Assessment Results with the Science/Technology/Society Approach

Take a look at assessment results when elementary teachers take the STS approach with their students.

By Robert E. Yager

THE IOWA CHAUTAUQUA Program was conceived as a way of moving science teachers away from a didactic approach to teaching science concepts and process skills and toward an approach which is student centered and organized around student questions and current issues. The National Science Teachers Association (NSTA) defined Science/Technology/Society (STS) as the teaching and learning of science/technology in the context of human experience. Students' firsthand experiences provide real-world situations or contexts, which in turn provide relevancy and a concrete point of reference.

Often, teachers either identify a general area of instruction themselves or they follow one in the scope and sequence of a textbook series or district-wide curriculum. However, in an STS situation, teachers no longer plan and organize their material step-by-step and activity-by-activity. Instead, students become full partners in planning and carrying out their own science lessons.

Fundamental Truths About Learning

1. Learning first takes place by a process much like osmosis.
2. Authentic learning comes through trial and error.
3. Students will learn only what they have some proclivity for or interest in.
4. No one will formally learn something unless *that person* believes he or she can learn it.
5. Learning cannot take place outside an appropriate context.
6. Real learning connotes *use.*
7. No one knows how a learner moves from imitation to intrinsic ownership, from external modeling to internalization and competence.
8. The more learning is like play, the more absorbing it will be.
9. For authentic learning to happen, time should occasionally be wasted, tangents pursued, side-shoots followed up.
10. Traditional tests are very poor indicators of whether an individual has really learned something.

(from Reinsmith's 1993 Ten Fundamental Truths About Learning)

Figure 1. Students in STS classrooms are challenged to illustrate their progress keeping in mind Reinsmith's fundamental truths.

Examples of Assessment in the STS Classroom

Model One: After a week-long unit on electricity, the teacher and students set up a bicycle and a generator connected to a light placed above a group of plants. Timers on the light and bike recorded how long the light was on and how long the bicycle was pedaled. Students recorded and interpreted data related to power output and plant growth.

Concept Domain: At three points, students created mind maps to illustrate how key concepts were connected. Students built individual as well as group maps. The teacher evaluated the maps based on the number of concepts identified and, more importantly, the number of connections made between concepts.

Process Domain: In groups, students created a plan for their pedaling project. They decided on how to proceed with data collection and analysis. Together with their teacher, they created a checklist to use to monitor their progress. The students challenged one another to always improve on the process.

Application Domain: Students monitored the use of lights in their own homes, calculating how long they would have to pedal to generate the power needed to keep them on for a day, week, and month. Students were also challenged to monitor the use of community lights; for example, they examined streetlights to find the most efficient way to keep the streets safely lighted at night. These experiences provided information on how the students could use information in new situations.

Creativity Domain: Student creativity was tapped to draw cartoons of key concepts related to electricity. The "sci-toons" illustrated such ideas as conductors, electric fields, and circuits. Students were evaluated on the basis of how many sci-toons they created and how unique those sci-toons were.

Attitude Domain: Students kept a daily journal that provided insight into their feelings and perceptions related to the class experiences. These journals were read three times by the teacher to see how students were reacting to specific activities. Rubrics were constructed to help define levels and changes regarding positive attitudes.

Model Two: Sixth-grade students surveyed members of their community about local air, soil, and water pollution. They then identified major concerns expressed by survey respondents and proceeded to investigate them. They sought out experts in environmental safety, agriculture, and city planning. The written record of their work was published in the local newspaper.

Concept Domain: Students were asked to award numbers to 10 concepts of soil and water pollution: 1 = never heard of it; 2 = heard about it, but can't use it; 3 = heard about it, can use it; 4 = heard about it, can use it, and understand it; and 5 = I know it so well I could teach it. Then students chose five of the concepts to use in a short paragraph to show their understanding.

Process Domain: Students used surveys to find out major problems centered around the local river. They used charts and graphs to illustrate the results. With careful measurements, observations, and experimentation, they tested soil and water samples.

Application Domain: Students were to create and implement a plan for recycling in their homes. The plan was developed in the home by the student and his or her family. It became part of the daily discussions and journal entries. Rubrics were developed to help evaluate successes in applying concepts and processes encountered and used.

Creativity Domain: Students were asked to write questions, causes, and consequences to the statement, "Pretend you woke up this morning and looked in the backyard, and you saw that it was the town garbage pit." Student responses were evaluated by analyzing changes in quality and originality as the unit progressed.

Attitude Domain: Students were surveyed using key questions designed to reveal their feelings about the science classroom. The surveys included such choices as, "Science classes are fun," and, "The things studied in science class are useful in daily life."

Figure 2. These examples illustrate ways to assess learning in the STS classroom.

Students in STS classrooms are also partners in determining how they can assess their own learning. They are challenged to illustrate their progress—keeping in mind Reinsmith's 10 truths about human learning (see Figure 1).

The Five Domains

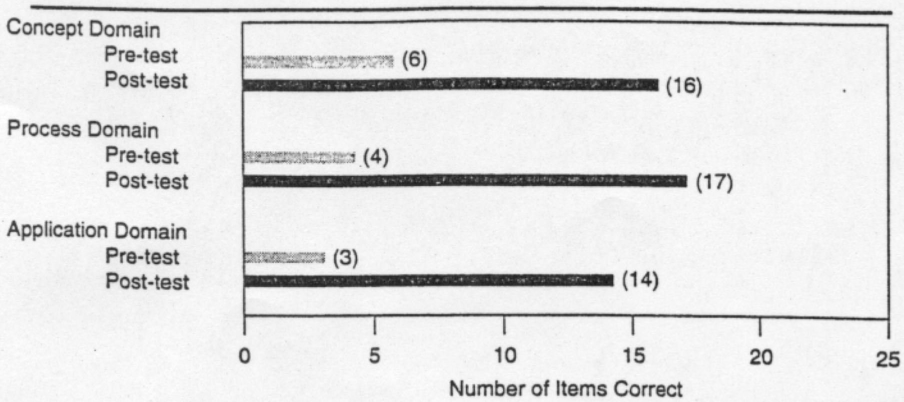
What does an STS approach provide in terms of student learning? Yager and McCormack (1989) offered a new view of science as it relates to learners and proposed five domains that are important in identifying instructional goals, planning the curriculum, rethinking instructional strategies, and establishing assessment programs.

The five domains for STS teaching and assessment are

- concept domain (mastering basic content constructs);
- process domain (learning the skills scientists use in sciencing);
- application and connection domain (using concepts and process in new situations);
- creativity domain (improving in quantity and quality of questions, explanations, and tests for the validity of personally generated explanations);
- and attitudinal domain (developing more positive feelings concerning the usefulness of science, science study, science teachers, and science careers).

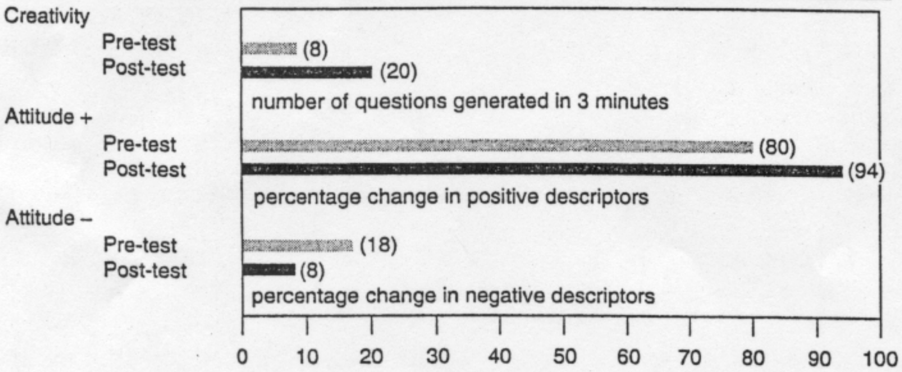
Assessment of science rarely moves beyond the requirements for students to recall information covered in classrooms and to demonstrate their ability to use a process skill—usually with no regard to a real-world context or application. In contrast, Figure 2 offers examples from two STS models of assessment items that fall within each of the five domains. These demonstrate STS as an approach to science teaching that provides a new focus for instruction which seeks growth, or positive change, in each assessment domain. Such assessment is considered more "authentic" be-

Figure 3. This bar graph shows the differences between pre- and post-test scores for new STS teachers in concept, process, and application assessment domains.



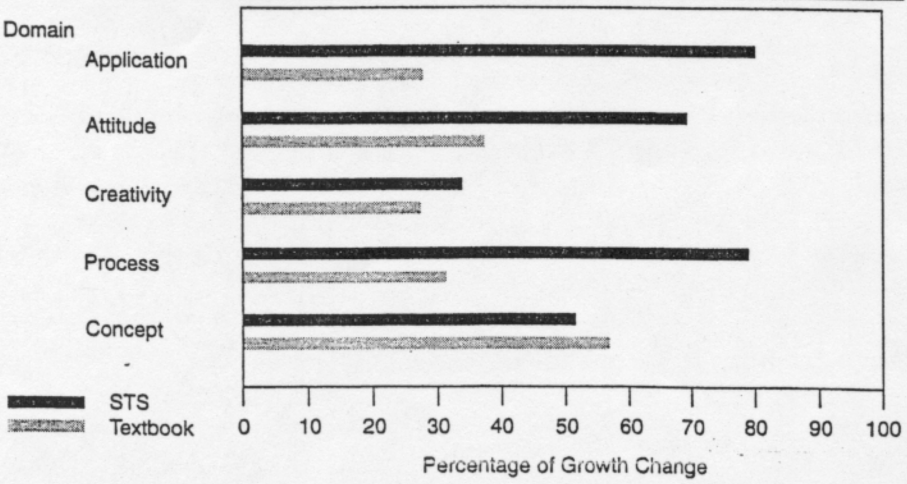
teachers: N = 80 K–6 teachers; students: N = 2,383; t-tests were used to note differences between pre- and post-testing; a level of confidence was set at 0.05. The instruments for pre-testing and post-testing in the five assessment domains are described in The Iowa Assessment Handbook. *Reliability for all measures has been repeatedly reported at 0.80 or higher depending on instruments, grade level, and administration. The data are from a variety of studies, including six Ph.D. dissertations (Blunck, 1993; Iskandar, 1992; Liu, 1992; Lu, 1993; Mackinnu, 1991; and Myers, 1988).*

Figure 4. This bar graph shows the differences between pre- and post-test scores for new STS teachers in the creativity and attitude domains.



teachers: N = 80 K–6 teachers; students: N = 2,383; t-tests were used to note differences between pre- and post-testing; a level of confidence was set at 0.05.

Figure 5. This bar graph shows a comparison of student growth in the five domains for those enrolled in textbook and STS sections taught by 10 K–6 lead teachers.



STS students: N= 363; Textbook students: N= 321. Based on adjusted scores (difference between pre- and post-tests) from Iskandar, 1991; Liu, 1992; Mackinnu, 1991; Myers, 1988; and Yager, 1990.

cause the results focus upon what students can do and how they feel about science and technology in the real world. Successful science teaching in the elementary school must do more than produce students who know some new words and who like to play with objects during a school period labeled "science."

All 80 teachers in the 1989–90 Chautauqua program used *The Iowa Assessment Package* (McComas and Yager, 1988) as a guide, both for selecting assessment instruments and strategies for determining instructional impact in the five domains, and for reporting pre- and post-test scores. Ten "lead teachers" also collected similar information for their students. These 10 teachers were experienced with STS approaches and were part of the staff team working with the 80 new teachers. All assessment instruments used to measure the STS efforts had been validated by the faculty and staff at the Science Education Center of The University of Iowa.

Figures 3 and 4 provide information concerning the effect of STS instruction on student achievement regarding concept and process mastery, applications of both, as well as creativity and attitude for the 80 new teachers. Figure 5 reports differences for the 10 lead teachers in the same five assessment domains when student performance is compared between STS and non-STS classes. In the case of the lead teachers, the changes were all significantly greater than those which occurred in control class sections where STS strategies were not used. Unfortunately no such controls were available for the 80 new teachers who tried the STS approach for the first time.

It is apparent from the percentages reported in Figure 6 that new teachers are not as successful in stimulating significant positive growth (between pre- and post-measures) as are the experienced and successful lead teachers. At the same time, it is impressive to see such dramatic successes with use of the STS strategies in a relatively short period of time (four to nine weeks). The success of both new and experienced STS teachers provides striking evidence in favor of teaching science with strategies characterizing STS.

The STS instructional approach results in significant growth or change in all five of the Yager-McCormack domains (1989). The Iowa Chautauqua Program helps teachers and schools make the transition to the STS approach, which helps students grow and improve in terms of concept mastery, use of process skills, new applications of concepts and processes, creativity skills, and the development of more positive attitudes about science, science classes, and science teachers. Assessing actual changes in students is important in establishing the advantages of the STS approach in elementary schools.

Resources

Blunck, S.M. (1993). *Evaluating the effectiveness of the Iowa Chautauqua Program: Changing the reculturing behaviors of science teachers K–12.* Unpublished doctoral dissertation, The University of Iowa, Iowa City.

Iskandar, S.M. (1991). *An evaluation of the science-technology-society approach to science teaching.* Unpublished doctoral dissertation, The University of Iowa, Iowa City.

Liu, C. (1992). *Evaluating the effectiveness of an inservice teacher education program: The Iowa chautauqua program.* Unpublished doctoral dissertation, The University of Iowa, Iowa City.

Lu, Y. (1993). A *study of the effectiveness of the science-technology-society approach to science teaching in the elementary school.* Unpublished doctoral dissertation, The University of Iowa, Iowa City.

McComas, W.F., and Yager, R.E. (Eds.). (1988). *The Iowa assessment package for evaluation in fi[ve] domains of science educatio[n]*. Iowa City, IA: The University [of] Iowa, Science Education Center.

Figure 6. This table shows the per[centage of] growth between pre- and post-te[sts for] elementary teachers.

Experience/ Grade Level	N	Concept	Pr
New Teachers			
K–3	25	93.3	
4–6	55	92.7	
Lead Teachers			
K–3	2	100	
4–6	8	100	

N = number of teachers

t-tests were used to determine significa[nce] confidence)

Mackinnu. (1991). *Comparison [of] learning outcomes between class[es] taught with a science-technolog[y-] society (STS) approach and a tex[t]book oriented approach.* Unpublished doctoral dissertatio[n,] University of Iowa, Iowa City.

Mestre, J.P., and Lochhead, J. (199[0]). *Academic preparation in scienc[e:] Teaching for transition from hig[h] school to college.* New York, N[Y:] College Entrance Examinati[on] Board.

Myers, L.H. (1988). *Analysis of stu[dent] outcomes in ninth gra[de] physical science taught with a sc[i]ence/technology/society focus ve[r]sus one taught with a textbook or[i]entation.* Unpublished doctor[al] dissertation, University of Iow[a,] Iowa City.

National Science Teachers Associ[a]tion. (1990–1991). Science/tec[h]nology/society: A new effort for pr[o]viding appropriate science for [all] (position statement). In *NST[A] Handbook* (pp. 47–48). Washin[g]ton, DC: Author.