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Achieving STS Goals Through Experiential Learning

Educators from a number of disciplines are currently giving attention to the inclusion of technology in the curriculum. However, many of them seem to be juggling technology in order to determine where and how it fits into the curriculum. Should it be incorporated with science? social studies? Is it a separate discipline? Is it interdisciplinary?

Part of the confusion results from the fact that technology is described in multitudinous ways; hence, approaches to studying it are abundant. Some people equate technology with things, especially computers and automated machines. Others associate technology with words or ideas, such as progress, change, advancements, or dilemmas. Still others connect technology with a special form of knowledge or know-how (De Vore, 1980; Savage & Sterry, 1990). Each of these perspectives leads educators to develop different approaches to studying this multifaceted phenomenon.

Many educators involved in the science-technology-society (STS) movement seem to support the study of technology as an integral part of other elementary and secondary subject areas, such as science and social studies. At higher educational levels, they condone the study of technology in a liberal arts context. These interdisciplinary or multidisciplinary approaches are often focused on the products of technology (the artifacts or "things"), their development within a certain historical and/or social backdrop, or their impact on society and the environment (Cutcliffe, 1989). Studies may center around general themes, such as technological change, or they may focus on the development of specific artifacts or techniques, such as telephones, interchangeable parts, and steam engines. For the most part, these studies may be classified as *"outside,"* or externalist, approaches because students study *about* technology, not *in* technology.

In contrast, technology educators have an *"insider,"* or internalist, approach. They primarily focus on the human process of creating technology; students study *in* technology more than they study *about* it. The technology educator's approach is more process oriented and people centered. This approach to studying technology is further delineated in this article with the goal of explaining and demonstrating technology educators' two major contributions to STS education: (a) presenting a different view of technology and (b) providing an experiential arena in which to achieve the STS goals.

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Technology Educators' Perspective

Technology educators portray technology as an active process that requires human thought and action for the main purpose of satisfying

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people's wants and needs (Savage & Sterry, 1990). When people engage in purposeful activity in order to use or change their natural environment to satisfy their wants and needs, they are engaging in technological activities.

A Different View of Technology

A number of educational activities, courses, or programs implemented since the 1970s include the term technology in their name. The focus of many of these, however, is on technological artifacts—products of technology—and their impact on society and the environment. If technology was synonymous with hardware or machines, such as computers or military weaponry, then perhaps these approaches to studying technology would be sufficient.

However, technology is not simply the equivalent of artifacts. Educators often assume that they are providing a complete picture of technology in their curriculum by merely adding more technological tools or machines to their repertoire of instructional media or including more discussions and readings about them. Albeit necessary or useful to do this, this "outside" approach to examining technology does not supplant the need for exploring technology as something greater than the sum of its products and their influence on society and the environment.

Further, the "outside" approach minimizes the human role in designing or creating the technology. While technological artifacts and processes affect society and the environment, they are also products of human ingenuity and imagination that were influenced by social or environmental wants or needs. These facets of technology—purposeful human endeavor and the special knowledge or skills required to make it possible—are often overlooked by other methods of inquiry (i.e., sociological, philosophical, historical, scientific). They are, however, the core of the technology education curriculum.

People have engaged in technological activities since prehistoric times. The stone ax, pencil, and electric generator are as much products of our technological heritage as are the robotic welder, computer, and breeder reactor. People used special knowledge, skills, and processes in order to create these inventions and innovations. Today, people continue to solve problems or provide for human sustenance and comfort by engaging in technological activity. This systematic process and know-how forms the content base for technology education and provides students with a different, yet important, view of technology.

An Experiential Approach

The hallmark of the technology educators' approach is the value they place on experiential learning. Technology education and its precursors (i.e., industrial arts, practical arts, manual arts, manual training) have consistently exemplified the importance of practice and experience in education (Zuga, 1991). In the words of educational philosopher, Alfred North Whitehead (1929):

> First-hand knowledge is the ultimate basis of intellectual life. To a large extent book-learning conveys second-hand information, and as such can never rise to the importance of immediate practice. (p. 79)

Modern technology education programs continue to highlight this first-hand knowledge approach by actively engaging students in solving technological problems and using technological products. This methodology is founded on the belief that technology is experience based and people centered. Human activity is key to technology; hence, human activity continues to be the most efficient and effective method of teaching technology in the technology education setting.

In technology education, students are thrust into technologists' roles through a variety of activities that require them to analyze human wants and needs, create technological solutions, and use technological products. Students see and experience another side of technology—the technologists' perspectives—the points of view of people who conceive of the ideas and make them work. This experience helps them to develop a more complete and realistic view of technology.

Making STS Goals Achievable

The technology educators' approach differs from that of other educators (e.g., science and social studies educators). However, the combination of all these approaches and perspectives is what makes STS studies so appealing and essential. It is through this concerted effort that students have the greatest opportunity to achieve the primary goal of STS studies—to become scientifically and technologically literate (NSTA, 1985).

According to a position statement made by the board of directors of the National Science Teachers Association (NSTA, 1985), a scientifically and technologically literate (S&TL) person exhibits 13 characteristics. Several of these traits bear close resemblance to the characteristics of technological literacy for high school graduates identified in a study by Croft (1989). Although the phrasing of characteristics differs in each report, the similarity lends support to the idea that particular characteristics may be more representative of technological literacy (TL) than scientific literacy (SL). The primary goal of technology education is to advance TL.

Figure 1 presents five characteristics of the S&TL person (NSTA, 1985) adjacent to technology education program objectives that address similar concepts (Snyder & Hales, 1981, p. 42). This figure describes those areas in which technologyeducation has the potential to make the greatest contribution to students' scientific and technological literacy.

For decades, technology educators and their predecessors have demonstrated expertise and success in promoting students' attainment of the types of skills and understandings currently associated with SL or TL. This has been, and continues to be, accomplished through an action-oriented curriculum that engrosses students in creating and using technology.

In the sections that follow, numerous technology educators' approaches are described. The sections correspond to the five characteristics of the S&TL person shown in Figure 1. They are a representative sample of technology education activities under way across the United States that were specifically designed to help students attain SL or TL, as described by NSTA (1985) and Croft (1989).

Understanding The STS Relationship

Many young people have only a vague understanding of the relationship between science, technology, and society. This is partly due to the fact that the fragmented school curriculum does

Scientifically and technologically literate persons[1]:	Technology education students will[2]:
Understand how society influences science and technology as well as how science and technology influence society	Understand and appreciate the evolution and relationships of society and technical means
Recognize the limitations as well as the usefulness of science and technology in advancing human welfare	Develop attitudes and abilities in the proper use of tools, techniques, and resources of technical and industrial systems
Appreciate science and technology for the intellectual stimulus they provide	Explore and develop human potentials related to responsible work, leisure, and citizenship roles in a technological society
Understand the applications of technology and the decisions entailed in the use of technology	Establish beliefs and values based upon the impact of technology and how it alters environments
Have sufficient knowledge and experience to appreciate the worthiness of research and technological development	Develop creative solutions to present and future societal problems using technical means

1. These characteristics are taken from a position statement made by NSTA's board of directors (1985, unnumbered).
2. These technology education program objectives are taken from Snyder and Hales (1981, p. 42).

Figure 1. Characteristics of a scientifically and technologically literate person compared with technology education program objectives.

not easily accommodate subject matter that crosses subject lines. It is often presumed that students will make the connections themselves by piecing together things they learn in each subject.

Technology educators do not presume that students can grasp the complex relationship between science, technology, and society on their own. They have designed and implemented numerous activities over the years that give students concrete opportunities to explore this relationship (e.g., ITEA, 1985; Maley, 1973, 1985, 1989; New York State, 1987).

For example, a popular activity in many technology education classrooms involves student-generated prototypes of technological products, such as the waterwheel, elevator, camera, and hydroelectric power plant. Typically, students choose a significant technological invention or innovation based on their review of various printed materials, including social studies textbooks and library books. Students create a scale model of the device based on the information they uncover during their research. They use the materials, tools, and machines available to them in the technology education facility to create a model that is as authentic as possible. Wherever possible, the scale models are working models that can be used and tested.

During this process, students have the opportunity to see and experience the science-technology-society relationship. They draw their idea from a social or historical context; they create the device based on the scientific and technical information available; and, whenever possible, they test or use their device for the purpose of developing a better comprehension of the scientific, technological, or social significance of this innovation.

Throughout this process, the teacher serves as a resource by directing students to new sources of information, asking probing questions, demonstrating necessary production techniques, and encouraging students to recognize and appreciate the intricacies of science, technology, and society with respect to this specific device. It is through this complete educational process that students can truly assimilate the integrated nature of STS.

Recognizing Limitations and Usefulness

Technology educators have done a superb job of addressing the limitations and usefulness of science and technology in advancing human welfare. In fact, this may well be their greatest strength in terms of strengthening students' achievement of STS goals.

Many technology education facilities are well equipped to engage students in practical activities aimed at demonstrating the limitations and usefulness of science and technology. The activity based, application-oriented curriculum is designed to turn abstract concepts into concrete experience, thereby making technical and seemingly complicated ideas understandable to students. One way this is accomplished is through activities aimed at showing students how things work or how things are done.

For example, a high school industrial arts teacher, Robert Gauger, described a situation he once encountered that instigated a welcomed change in his school curriculum (Gauger, 1989). A chemistry teacher at Gauger's school asked him to give a demonstration for the science students on how an air conditioning system works. The chemistry teacher wanted the science students to see a practical application of phase change. Students and teachers called the demonstration a great success. In fact, the experience led Gauger to introduce into his technology education curriculum two new courses that specifically focused on science-technology linkages. Gauger called the idea "unified science-tech" and named his courses "technology of chemistry" and "technology of physics."

For generations, the industrial arts and technology education curriculum has provided students with unified science-tech (Gauger, 1989) experiences—they just have not had that name. Students have ample opportunities to see and experience the limitations and usefulness of science and technology through a variety of technology laboratory experiences (ITEA, 1985). In the example described (Gauger, 1989), students saw the usefulness of knowing about phase change. Likewise, they learned how the laws of science and nature impose restrictions (limitations) on the design of the air conditioner.

As another example, high school technology students learn about molecular chemistry when they shape or form plastics and metals for various production projects (Wright, 1987). Other students enrolled in construction courses put physics concepts to work when they build structures that must meet specific criteria (Huth, 1989). Middle school students learn about aerodynamics and Newton's laws of motion when they participate in a technology module on flight (Iley, 1987; Smith, 1987). Elementary school students who participate in the Mission 21 Technology Education Program (Brusic & Barnes, 1992; Dunlap, Croft, & Brusic, in press) do technological activities that apply concepts from earth and physical science units. The technology education curriculum is overflowing with concrete examples on how students can explore ways that science and technology advance human welfare (i.e., give people things they want and need) within certain limitations (i.e., laws of science and nature).

Appreciating the Intellectual Stimulus

By their very nature, science and technology can arouse curiosity and interest. Unfortunately, though, many students do not appreciate these qualities. Various educational reports released during the 1980s (see AAAS, 1989; Mullis & Jenkins, 1988; National Science Board Commission, 1983) suggest that large numbers of students are disinterested in science and technology and that they will be ill prepared for their future roles as consumers, citizens, and workers in a technological society. This STS objective addresses this concern by emphasizing the critical importance of developing students' appreciation for the intellectual stimulus that science and technology provide.

In The Woodlands, Texas, technology educators found a way to achieve this objective by involving students in learning about science, technology, and other school subjects in an exciting, new way. They use a central project approach made up of many smaller, component projects (McHaney & Bernhardt, 1988, 1989).

The focus of the central project during the first year was "to research, design and build a habitat which would sustain four people in an outer space simulation for 72 hours and . . . carry out the 3-day mission" (McHaney & Bernhardt, 1989, p. 2). The activity, then dubbed "Project Space Station" (McHaney & Bernhardt, 1988) involved more than 400 students at their school. The space theme was relevant and meaningful to students in their community, which is just north of Johnson Space Center in Houston, Texas. McHaney and Bernhardt stress the importance of choosing central project ideas that are relevant to a school's community.

The success of the project during the 1987-88 school year led them to expand it during the next school year. In an effort to parallel the National Aeronautics and Space Administration's (NASA) plans, they expanded the project to include the development of a staffed-lunar outpost and invited students in Canada and Japan to participate in the activity. The expanded central project activity was now designated as the "International Student Space Simulation (ISSS)" (McHaney & Bernhardt, 1989).

Today, the ISSS is being conducted simultaneously in a number of schools (Bernhardt & McHaney, 1990). Students at each site design and build a mock space station suitable for human habitation for 72 hours. They also envision and solve numerous engineering and technological problems prior to the culminating event—the mock launch of the space station and its 72-hour mission. Bernhardt & McHaney (1990) describe the educational experience taking place in these schools:

> [The students were] separated by thousands of miles, skin colors, cultural and religious differences, and varying governmental philosophies . . . yet everyone was united in the quest of the unknown and the dedication to explore the heavens together. . . . This mission demonstrated the potential and the desire that exist to work together to solve problems and to explore space. (p. 44)

McHaney's and Bernhardt's (1988, 1989) central project approach is just one example of how technology educators can make science and technology education exciting and, hence, intellectually stimulating. Other technology educators have devised and implemented other approaches that have been equally innovative and successful at the elementary level (Brusic, Dunlap, Dugger, & LaPorte, 1988) and the middle school level (Iley, 1987; New York State, 1987; Smith, 1987; Welty, 1989).

Understanding Applications and Decisions

Technology educators specialize in helping students to understand and appreciate the *human-made* world. This differs from science educators' focus on the *natural* world and social studies educators' focus on the *interactions* of societies and cultures within these worlds. One way technology educators help students to understand and appreciate the human-made world is through an experiential curriculum that engages students in applying technology and making decisions about its use. Nowhere is this more apparent than in technology education classrooms and laboratories where students engage in realistic manufacturing or construction simulations such as those first introduced through the Industrial Arts Curriculum Project (Lux & Ray, 1970, 1971).

The primary educational purpose of these activities or courses is to help students comprehend the systems by which products are manufactured and structures are constructed. These simulations involve students in the complete manufacturing or construction process, from planning through product design, management, production, and marketing. Students often form mock companies, sell stock, and organize themselves into working teams, which have specific responsibilities within the company.

In manufacturing classes, the end goal is to mass produce quality, marketable products in the technology facility. In construction classes, the goal is to erect, on-site, a structure that meets the customer's expectations or is marketable. Moreover, students strive to do this work within reasonable time frames, by industry's standards, and to realize a profit for the shareholders in their mock company.

Students experience the complete process, including the creative-thinking, decision-making, and problem-solving responsibilities that are inherent in the operation. Likewise, they experience the excitement of successes and the agony that arises from inadequate planning or bad decisions.

Manufacturing and construction simulations have been remarkably successful in technology education. However, other types of simulation experiences can be equally effective when organized by technology education teachers with expertise in other areas, such as communication technology (Sanders, 1991) and energy technology.

Gaining Knowledge, Experience

The experiential curriculum of technology education centers around the idea that appreciation comes from knowledge and experience. Every technology education activity described thus far likewise supports the STS objective of developing this appreciation.

However, technological development is the central focus of some technology education activities, which makes them especially useful for helping students to achieve this objective. These activities explicitly involve students in the process of technological development, often referred to by technology educators as technological problem solving (Waetjen, 1989).

Technological problem solving is realized in numerous ways in technology classrooms. Most often, students are presented with problems (human wants or needs). Students analyze the problem, develop alternate solutions, choose the optimal solution that fits within the constraints, and then create and test their solution.

Problems are highly varied. Elementary school students might create a battery-powered question and answer game that informs players when their answers are right or wrong (Brusic & Barnes, 1992). In a middle school class, students might solve a transportation problem by building rubberband-powered vehicles (New York State, 1987). High school students in Bellevue, Washington, design and make appropriate packaging for materials or goods produced in foreign countries (Rye & Watson, 1987). College students enrolled in a communication technology course may plan and create various components for a product's promotional campaign, including a television commercial with computer-generated graphics, radio announcement, photographic display, and printed brochures (Sanders, 1991).

Technological development or problem solving is a doing process, and it is a significant part of technology education curriculum today. If educators truly want students to appreciate the worthiness of research and technological development, they need to grant students more opportunities to experience its excitement firsthand.

Conclusion

Technology educators have a wealth of knowledge and experience to contribute to STS education. Their experiential approach to studying technology makes their perspective on technology different from, yet equally important as, that of other educators who strive to help students attain scientific and technological literacy. The challenge lies in finding the best way to meld their expertise with that of educators from other disciplines in order to establish a holistic STS curriculum for students of all ages. In the words of Alfred North Whitehead (1929):

> Education should turn out pupil[s] with something [they know] well and something [they] can do well. This intimate union of practice and theory aids both. The intellect does not work best in a vacuum. The stimulation of creative impulse requires . . . the quick transition to practice. (p. 74)

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