor for what goes on in an inquiry-based classroom" [4]. Inquiry can be demonstrated on a continuum. The National Research Council (NRC) defined it as full, partial, open, and guided: full inquiry is when students engage in all features of inquiry; partial is when students engage in fewer essential features of inquiry; open is when fully directed by the students; and, guided is when the teacher directs the activities [6].

Some educators equate inquiry with discovery learning. Discovery learning only involves students using their minds to gain insight into a concept or principle. While in inquiry, an individual may use all of the discovery mental processes in addition to formulating problems, hypothesizing, designing experiments, synthesizing knowledge, and demonstrating such attitudes as objectivity, curiosity, open-mindedness, and respect for theoretical models, values, and attitudes. Inquiry methods seem to engender the following: increase higher level thinking; cause a shift from extrinsic to intrinsic rewards; help students learn how to investigate; increase knowledge retention; make instruction student-centered, thereby contributing to a person's self-

concept; increase expectancy level; develop multiple, not just academic, talents; and, allow more time for students to assimilate and accommodate information [4].

Many researchers, scientists, and educators have studied classrooms and evaluated investigations, experiments, and practices to see the commonalities of those labeled as "inquiry practices." All hands-on activities are not inquiry activities. If students are solving a problem using data analysis which began with a research question, then it is most likely an inquiry-based practice or activity. Another criteria for labeling a science practice or activity as inquiry is if the students use the collected data to answer the research question [2].

Research on Inquiry Practices

Dalton, et al. directly compared two hands-on curricula that made a difference in students learning some physics concepts [11]. It was found that the hands-on activities alone were not sufficient for conceptual change. Students also needed an opportunity to process the activities and concepts. Discussing meaning and interactions through class discussions of the reasons behind the observations in their independent design activity were needed for conceptual change.

Crawford found that mentor teachers' beliefs and preferred instructional approaches influence pre-service teachers' willingness to take risks in creating inquiry-based lessons [6, 12]. Demer and Abell found that teachers not only had a wide variety of conceptions of inquiry, but also considered inquiry as any student-driven activities, student generated questions, and student independent research with either little or no teacher intervention [6]. To promote inquiry in all levels of education, practitioners need to recognize broader views of inquiry that include the essential features of inquiry as supported by the NRC.

It was found in a study by Minner, Levy, and Century that the majority (51%) of their fifty-eight studies showed positive impacts of some level of inquiry on science instruction on student content learning and retention [9]. Forty-five (33%) showed mixed impact of inquiry instruction, nineteen (14%) showed no impact, and three (2%) showed negative impact. There were nine studies that looked at some contrasting aspects of student responsibility for learning. Six of those studies found a statistically significant increase in student conceptual learning when there was more student responsibility in the instruction with higher inquiry saturation. In studies where there were more teacher-directed learning goals and activities or lower inquiry saturation, the student conceptual learning was very low. Five of the six studies also showed a statistically

significant improvement in student conceptual learning from instruction that had hands-on activities with more inquiry saturation when compared with treatment with less emphasis on inquiry-based practices.

The Education Development Center, Inc. (EDC) did a four-year study to address the research question, "What is the impact of inquiry science instruction on K-12 student outcomes?" [13]   One hundred thirty-eight studies were analyzed; they indicated a clear positive trend favoring inquiry-based instructional practices, particularly instruction that emphasized student active thinking and drawing conclusions from data. Teaching strategies that actively engaged the students in the learning process through scientific investigations were more likely to increase conceptual understanding than the strategies that used more passive techniques [9].

The value of the inquiry approach has yielded positive evidence as related to students' attitudes and self-concept, and involving critical thinking rather than traditional instruction. Carnegie-Mellon University found that an inquiry-oriented social studies curriculum significantly increased students' abilities to inquire about human affairs, compared to those who were studying non-inquiry materials [14].

The term "inquiry" has invaded science education with three distinct categories of activities: 1) what scientists do; 2) how students learn; and, 3) a pedagogical approach that teachers use [3, 15]. Whether it is the students, the scientists or the teachers, there are six essential features or components from the learners' perspectives as essential features of classroom inquiry:

1)   Learners are engaged by scientifically oriented questions.

2) Learners give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions.

3) Learners formulate explanations from evidence to address scientifically oriented questions.

4) Learners evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding.

5) Learners communicate and justify their proposed explanations [6, 9, 16].

6) The amount of direction and decision making done by the teacher versus the student has produced distinctions, such as open and guided inquiry [16].

Additional Benefits of Inquiry

Project 2061 defined the goal of inquiry as helping people in every walk of life deal knowledgeably with problems that often involve evidence, quantitative considerations, logical arguments, and uncertainty. Much of the research explained how engaging students in scientific inquiry can serve many purposes, including student motivation, the preparation of future scientists, and the development of citizens who will be autonomous, independent thinkers [6]. Inquiry methods seem to give rise to the following: increase intellectual potency; cause a shift from extrinsic to intrinsic rewards; help students learn how to investigate; increase memory retention; make instruction student-centered, thereby contributing to a person's self-concept; increase expectancy level; develop multiple, not just academic talents; avoid learning only on the verbal level; and, allow more time for students to assimilate and accommodate information [17]. There are many benefits for students using the inquiry method when it is taught correctly.

Inquiry Teaching

There are definitely two aspects of inquiry: one is the students' learning, their attitudes, and their abilities; the other is teaching approaches and learning strategies. Therefore, inquiry instruction can be defined as an active process in which students answer a research question through data analysis. Teachers should be able to scaffold inquiry instruction for the students to help them develop inquiry abilities. By varying the amount of information given to students, teachers can scaffold inquiry activities and model the process of scientific inquiry [2, 18].

An old adage states, "Tell me and I forget; show me and I remember; involve me and I understand." One dictionary defines "inquiry" as "a close examination of a matter in search for information or truth" [19]. That same dictionary defines "involvement" as the process of occupying or engaging the interest of someone. The learning process embraced by inquiry-based learners allows them to utilize what they already know about a topic as the basis for continued learning. The inquiry-based learning approach encourages students to investigate and discover more knowledge about a topic or natural phenomenon as they attempt to determine and understand why something is the way it is or how it works. So, how does this apply to the classroom?

Inquiry-based teaching is a teaching method which combines the curiosity of the students and the scientific method, while developing critical thinking skills of science. Students usually engage in five activities when participating in inquiry practices. The students usually question, investigate, connect evidence to knowledge, share findings, and use evidence to describe, explain, and predict [20].

Inquiry-based lessons encourage students to formulate explanations that address scientific questions. This approach to learning guides students into developing the skills needed to convert information and data into useful knowledge that they can convey to others successfully. According to Chiappetta and Koballa, "Scientific inquiry centers on natural phenomena and is an attempt to understand nature, to explain that understanding, to make accurate predictions from knowledge, and to apply the knowledge to societal needs" [21].

Successful implementation of inquiry-based learning requires that lessons, when developed, encourage students to collaborate with one another, gain a new or deeper understanding of why something is the way it is, and to use this understanding effectively to communicate with others about their findings [3]. This approach differs from the traditional classroom where individual learning is prized, even demanded and tested. Although both classrooms would embrace the scientific method during the learning process, the traditional approach differs in that it offers students a lab with sequenced steps, basic questions, and pre-determined conclusions. The traditional approach makes no allowances for student prior learning or for the individual thought process encouraged by the opportunity to inquire freely. In contrast, students are encouraged to protect their findings from their peers, to share ideas of ways to improve the investigation only if asked, and to communicate with other students during the learning experience only when allowed by the teacher—if they are allowed to talk at all. To be successful with inquiry-based learning, teachers must have an in-depth knowledge and understanding of the topic being presented. They should have the pedagogical tools to support the students in their thought processes while stimulating their interests in learning more than they already do [21]. Just as scientists do, students should have the opportunity to share as they learn, and the teachers should be able to facilitate a forum that encourages discussions and arguments among the students. Having a strong background in the topic is essential. Without in-depth, critical knowledge about a topic, teachers are not going to be effective in leading collaborative discussions which encourages students to evaluate or synthesize what is being presented by classmates. For example, students may need to clarify what they have stated or incorporate visual

models for a better understanding of their position. Teachers should be able to identify that need and facilitate these interactions.

During lesson planning, teachers should anticipate opportunities that may arise where they will need to encourage students to dig deeper into the topic content. Teachers need to consider students' thought processes in their lesson [21]. As teachers compose their lesson plans, the focus should be on ensuring that students will gain the conceptual understanding for the skill or concept. The lesson objectives and assessment measures must reflect this focus. As an example, goals in an introductory, inquiry-based learning lesson would be for students to understand what inquiry is, conduct an investigation utilizing inquiry-based learning, conceptually understand the topic, and demonstrate growth in knowledge by how they develop their conclusions about their investigation.

Because the inquiry-based approach to learning deviates from the traditional classroom approach, teachers must motivate students to learn by inquiry, rather than directing them. In order to motivate students in this learning approach, teachers need to create a rapport with the students. Teachers need to reassure students that there is a support system behind the approach that will not leave them fumbling around, but will offer guidance and structure when required. It is the responsibility of the teachers to ensure that students have a warm, welcoming learning environment that encourages student learning instead of "student floundering." This is a critical factor to ensure individual success in learning.

The demonstration that learning has taken place results when students finish their investigation and are able to apply it to real life, explaining how their findings contribute to society. Full lesson effectiveness is demonstrated when students are able to apply the outcomes of their investigation—their artifacts—across the curricula. This means that students are able to show correlations or applications within subject areas, such as mathematics and language arts. This would be demonstrated by improved expression when writing, and improved analysis when working with mathematics problems.

For students that need enrichment or remediation, inquiry-based learning supports all of the multiple intelligences. Inquiry-based learning encourages students to use their preferred learning style, allowing them to learn in ways that are comfortable for them. This increases successful learning by these students because it reduces stress during the learning process. The

sky is the limit! Using inquiry-based learning allows students who think outside of the box to do so, as well as stay outside the box as long as they wish. It also allows those students that like the "middle of the road" to be in their comfort zone. For remedial students, this approach encourages them to collaborate with others, to develop their own ideas, and to capture explorations on paper in a way that is less threatening, because help from mentoring students or even from the teacher is part of the course of learning rather than the exception. It allows these students to explore and learn by doing, thus giving them control over how they learn. It is the role of the teacher to facilitate the learning process, keep students on task, and ensure a learning environment that encourages each student to strive for their full potential.

Inquiry-based learning is supported by both long-term and short-term goals, just as any learning should be. The experiences of inquiry-based learning support all learners regardless of their educational background or capabilities. Teachers are challenged by inquiry-based learning to create environments and experiences that ensure all students will gain additional knowledge, apply that knowledge, and evaluate that knowledge culminating in the ability of the students to apply their new knowledge to real-life experiences. Inquiry-based learning is a proven approach that teachers can use successfully to develop students interested in answering their own questions and owning their own knowledge.

Teaching Models

To ensure that students have successful experiences using inquiry, teachers must feel secure that they can teach and coach the students in the inquiry process. The authors introduce the teachers to four inquiry teaching models: 1) the traditional Suchman model, 2) the 5-E model, 3) the Science Technology Society (STS) model, and 4) the Problem-Based model. Each teaching model relinquishes more responsibility to the students to the extent that the STS and Problem-Based Learning models can be full inquiry.

Traditional Suchman Inquiry Model — The traditional Suchman inquiry model consists of five steps: 1) posing a question; 2) constructing a hypothesis; 3) designing a plan to answer or research the hypothesis; 4) reevaluate the hypothesis after the collection of data; 5) forming a general statement about the results from the data collection process, and then sharing and teaching it to the class [3, 22-25]. In pre-service classes and professional development sessions, I use the Traditional Inquiry Model organizer with the teachers. Phase I of this process introduces the teachers to the variability of inquiry (see Appendix A) and shows how to focus on the student

and not just the task. The phases or steps in this model are defined and explained in Appendix B. Teachers are then asked to complete the organizer (see Appendix C), anticipating what the students will do when answering research questions. It is visible and written for the teacher to see that the student is to do these activities and practices without the intervention of the teacher. It takes some time, but after several practices, written and orally, the teachers begin to understand that inquiry is about the students' learning, hypothesizing, examining, and forming conclusions.

5-E Inquiry Model — The five steps learning cycle, or the 5-E model, includes five phases: 1) engagement, 2) exploration, 3) explanation, 4) elaboration, and 5) evaluation. The engagement phase is used to pique the students' interest and provide focus for the activities. The exploration phase proceeds like guided discovery where the teacher serves as a facilitator. The explanation phase includes more involvement of the teacher with the introduction of new concepts while answering questions and guiding students to connect the new knowledge with their prior knowledge. The elaboration phase follows the explanation phase and includes students or students' groups applying newly learned concepts to new situations. Students show the ability to transfer their learning in this phase. The final phase is the evaluation phase where the learning and understanding are assessed. This assessment can be formal, informal, or even a self-assessment, but students are given feedback at this time [26]. The stages are dominated by the students' actions, except the explanation phase (see Appendix D) where the teacher can lead discussions and help students make connections with the new knowledge.

Science Technology Society (STS) Inquiry Model — The third model, Science Technology Society (STS), is similar to the traditional Suchman inquiry model except students study an issue and then exhibit or propose a behavior change. They (students in pairs or groups) proceed through the five steps; in addition, they propose a solution to the issue, and design and execute a plan to address or solve the issue. The STS movement/curricula intent was to integrate technological and societal issues into the science classroom. It put the motivation for science instruction in the natural curiosity to understand the world. Once the understanding is obtained, the knowledge is then applied [27].

The STS lesson is an integrated science lesson which shows the impact of science on technology and the impact of technology on society. It demonstrates the following: how progress affects people; how people interact with progress or new technology; and, the impact of new technology on the world. The STS lesson not only teaches content and technology, but it

requires some actions from the students. The students must perform some task, such as make a presentation to a governing body, construct posters to inform the community, or survey the community to see if they are aware of a specific issue. It can be used with either the Traditional Inquiry Method (see Appendix B) or the 5-E Model (see Appendix D).

Problem-Based Learning (PBL) — Another approach to science education and the teaching of science is the design-based or project based immersion units referred to as full inquiry units or Project-Based Science (PBS). Those units usually last for some weeks and provide students with one overarching problem. Most of the projects have learning goals in areas that include communication about scientific explanations or arguments, and students developing scientific reasoning. Design-based curriculum like PBS evolved out of an engineering model of teaching and learning, and has a strong focus on applying science concepts to solve real-world problems [28]. This epistemological view, like the integrative view, is nonlinear. Knowledge taught to students in an integrative curriculum is taught around broad themes and issues that are important to students and part of their lives: "Curriculum is integrative when it helps make sense of their life experiences" [29, 30]. It helps students find answers to their questions and solve problems in the learning process. Many studies which have used this method have had successful and promising results [31].

The distinction between problem-based learning and other forms of active learning often are confusing because they share certain common features and approaches. However, an essential component of problem-based learning is that content is introduced in the context of complex, real-world problems. In other words, *the problem comes first* [32, 33]. This contrasts with prevalent teaching strategies where the concepts, presented in a lecture format, precede "end-of-the-chapter" problems. In problem-based learning, students working in small groups must identify what they know and, more importantly, what they don't know and must learn (learning issues) in order to solve a problem. These are prerequisites for understanding the problem and making decisions required by it. The nature of the problem precludes simple answers. Students must go beyond their textbooks to pursue knowledge in other resources in between their group meetings. The primary role of the instructor is to facilitate group process and learning, not to provide easy answers. Different forms of assessment come with the change in format, such as group examinations and application of the new knowledge.

The model for problem-based learning comes from a few medical schools, notably McMaster, where more than twenty-five years ago, they questioned how well traditional, pre-clinical science courses trained physicians to be problem solvers and lifelong learners [34]. Information-dense lectures presented by a series of content experts to large student audiences seemed disconnected from the practice of medicine that required integration of knowledge, decision making, working with others, and communicating with patients. The curricula of several medical schools now include problem-based, pre-clinical science courses. The effectiveness of the problem-based learning approach in the medical school environment has been debated, evaluated, and given qualified endorsement based on a number of studies [35-37].

In problem-based learning (PBL), students use "triggers" from the problem case or scenario to define their own learning objectives. Subsequently, they do independent, self-directed study before returning to the group to discuss and refine their acquired knowledge. Thus, PBL is not about problem solving per se, but rather it uses appropriate problems to increase knowledge and understanding. The process is clearly defined, and the several variations that exist all follow a similar series of steps (see Appendix E).

There have been significant scholarly achievements seen with PBL. With the successful achievement results, it is believed that PBL should be promoted in middle school classrooms [31, 38]. Traditionally underrepresented groups in science have higher achievement with problem-based learning, and this would provide an opportunity for increased science achievement by all students.   Problem-based learning is compatible to many of their learning styles, field dependency. Problem-based learning would give all students an opportunity for higher-level thinking and transformational opportunities in their daily lives. The problems are usually relevant, but always involve the students' contributions and understanding.

Inquiry Lessons

There are seven important elements of any inquiry lesson:

1) The Problem—Meets the condition of focus, and the problem should be real, meaningful, and capable of study [39];

2) The Background Information—Some means of putting the class on a common level;

3) The Materials—Same as Suchman's responsive environment;

4) The Guiding Question—Consists of an anticipated list of questions to be asked by the teacher to direct students' thought processes;

5)   The Hypothesis—Should be formulated as a result of discussions and guiding questions;

6)   The Data Gathering and Analysis—The hands-on components and experimental parts of the inquiry lesson (this is a low pressure area to allow for mistakes and repeats);

7)   The Conclusion—The lesson's closure should culminate in some final result based on experimentation and discussion (group conclusions are accepted) [4].

There is a great deal of information and various models to enable use of inquiry in the classroom. Because of its effectiveness with all students, it can be applied as guided and full inquiry using some of the traditional lessons. It depends on the amount of student interaction compared to the teacher interaction and input. For the classroom teacher, Appendix F shows a traditional lesson converted to a guided inquiry lesson. This is to illustrate that "It is easier than you think!"

References

[1]   *National Science Education Standards: A Sampler*, National Commission on Science Education Standards and Assessment, National Research Council, Washington, DC, 1992.

[2]   R. Bell, J. Maeng, and E. Peters, "Teaching about Scientific Inquiry and the Nature of Science: Toward a More Complete View of Science Executive Summary," 2010; Internet: www.vamsc.org.

[3]   *National Science Education Standards*, National Research Council, Washington, DC, 1996.

[4]   L. Trowbridge, R. Bybee, and J. Powell, *Teaching Secondary School Science: Strategies for Developing Scientific Literacy*, Pearson Publishing, NJ, 2004.

[5]   J. Dewey, *Democracy and Education*, Macmillan Publishing, New York, 1944.

[6]   A. Demir and S. Abell , "Views of Inquiry: Mismatches between Views of Science Education Faculty and Students of an Alternative Certification Program," *Journal of Research in Science Teaching*, **47**(6) (2010) 716-741.

[7]   F. Rutherford, "The Role of Inquiry in Science Teaching," *Journal of Research in Science Teaching*, **2** (1964) 80-84.

[8]   J. Schwab, "The Teaching of Science as Inquiry," in J.J. Schwab and P.F. Brandwein (eds.), *The Teaching of Science,* Harvard University Press, Cambridge, MA, 1962.

[9]   D. Minner, A. Levy, and J. Century, "Inquiry-Based Science Instruction—What Is It and Does It Matter? Results from a Research Synthesis Years 1984 to 2002," *Journal of Research in Science Teaching*, **47**(4) (2010) 474-496.

[10]   G. DeBoer, "Historical Perspectives on Inquiry Teaching in Schools," in L. Flick and N. Lederman (eds.), *Scientific Inquiry and the Nature of Science: Implications for Teaching, Learning, and Teacher Education*, Kluwer, Dordecht, The Netherlands, 2004.

[11]   B. Dalton, C. Morrocco, T. Tivnam, and P. Mead, "Supported Inquiry Science: Teaching for Conceptual Change in Urban and Suburban Classrooms," *Journal of Learning Disabilities*, **30** (1997) 670-684.

[12]   B. Crawford, "Learning to Teach Science as Inquiry in the Rough and Tumble of Practice," *Journal of Research in Science Teaching*, **44** (2007) 613-642.

[13]   Education Development Center, Inc. website; Internet: http://www.edc.org.

[14]   E. Fenton, "Inquiry Techniques in the New Social Studies at Carnegie-Mellon University," *The High School Journal*, **55**(1) (1971) 28-40.

[15]   *Science for All Americans*, American Association for the Advancement of Science, Washington, DC, 1989.

[16]   *Inquiry and the National Science Education Standards*, National Research Council, Washington, DC, 2000.

[17]   J. Bransford, A. Brown, R. Cocking (eds.), *How People Learn: Brain, Mind, Experience, and School*, National Research Council, Washington, DC, 2000.

[18]   R. Bell, L. Smetana, and I. Binns, "Simplifying Inquiry Instruction: Assessing the Inquiry Level of Classroom Activities," *The Science Teacher*, **72**(7) (2005) 30-33.

[19]   American Heritage College Dictionary, Houghton Mifflin Harcourt, Boston, MA, 2010.

[20]   A. Warner and B. Myers, "Implementing Inquiry-Based Teaching Methods," 2011; Internet: http://edis.ifas.ufl.edu/wc076.

[21]   E. Chiappetta and T. Koballa, *Science Instruction in the Middle and Secondary Schools*, Allyn & Bacon, NY, 2010.

[22]   A. Cavallo and P. Dunphey, "Sticking Together: A Learning Cycle Investigation about Water," *The Science Teacher*, **69**(8) (2002) 24-28.

[23]   A. Bodzin and K. Beerer, "Promoting Inquiry-Based Science Instruction: The Validation of Science Teacher Inquiry Rubrics (STIR)," *Journal of Elementary Science Education*, **15**(2) (2003) 39-49.

[24]   D.W. Sunal and C.S. Sunal, *Science in the Elementary and Middle School*, Merrill-Prentice Hall, Upper Saddle River, NJ, 2003.

[25]   D. French, "'Inquiry' a Mistake? It's All in the Name," *Journal of College Science Teaching*, **35**(1) (2005) 60.

[26]   A. Carin, J. Bass, T. Contant, *Teaching Science through Inquiry*, Pearson, NJ, 2005.

[27]   A. Lawson, *Science Teaching and the Development of Thinking*, Wadsworth, Belmont, CA, 1995.

[28]   C. Buxton and E. Provenzo, *Teaching Science in Elementary and Middle School*, Sage Publications, CA, 2007.

[29]   *This We Believe*, National Middle School Association (NMSA), OH, 1999.
[30]   S. Thompson, *Reforming Middle Level Education*, Information Age Publishing, CT, 2004.

[31]   O. Lee and A. Luykx, *Science Education and Student Diversity*, Cambridge Press, Cambridge, UK, 2006.

[32]   D. Boud, *Reflection: Turning Experience into Learning*, Routledge, New York, NY, 1985.

[33]   D. Boud and C. Feletti, *The Challenges of Problem-Based Learning*, St. Martin's Press, New York, 1991.

[34]   H.S. Barrows and R. Tamblyn, "Problem-Based Learning: An Approach to Medical Education," Springer Publishing Co., New York, NY, 1980.

[35]   M. Albanese and S. Mitchell, "Reviews of the Effectiveness of Problem-Based Learning," 1993; Internet: http://www2.glos.ac.uk/offload/ceal/resources/reviews.pdf.

[36]   L. Berkson, "Problem-Based Learning: Have Expectations Been Met?" *Academic Medicine*, **68** (1993) 579-588.

[37]   D.T. Vernon and R. Blake, "Does Problem-Based Learning Work?" *Academic Medicine*, **68** (1993) 550-553.

[38]   Y. Majors and S. Ansari, "Cultural Community Practices as Urban Classroom Resources," in L. Tillman (ed.), *Handbook of African-American Education*, Sage Publications, New York, 2009.

[39]   A.L. Suchman, "Control and Relation: Two Foundational Values and Their Consequences," in A.L. Suchman, R.J. Botelho, and P. Hinton-Walker (eds.), *Partnerships in Healthcare: Transforming Relational Process*, Univ. of Rochester Press, Rochester, NY, 1998.

Appendix A
The Inquiry Process

Phase 1: Description of Inquiry Activities

I. Inquiry can be viewed as a systematic way to investigate a question or problem.
Scientists use the process of inquiry to generate and validate knowledge.

Examples: The investigation of disease and other health-related matters are all essentially inquiry problems.

- The tentative conclusions suggesting that smoking, high cholesterol foods, excessive weight, and lack of exercise are detrimental to health are the result of inquiry.
- They originate in studies that ask questions, such as "Why does one sample of people have a higher incidence of heart disease than does another?"
- The decision to install black boxes in aircraft attempts to answer the question, "Why did the accident happen?"
- "Why did the students in one set of classrooms achieve more than those in another set of classrooms?"

Inquiry is a process for answering questions and solving problems based on facts and observations.

II. At the classroom level, inquiry is a teaching strategy designed to teach students how to attack questions and problems encountered in various content areas. As a teaching strategy, the Inquiry Model is operationally defined as a five-step method that proceeds as follows:
   1. Question or problem identification
   2. Hypothesis generation
   3. Data gathering
   4. Assessment of hypotheses through data analysis
   5. Generalizing

III. Inquiry is a model designed specifically for the development of thinking skills.
Students develop their skills first at the general problem-solving level, and they also practice the specific micro-thinking skills contained within the model, such as generating hypotheses and analyzing data.

Appendix B
The Inquiry Teaching Model

Phase II. 5 General Steps

This Inquiry Teaching Model is designed to aid the student to facilitate inquiry science processes while teaching traditional science concepts. This model reflects and resembles the Scientific Methods which is an inquiry method as well. It allows the students to imitate the scientists and investigate questions of their own. The 5 general steps are:

1. **Question or problem identification—**student or groups brainstorm and identify a problem or question they wish to solve.

2. **Hypothesis generation—**student or groups brainstorm and identify a hypothesis they wish to test**.**

3. **Data gathering**—student or groups brainstorm and identify a procedure they wish to follow. They write out the procedure they wish to use, gather materials needed, and test for their variable. They collect data in this step and use it to accept their hypothesis and form their result statement or generalizing statement.

4. **Hypothesis Assessment—**student or groups brainstorm and decide to accept their hypothesis or reject it. They discuss the results they got and compare it with the question and hypothesis. Based upon their decision, they form a generalizing statement based upon what they did in their investigation.

5. **Generalizing—**student or groups brainstorm and identify a generalizing statement from their experimentation. All groups will share their results with the class for the class to form a generalizing statement/s if possible.

Appendix C
Inquiry Teaching Model

Phase III. Students' Actions

In the procedure section of your lesson plan or the presenter's lesson, one should see the five steps of the Inquiry Model of Teaching. Please check it off as it is indicated in the column under "The Student will." The Inquiry model is a student-centered model, so the students should perform the actions. Please write what the students will do for each step under the column, "Actions by students/The Student will:"

Steps	Actions by students/The Student will:
1. Question or problem identification	
2. Hypothesis generation	
3. Data gathering and plan of testing	
4. Hypothesis Assessment	
5. Generalizing	

Appendix D
5-E (Inquiry) Teacher and Student Actions

Stages Of the Instructional Model	What the Teacher Does	What the Student Does
Engage	Creates interest. Generates curiosity. Identifies what the student knows about the topic.	Asks questions, such as: Why did this happen? What do I already know about this? What can I find out about his? Show interest in the topic.
Explore	Encourages students to work together without direct instruction from the teacher. Observes and listens to students as they interact. Asks probing questions to redirect students' investigations when necessary. Provides time for students to puzzle through problems. Acts as a consultant for students.	Thinks freely, but within the limits of the activity. Tests predictions and hypotheses. Forms new predictions and hypotheses. Tries alternatives and discusses them with others. Records observations and ideas. Suspends judgment.
Explain	Encourages students to explain concepts and definitions in their own minds. Asks for justification (evidence) and clarification from students. Formally provides definitions, explanations, and new labels. Uses students' previous experience as the basis for explaining concepts.	Explains possible solutions or answers to others. Listens to and tries to comprehend explanations offered by the teacher. Refers to previous activities. Uses recorded observations in scientific explanations.
Elaborate	Expects students to use formal definitions and explanations. Encourages students to apply the concepts and skills in new situations. Reminds students to data and evidence and asks: What do you already know? Why do you think..?	Applies new labels, definitions, explanations and skills in new, but similar, situations. Uses previous information to ask questions, propose answers, make decisions, design experiments. Draws reasonable conclusions from evidence. Records observations and explanations. Checks for understanding among

		peers.
Evaluate	Observes students as they apply new concepts and skills. Assesses students' knowledge and/or skills.	Answers open-ended questions by using observations, evidence, and previously accepted explanations.
	Looks for evidence that students have changed their thinking and behaviors.	Demonstrates an understanding or knowledge of the concept or skill.
	Allows students to assess their own learning and group-process skills. Asks open-ended questions, such as: why do you think..? What evidence do you have? What do you know about? How would you explain..?	Evaluates his or her own progress and knowledge. Asks related questions that would encourage future investigations.

Appendix E
STS Sample Lesson 2 for Pre-Service and In-Service Teachers

Major Standards and Prompt

1. Content. Teachers of science understand and can articulate the knowledge and practices of contemporary science. They can interrelate and interpret important concepts, ideas, and applications in their fields of licensure, and can conduct scientific investigations. To show that they are prepared in content, teachers of science must demonstrate that they:

(a) understand and can successfully convey to students the unifying concepts of science delineated by the National Science Education Standards;

(b) understand and can successfully convey to students important personal and technological applications of science in their fields of licensure.

2. Nature of Science. Teachers of science engage students effectively in studies of the history, philosophy, and practice of science. They enable students to distinguish science from nonscience, understand the evolution and practice of science as a human endeavor, and critically analyze assertions made in the name of science. To show they are prepared to teach the nature of science, teachers of science must demonstrate that they:

(a) understand the historical and cultural development of science and the evolution of knowledge in their discipline;

(b) understand the philosophical tenets, assumptions, goals, and values that distinguish science from technology and from other ways of knowing the world.

3. Inquiry. Teachers of science engage students both in studies of various methods of scientific inquiry and in active learning through scientific inquiry. They encourage students, individually and collaboratively, to observe, ask questions, design inquiries, and collect and interpret data in order to develop concepts and relationships from empirical experiences. To show that they are prepared to teach through inquiry, teachers of science must demonstrate that they:

(a) understand the processes, tenets, and assumptions of multiple methods of inquiry leading to scientific knowledge.

4. Issues. Teachers of science recognize that informed citizens must be prepared to make decisions and take action on contemporary science- and technology-related issues of interest to the general society. They require students to conduct inquiries into the factual basis of such issues and to assess possible actions and outcomes based upon their goals and values. To show that they are prepared to engage students in studies of issues related to science, teachers of science must demonstrate that they:

(a) understand socially important issues related to science and technology in their field of licensure, as well as processes used to analyze and make decisions on such issues.

5. General Skills of Teaching. Teachers of science create a community of diverse learners who construct meaning from their science experiences and possess a disposition for further exploration and learning. They use, and can justify, a variety of classroom arrangements, groupings, actions, strategies, and methodologies. To show that they are prepared to create a community of diverse learners, teachers of science must demonstrate that they:

(a) Vary their teaching actions, strategies, and methods to promote the development of multiple student skills and levels of understanding;

(b) Successfully promote the learning of science by students with different abilities, needs, interests, and backgrounds;

(c) Successfully organize and engage students in collaborative learning using different student group learning strategies;

(d) Successfully use technological tools, including but not limited to computer technology, to access resources, collect and process data, and facilitate the learning of science;

(e) Understand and build effectively upon the prior beliefs, knowledge, experiences, and interests of students;

(f) Create and maintain a psychologically and socially safe and supportive learning environment

6. Science in the Community.   Teachers of science relate their discipline to their local and regional communities, involving stakeholders and using the individual, institutional, and natural resources of the community in their teaching. They actively engage students in science-related studies or activities related to locally important issues. To show that they are prepared to relate science to the community, teachers of science must demonstrate that they:

(a)   identify ways to relate science to the community, involve stakeholders, and use community resources to promote the learning of science.

An Example of a STS Lesson

Prompt: You will be given or allowed to choose a relevant and current issue in the scientific perspective, include opinions of all stakeholders, and propose a solution based upon the data collected (NSTA 3.0).

Example: In a city in a southern state, there is a prominent chemical company named Velux. *If you investigated this problem, you would find out what chemical Velux manufactures and give the chemistry background of the chemical.* Velux has been accused of dumping the chemicals and by-products into Calm Creek which runs through several northern communities (NSTA 4.0, 7.0). These communities have been found through research and documentation to have high deaths due to cancer. *You will need to get the facts from past records and interview a sample of persons from each affected neighborhood to get the perspectives of these stakeholders. The opinions of the Velux employees and owners are important, too* (NSTA 2.0).

The public asserts that Velux's chemical has penetrated the soil of the surrounding communities and has caused illness in children, also. *You can do soil testing or find records of soil testing done in the areas. If you are a biology teacher, you may want to look for flora and fauna at, in, and along the creek* (NSTA 1.0).   *You may want to survey the schoolchildren or*

children living near Calm Creek to see if they noticed anything or has any idea about this issue. Soil around one apartment complex was excavated and replaced. An earth science teacher may wish to pursue this. *Find out what the apartment manager/owner knows and what is told to prospective renters about the soil.*

I think you are getting the picture and can see that science is an important and integral part of local and regional communities. It is also relevant to your students. You will notice that scientific and community issues involve stakeholders, and whether individual or institutional, they value the natural resources of the community, but in different ways. As you design your inquiry STS project, you will identify a discipline and a concept to follow as you identify ways to relate science to the community, involve stakeholders, and use community resources to promote the learning of science (NSTA 7.0).

Finally, you will write a lesson plan and scoring rubrics to show how you would involve students successfully in activities that relate your science issue to resources and stakeholders in the community and to the resolution of issues important to the community. You will state the follow-up action/behavior expected of your students based upon this data (see Appendix G).

Appendix F
Sample Lessons for Classroom Students

I.   Hydrogen Peroxide and Potatoes: Actions of an Enzyme

Grade Level: 7-12
National Science Standards: Life Science Content Standards
- Using concepts and processes
- Science as inquiry
- Physical science: chemical reactions

Lesson Objectives:
- The student will experience inquiry through this investigation.
- The student will explore and discover what happens when hydrogen peroxide and potatoes come in contact.
- The student will evaluate what a catalase is and how it is used.
- The student will describe the relationship between organic matter and a catalase.

Materials:
Tomatoes, raw chicken livers, potatoes, hydrogen peroxide, eye droppers, knife.

Safety:
Applicable safety rules will be written on a poster and discussed before beginning the activity.

Lesson Activities:
1. Students will pair in groups of four to do the experiment. They will gather prior knowledge about hydrogen peroxide and how it reacts with organic material. Students will create a KWL chart to determine what questions they need to answer based on the guidelines of the experiment.
2. Students will research hydrogen peroxide and catalase. They will make predictions of the possible outcomes prior to beginning the experiment. Students will write a problem and then a hypothesis based on their research (see Appendix E).
3. Students will perform the experiment based on the guidelines that are given by the teacher or on the ones they are allowed to develop themselves. Students may choose to modify the experiment based on research and permission from the teacher. The students will test the catalase on the tomatoes, chicken livers, and potatoes to discover and explore what happens.
4. The students will record their data in each group and collaborate together to determine if their results validated their hypothesis or if another experiment needs to take place.
5. Once the students have determined what a catalase is, what the reaction is and why it takes place, the students will create a presentation to present their findings.

6. The presentation will report their findings. The teacher should look for relationships, correlations, and discoveries during the presentation to gauge the students' conceptual understanding.   This will tell the teacher how to proceed with the students.   The objectives should be stated in their own words by explaining how they conceptually understood them (Johnson and Raven, 2001).

Assessment:
Participation Rubric, Presentation Rubric, Graded Teacher-Created Worksheet

Enrichment:
Where else can we see catalase or any enzyme being used? What are advantages and disadvantages of catalase or other enzymes?
Students will be asked to design another experiment that will further their understanding of organic/inorganic matter and catalase.

Appendix G
Lesson Design for Learning

Daily Lesson Planning Form
(For all types of science lessons)

Name_____Subject/Grade_____Date_____	

Curriculum Connections   ___Six Weeks   Length of Lesson _____days

Curriculum Guide Objective/National Science Standards:
 1.0 Content
 2.0 Nature of Science
 3.0 Inquiry
 4.0 Issues
 5.0 General Skills of Teaching
 7.0 Science in the Community

For SPI, see the Major standards on the prompt page.

Guiding Question

How does pollution from plants and factories affect the environment?

Concepts: chemistry, biology, botany, pH, soil types

Motivation

How many of you pass the bakery on the way to school or home? How can you tell when you are near it? Why?

Student Participation: Whole class, individually, and in pairs.

Relate to Previous Learning: Remember when we talked about ozone, car emissions, and how it affected the atmosphere? How do you feel about carbon emission today? Why?

Relate to Student Experience: Do you remember how this community got sidewalk recycling bins? (*Some students may remember my class taking a survey to see who would use the bin at their home if the City gave them free recycling bins. They then mailed officials at City Hall and told them what data they had collected concerning recycling bins in their neighborhood.*)

Today we will look at another issue confronting this community.

Strategies/Activities/Distributed Practice/Intervention	**Assessment/s**
• Students will get in groups of four and	• Notes on concepts being researched.

brainstorm their problems using the traditional inquiry model worksheet (student version). • All groups will debrief to the whole class. • Students will get in pairs and decide if they want to change their hypothesis and research a different part of the problem. • They will write another plan and begin to do their research. They will do most of the research out of class and in class, the content and concepts will be discussed.	• Written report containing academic language for the project. • Having a plan deciding how to address the issue. • Result of the action to address the issue. • Result of the research showing information on increased knowledge related to the chosen concept. (*The rubric will usually help detect this, but teachers should look for this growth in the reports.*)

Closure

Each pair of students will report and afterward the whole class will respond to the community and other stakeholders to offer assistance and gratitude.

Extend and Refine Knowledge	**Assessment/Student Products and Performances/Technology**
Students may make an informative brochure for the stakeholders with the company or the positive stakeholders. They may investigate other companies within communities.	Students can make a video of the community showing the positive and negative effects of the company. They can sponsor a health night with the medical community and find out if the community has a health problem related to the company.

Appendix G (cont'd.)
The STS Lesson Rubric Criteria

Explanations

Explanation of the points 0, 1, 2 are shown below on the abbreviated rubric. These are from the *National Science Education Standards* and they explain what the pre-service teacher (candidate) should be able to do in a college classroom and in a public school classroom. (0 means that the knowledge is limited and the academic language is not there; 1 means that the knowledge level is acceptable and the academic language is there; and 2 means that the candidate has successfully exhibited the knowledge requested and has used the academic language excellently.

Standards Correlation and Scoring Rubric

NSTA Standards	0 Unacceptable	1 Acceptable	2 Optimal
NSTA 1B	Candidate does not understand and cannot successfully convey to students the unifying concepts of science.	Candidate understands and can minimally convey to students the unifying concepts of science.	Candidate understands and can successfully convey to students the unifying concepts of science delineated by the *National Science Education Standards*.
NSTA 1C	Candidate does not understand and cannot convey to students important personal and technological applications of science.	Candidate can convey to students some important personal and technological applications of science.	Candidate understands and can successfully convey to students important personal and technological applications of science in their fields of licensure.
NSTA 2A	Candidate does not understand the historical and cultural development of science and the evolution of knowledge in	Candidate understands the historical and cultural development of science and the evolution of knowledge in their	Candidate successfully understands the historical and cultural

	their discipline.	discipline.	development of science and the evolution of knowledge in their discipline.
NSTA 2B	Candidate does not demonstrate the philosophical tenets, assumptions, goals, and values that distinguish science from technology and from other ways of knowing the world.	Candidate does demonstrate the philosophical tenets, assumptions, goals, and values that distinguish science from technology and from other ways of knowing the world.	Candidate does demonstrate and understand the philosophical tenets, assumptions, goals, and values that distinguish science from technology and from other ways of knowing the world.
NSTA 3A NSTA 3B	Candidate does not demonstrate the processes, tenets, and assumptions of multiple methods of inquiry leading to scientific knowledge.	Candidate demonstrates the processes, tenets, and assumptions of inquiry leading to scientific knowledge.	Candidate demonstrates and understands the processes, tenets, and assumptions of multiple methods of inquiry leading to scientific knowledge.
NSTA 4A	Candidate does not demonstrate the socially important issues related to science and technology and the processes used to analyze and make decisions on such issues.	Candidate demonstrates important issues related to science and technology and some processes used to analyze and make decisions on such issues.	Candidate demonstrates and understands socially important issues related to science and technology, as well as processes used to analyze and make decisions on such issues.
NSTA 7A	Candidate does not identify ways to relate science to the community, involve stakeholders, or	Candidate does identify ways to relate science to the community, involve stakeholders, and use	Candidate understands and identifies ways to relate science to the

	use community resources to promote the learning of science.	community resources to promote the learning of science.	community, involve stakeholders, and use community resources to promote the learning of science.
NSTA 1B NSTA 5A	Candidate does not give the title of the lesson and the designated grade (s) within specified time.	Candidate gives the title of the lesson and the designated grade (s).	Candidate successfully displays the title of the lesson, designated grade (s) and specified time.
NSTA 1B9 NSTA 5A	Candidate does not specify the NSTA or district science standards.	Candidate identifies the NSTA or district standards.	Candidate specifies the NSTA and the district science standards.
NSTA 1B9 NSTA 5.0	Candidate does not identify a major question or issue to guide the lesson.	Candidate gives a question or issue which weakly connects to or guides the lesson.	Candidate successfully identifies a major question or issue to guide the lesson.
NSTA 5.0 NSTA 1C	Candidate does not identify or name the major concepts which will be taught.	Candidate identifies a concept which will be taught.	Candidate successfully identifies major concepts and connections which will be taught.
NSTA 1B9	Candidate does not identify stakeholders and views.	Candidate identifies some stakeholders and some views.	Candidate identifies all stakeholders and examines all views.
NSTA 1B	Candidate does not identify a focus or attention set to start the lesson.	Candidate attempts a focus or attention getter to start the lesson.	Candidate successfully begins lesson with a relevant focus or attention getter to start the lesson.
NSTA 1B3	Candidate does not use community resources to	Candidate uses some community resources to	Candidate successfully uses

NSTA 7A	teach the lesson (people, natural, institutional).	teach the lesson (people, natural, or institutional).	community resources to teach the lesson (people, natural, institutional).
NSTA 1A	Candidate does not specify strategy or integration to teach the science behind the issues.	Candidate does specify strategy or integration used to teach the science behind the issues.	Candidate successfully identifies specific strategy or integration to teach the science behind the issues.
NSTA 2B NSTA 4B	Candidate does not use technology or specify interaction with and impact on society.	Candidate uses technology and minimally integrates the impact on society.	Candidate uses technology and successfully integrates the interaction with and impact of technology on society.
NSTA 1B9 NSTA 4B	Candidate does not relate science to the resources and to the resolution of the issues.	Candidate does relate science to the resources and to the resolution of the issues.	Candidate successfully relates science to the resources and to the resolution of the issues.

Appendix G (cont'd.)
The STS Lesson Plan Grading Rubric

This rubric is used to grade/evaluate your lesson plan. The above rubric categories have been shortened to state which standard is being used, such as NSTA 1b, and the earned points for each standard will be circled and totaled.

Components	Descriptions	Points
	NSTA Standards	
1.NSTA 1B	Unifying concepts of science are delineated.	0 1 2
2.NSTA 1C	Personal and technological applications of science are delineated.	0 1 2
3.NSTA 2A	Understand the historical and cultural development of science and the evolution of knowledge in their discipline.	0 1 2
4.NSTA 2B	The philosophical tenets, assumptions, goals, and values that distinguish science from technology and from other ways are discussed.	0 1 2
5.NSTA 3A	The processes, tenets, and assumptions of multiple methods of inquiry are demonstrated.	0 1 2
6.NSTA 4A	Socially important issues are related to science and technology, and decisions made on such issues.	0 1 2
7.NSTA 7A	Related science to the community and stakeholders.	0 1 2
	Lesson Plan Components	
8.NSTA 9.0 **Safety**	Appropriate safety rules and safety plans are reviewed with students.	0 1 2
9.NSTA 5.0 **Grade Level, Title, Length of Time**	Title of the lesson and the designated grade (s) within time specified.	0 1 2
10.NSTA 5.0	The NSTA, and Memphis City School standards are specified.	0 1 2

Standards		
11.NSTA 5.0 **Guiding Question**	A major question or issue is asked to guide the lesson.	0 1 2
12.NSTA 5.0 **Concepts**	Major concepts which will be taught are named.	0 1 2
13.NSTA 7A **Stakeholders**	All stakeholders and views are named and examined.	0 1 2
14.NSTA 5.0 **Motivation**	A type of focus or attention getter is used to start the lesson.	0 1 2
15.NSTA 3A **Strategies/Activities**	The inquiry method is used with various teaching strategies, including considerations of risks, costs, and benefits of alternative solutions; relating these to the knowledge, goals, and values of the students, and what behavior change is expected of the students.	0 1 2
16.NSTA 1B3 NSTA 7A **Community Resources**	Some community resources were used to teach the lesson (people, natural, institutional).	0 1 2
17.NSTA 5.0 **Learning of Science**	Specific strategy or integration is specified to teach the science behind the issues.	0 1 2
18.NSTA 2B NSTA 4B **Technology**	Technology and its interaction with and impact on society is specified.	0 1 2

19.NSTA 5.0 NSTA 1B NSTA 4B **Closure**	Students relate science to the resources and to the resolution of the issues.	0 1 2
Total Points		
Average Points Earned		

Points	**Score**
28-38 =	2 = Excellent; Optimal
17-27	1 = Acceptable; Good
0-16	0 = Unsatisfactory;
	Contact the professor

It is important that rubrics are used so that the students will know what is expected of them, and that they may be able to address everything and discuss with others what they do not know. It is also a helpful guide for the teacher; many students will be doing different things, but addressing some of the criteria from the rubrics will show the importance of the project and the value the teacher puts on it.