A remarkable phenomenon has occurred in American education since 1970. A hundred years of continuous fissioning of the body of knowledge into increasingly narrow specialties gradually halted and a trend towards integrating disciplines began. This epistemological turning point took place under the banner of a new interdisciplinary thrust called Science, Technology, and Society (STS).

STS has become a movement. As the name suggests, STS aims to integrate science and technology, the quintessential and pervasive characteristics of our culture, into all the traditional learnings of society. STS mimics life and reality in relating civil engineering to ethics, physical chemistry to philosophy, and technological decline to political choice; STS is unavoidable as the core of integrative general education.

STS is a major reassertion by the university of one of its principal functions—the unifying function. Discovering and proclaiming great unities should be the university's direct service to society. Which other institution could possibly be appropriate to unite the grand traditions of humankind handed down from one generation to the next with the latest knowledge, insights, deep truths, and indeed, problems and challenges which confront contemporary humans? And in a culture where the incredibly seductive and powerful forces of technology and science literally define what is characteristic and unique about our own culture, the unifying of Western values with the meanings of science and technology must surely be the focal point of the intellectual raison d'être of the modern university.

General education, presumably, is the place in the curriculum where unification could be done. The spate of general education reforms is testimony to the universal awareness that, on most campuses, general education remains a pork barrel for distribution of large-enrollment "service" courses. For the first time, in STS, a set of integrative principles has emerged which forms an intellectual core for much of general education decisively different from the "course distribution" requirements of a Chinese dinner. It is the genuine fusion of ideas, knowledge, and values which counters the fissioning of knowledge over the last century. Moreover, this integrative style also helps, by contagion, to render more porous the walls between the higher reaches of the disciplines. And conversely, it demands a radically different approach to teaching both technology and science in grades K–12.
A Short History of STS

Starting in 1970, a few U.S. universities—Cornell, Penn State, Stanford, and SUNY-Stony Brook—officially started programs that offered courses on subject matter which we today call STS. A consortium of British universities did the same. Gradually, across the country, other institutions joined in: small, elite four-year colleges (Wesleyan, Vassar), major research universities (MIT, RPI), scattered primary and secondary schools, and hundreds of institutions in between launched STS as an academic field.

By 1977, STS had gathered enough momentum to emerge as one of the five focal points of Norris Harms’ Project Synthesis (Harms, 1977). An STS task force for Project Synthesis outlined the goals of STS projects.

- Prepare students to use science for improving their own lives and for coping in an increasingly technological world.
- Teach students to deal responsibly with technology/society issues.
- Identify a body of fundamental knowledge that students should master to deal intelligently with STS issues.
- Give students an accurate picture of the requirements of and opportunities in the many careers available in the STS field.

After the Project Synthesis report in 1981 (Harms & Yager, 1981) the National Science Teachers Association initiated its Search for Excellence in Science Education program. STS was included as one of the initial search areas in 1982–83 and again in 1986.

Nationally, since the initial efforts, STS has flourished as a focus for school science—as an area for identifying new goals, new curriculum modules, new instructional strategies, and new forms for evaluation. It has been used as such for science education reform in Iowa since the initiation of the NSTA-NSF Chautauqua Program in 1983. Today, as a result of that program, more than 1,700 teachers, especially in grades 4–9, have developed and introduced STS modules into their science classrooms. Other state initiatives are found in Arizona, Florida, New York, and Wisconsin. In 1984, the NSTA Board unanimously adopted a statement recommending that all students in American high schools receive formal exposure to STS courses varying from 15 percent in the lower grades to 25 percent in the higher ones.

The movement was well accepted throughout the K–12 system and was soon to be institutionalized in a number of state departments of education. Thus by 1990 in the United States, STS was present in about 2,000 colleges in the form of STS courses, about 100 formal departments, divisions, or official interdisciplinary programs in most of the leading institutions, and thousands of high schools.

Comparing STS to Traditional Science Courses

STS programs have changed considerably since they were identified in NSTA’s Search for Excellence (Penick & Meinhard-Pellens, 1984). Table 1 identifies 12 points of contrast between standard science programs (as revealed by the NSF status studies and Project Synthesis) and many experimental STS programs found throughout the United States.
<table>
<thead>
<tr>
<th>Standard</th>
<th>STS</th>
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<tbody>
<tr>
<td>Surveys major concepts found in standard textbooks</td>
<td>Identifies problems with local interest/impact</td>
</tr>
<tr>
<td>Uses labs and activities suggested in textbook and accompanying lab manual</td>
<td>Uses local resources (human and material) to resolve problems</td>
</tr>
<tr>
<td>Students passively assimilate information provided by teacher and textbook</td>
<td>Students actively seek information to use</td>
</tr>
<tr>
<td>Focuses on information proclaimed important for students to master</td>
<td>Focuses on personal impact, making use of students’ own natural curiosity and concerns</td>
</tr>
<tr>
<td>Views science as the information in textbooks and teacher lectures</td>
<td>Views science content <em>not</em> as something that merely exists for student mastery because it is recorded in print</td>
</tr>
<tr>
<td>Students practice basic process skills—but don’t apply them for evaluation purposes</td>
<td>De-emphasizes process skills which can be seen as the glamorized tools of practicing scientists</td>
</tr>
<tr>
<td>Pays little attention to career awareness, other than an occasional reference to a scientist (most of whom are dead) and his/her discoveries</td>
<td>Focuses on career awareness, emphasizing careers in science and technology that students might pursue, especially in areas other than scientific research, medicine, and engineering</td>
</tr>
<tr>
<td>Students concentrate on problems provided by teachers and text</td>
<td>Students become aware of their responsibilities as citizens as they attempt to resolve issues they have identified</td>
</tr>
<tr>
<td>Science occurs only in the science classroom as a part of the school’s science curriculum</td>
<td>Students learn what role science can play in a given institution and in a specific community</td>
</tr>
<tr>
<td>Science is a body of information that students are expected to acquire</td>
<td>Science is an experience students are encouraged to enjoy</td>
</tr>
<tr>
<td>Science class focuses on what is previously known</td>
<td>Science class focuses on what the future may be like</td>
</tr>
</tbody>
</table>

Table 1 illustrates the conditions that exemplify STS classrooms as advanced by the NSTA position on STS. It also contrasts each of these conditions with the descriptions provided in the Project Synthesis final report of what typical conditions are like, especially pertaining to instruction. The Project Synthesis report included such contrasts in the areas of goals, curricula, assessment, and teacher education with respect to instruction. In
general, all the Synthesis features called "Desired States" apply to classrooms where STS approaches are used.

The assessment of STS has often centered on the five domains of science teaching: concepts, process, connections and applications, creativity, and attitude. These domains were advanced by Yager and McCormack (1989) as a way of broadening science beyond a unidimensional structure that is often used in textbooks, curriculum guides, and state frameworks labelled "science." Unfortunately, this limited view that science is an organization of concepts comprising a given discipline (e.g., biology, chemistry, Earth science, and physics) makes science seem unrelated to any human enterprise and to the daily living of most students. A look at each of the five domains provides another means for contrasting traditional science classrooms to STS classrooms. These contrasts relate to the features of STS described earlier, to the nature of instruction, and to instructional outcomes. Table 2 illustrates the differences between students involved in an STS program with respect to these domains. The differences are based upon the reports of the nature of traditional classrooms, including instructional techniques used, and the assessment of student learning from Project Synthesis. The situation for the STS classrooms arises from analyses of the features of STS (from NSTA definition) as well as the emerging research reports that are summarized in subsequent chapters.

**Table 2**

<table>
<thead>
<tr>
<th>Traditional</th>
<th>STS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Concepts</strong></td>
<td><strong>Concepts</strong></td>
</tr>
<tr>
<td>Students learn concepts so as to do well on a test</td>
<td>Students find science concepts useful in their own lives</td>
</tr>
<tr>
<td>Concepts are seen as results of teaching</td>
<td>Concepts are seen as a needed commodity for dealing with problems</td>
</tr>
<tr>
<td>The focus of science class is on students learning concepts</td>
<td>Learning concepts occurs because of activity; it is important, but not a focus in and of itself</td>
</tr>
<tr>
<td>Students do not retain concepts for long</td>
<td>Students who learn by experience retain concepts and can often relate them to new situations</td>
</tr>
<tr>
<td><strong>Process</strong></td>
<td><strong>Process</strong></td>
</tr>
<tr>
<td>Science processes are skills scientists possess</td>
<td>Science processes are skills students themselves can use</td>
</tr>
<tr>
<td>Students see processes as something to practice as a course requirement</td>
<td>Students see processes as skills they need to refine and develop themselves more fully</td>
</tr>
<tr>
<td>Teacher emphasis on process skills is not understood by students, because these skills rarely contribute to actions outside class or even to the course grade</td>
<td>Students readily see the relationship of science processes to their own actions</td>
</tr>
<tr>
<td>Traditional</td>
<td>STS</td>
</tr>
<tr>
<td>-------------</td>
<td>-----</td>
</tr>
<tr>
<td>Students see science processes as abstract, glorified, unattainable skills</td>
<td>Students see processes as a vital part of what they do in science classes</td>
</tr>
</tbody>
</table>

**Connections and Applications**

- Students see no value or use for the material studied in science class
- Students see no value in their science studies for resolving current societal problems
- Students recite information they studied
- Students cannot relate the science they study to any current technology
- Students can relate their science studies to their daily lives
- Students become involved in resolving social issues; they see science as a way of fulfilling their responsibilities as citizens
- Students seek out science information and apply it
- Students are engrossed in current technological developments and through them see the importance and relevance of scientific concepts

**Creativity**

- Students' ability to question declines because the questions they raise that do not conform to the course outline are often ignored
- Students rarely ask thought-provoking questions
- Students are ineffective in identifying possible causes and effects in specific situations
- Students have few original ideas
- Students ask more questions, and these questions are used to develop science activities and materials
- Students frequently ask unique questions that excite their own interests, that of other students, and that of the teacher
- Students are skilled in identifying possible causes and effects of certain observations and actions
- Students have a plenitude of ideas

**Attitude**

- Student interest in science declines at all grade levels (as evidenced by the 3rd, 4th, and 5th science assessments of the National Assessment of Educational Progress)
- Student curiosity about science seems to decrease
- Students see the science teacher as a purveyor of information
- Students see science as information to learn
- Student interest increases from grade level to grade level and in specific courses (see chapter 22)
- Students become more curious about the material world
- Students see the science teacher as a facilitator/guide
- Students see science as a way of dealing with problems

AN OVERVIEW OF STS
It is apparent from Table 2 that STS instruction aims to affect students in radically different ways in each of the five domains. Teachers in traditional science classrooms would probably find the desired features of STS as worthy, however, the traditional view of teaching (i.e., transmitting to learners what is known) results in few improvements except for the seeming mastery of basic science concepts. And attitudes typically become more negative as students progress through the required K–12 sequence of science courses (Huefle, Rakow, & Welch, 1983; NAEP, 1978; Weiss, 1987). The more positive conditions in the Connections and Applications processes and Creativity domains are illustrated specifically in the section of this volume which focuses on specific research results. The results provide evidence that STS instruction is successful in producing results described in Table 2.

Moving Towards STS Approaches

It is the present science education system, with its own epistemology, its own selection of subjects, its scope and sequence of courses, if you will, that has brought us to the present situation. We have a population turned off from science. We have an anti-technology bias in society. We have manifest technological illiteracy as a result of whatever we are doing now. Three years of the same chemistry and two years of the same physics cannot do anything at all to address the needs of the mainstream citizens in learning “appropriate science and technology.”

STS does not equal science education, but neither does physics or chemistry equal science education. Each of these is part of contemporary science education. STS is the matrix of every citizen’s science education within which various specializations may be added. STS means focusing on problems, on questions, on unknowns. It means searching for answers and explanations. The searching means that students encounter many new questions and problems. Science is a never-ending process. In fact, the best STS modules (and teacher experiences with STS) result in teacher comments like: “I never imagined that we would investigate so many questions . . .”; “I had no idea that STS would result in so much student initiative, enthusiasm, action . . .”; “The students did the work. They identified problems, proposed actions—they wouldn’t let it stop!”

All of these experiences with STS by teachers and students are hastening its spread. Unfortunately, such experiences are not universal, and word-of-mouth testimony is inadequate to sustain a reform effort. Moving beyond personal experience and testimony is possible. Still, the emerging results stimulate greater interest and agreement that STS exemplifies needed reform for most learners.

All reasonable projections agree on the universal penetration of STS as a K–12 and college-level approach to course structure and teaching approach throughout formal academia. There is little data on which to base a guess at the speed STS will penetrate all education. However, it is not unreasonable to project the goal that by the year 2000, more than one-half of all students in the K–Ph.D. pipeline will encounter STS in formal courses at some point in their education.

That would be a wonderful goal to attain. But it implies a challenging responsibility for all of us in academia, K–12 teachers, agency personnel, and others, to guide this innovation-in-education carefully. Federal and state agencies must be fully aware that the resources allocated to the burgeoning STS field are minuscule compared to those allocated to the traditional disciplines. STS is a great opportunity to reorient the American citizenry towards a new, healthy, balanced perspective on science.

STS has become more and more widely used during the ten years that have passed since Project Synthesis. STS activities provide excitement. Some STS developments have occurred in every state; many are used to illustrate
what reform should be like. Many STS programs are affecting entire school curricula, not just the nature of science courses and teaching. Perhaps it is time for a second Synthesis study to note with certainty the extent that STS programs have addressed the science education issues so clearly identified in 1978.

References


The Science, Technology, Society Movement

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