IDEAS

1. Technological Literacy: Beyond Mathematics, Science, and Technology (MST) Integration

by Thomas T. Liao

Technological literacy refers to the understanding of modern technology—its capabilities and limitations, underlying concepts, and societal impacts. Technological literacy spans the range from how specific devices or machines work to the understanding of the more complex systems for satisfying human needs and wants. Furthermore, technological literacy includes not only the application of scientific and mathematical principles underlying the devices and systems, but also consideration of the human, environmental, and societal impacts.

When designing curricula to help students to achieve technological literacy, the knowledge base can be categorized into five content areas:

- Technological systems and engineering concepts.
- Application of science concepts.
- Applied mathematics: Quantitative methods.
- How individuals interact with technology.
- How technological systems interact with our societal systems.

ASPECTS OF TECHNOLOGICAL LITERACY

Since technology education includes the study of how technology works and is designed and how it interacts with other societal systems, only an interdisciplinary approach to its study is appropriate. In my view, students need to study how five major content areas interact in today's technology-based society. First, they need to learn how mathematics, science, and technology (MST) concepts are connected. To enhance relevance, MST studies also need to include the personal and societal impacts of MST systems.

The connections among the five major aspects are shown in Figure 1. The approach in SUNY at Stony Brook's Department of Technology and Society is to start with the study of specific technological systems and related concepts. Ideas from the other four domains are introduced as needed. However, the focus of a course can start with any of the other "circles of knowledge."

UNDERSTANDING TECHNOLOGICAL SYSTEMS AND CONCEPTS

All technologies have evolved to help people better satisfy human needs and wants. Societies have developed techniques for using tools, materials, energy, information, and human resources for satisfying these needs and wants. A system's model can be used to clarify the operation and behavior of technological systems. Technological systems are designed and developed with engineering concepts and apply concepts from other disciplines. Technological systems result from engineering design and development. Engineers use mathematical and scientific concepts in their work. Thus, understanding of the behavior of technological systems requires study of how scientific and mathematical concepts are applied. But other concepts underlying modern technological systems are unique to engineering. For example, the control of systems via feedback is the basic concept of automation. Other concepts relate to ergonomics (human factors engineering) and aspects of decision making (criteria, constraints, modeling, and optimization).

APPLIED MATHEMATICS AND SCIENCE

The application of mathematics and science concepts and techniques to the analysis of socio-technological prob-

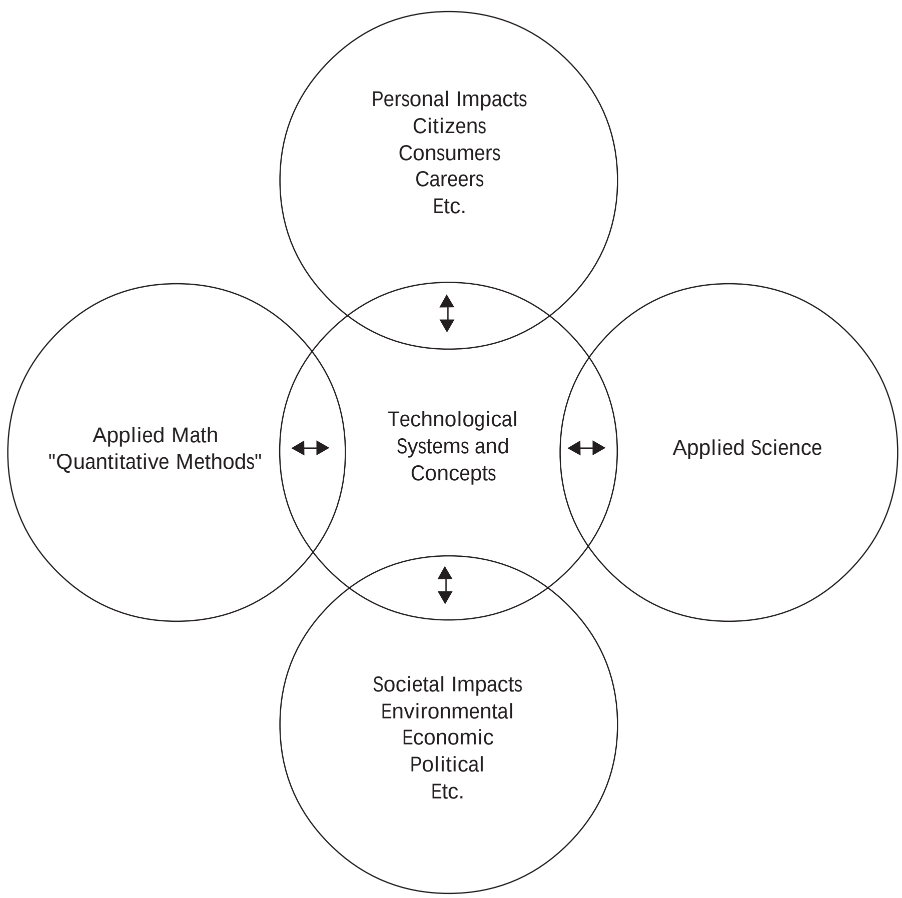

Figure 1. **Interaction among five major aspects of technological literacy.**

lems and issues makes the study of abstract concepts more concrete and meaningful. Many science educators, such as Shamos (1998), feel that it is the best way to help liberal arts students make sense of these subjects.

From a pedagogical perspective, studying disciplinary concepts via applications adds relevance to the learning experience. Students who are often "turned-off" to regular mathematics and science courses find technology-based courses to be more interesting and meaningful.

In order to study technology-based problems in a more precise and rational manner, both quantitative and scientific methods of analysis must be used. For example, the study of alternative energy sources requires that students learn how to measure amounts of energy and what happens when energy is converted. Risk analysis requires that students understand probabilistic models and how they are used.

TECHNOLOGY AND THE INDIVIDUAL

As individuals, we interact with technology as human users and citizens of a democratic society. As users of technology, we must learn to choose the most appropriate technology to satisfy our needs in the home as well as in the work environment. As more and more contemporary issues relate to the societal impact of technology, we need to learn how to use relevant information to make informed decisions. Those of us who create new technology, besides understanding technical concepts, must also be knowledgeable of human and societal impacts.

This aspect of technological literacy, for most of us, deals with learning the concepts and techniques of making the most cost-effective use of the technology. Decisions about selection, use, and maintenance of consumer products require an understanding of both the basic information about the product and the process of decision making.

Technology must be designed with the human user in mind. The match between the technology and the human user (ergonomics, or human factors engineering) is crucial to the optimization of health, safety, and comfort levels.

Besides making decisions about consumer-related technologies, individuals must also participate in local and national decisions about the choice of complex systems for satisfying our needs for shelter, food, energy, and security.

SOCIETAL IMPACT OF TECHNOLOGY

Another aspect of technological literacy is the ability to understand the limitations and capabilities of current and emerging technologies. Some people erroneously believe that technology can solve all our problems; others, equally naive, blame technology for most of our ills. These two extremes can be avoided if people learn what technology can do, what it can't do, and how to deal with it. A new web site, "Technorealism" (www.technorealism.org), provides an approach to defining this technological middle ground.

Other aspects of this, the social science, component of technological literacy include understanding the historical role of technology in human development, the relationship between socio-technological decisions and human values, the trade-offs in the use of alternative technological systems, the changes occurring in high technology areas (such as computers and genetic engineering applications), and the role of technology assessment as a method for studying the environmental, societal, political, economic, and other consequences of developing and using futuristic technologies.

TOWARD NEW TECHNOLOGY EDUCATION STANDARDS

At the kick-off meeting of the National Commission for the Technology for All Americans project, held January 19–22, 1995, everyone agreed that one of the unique features of technology studies is that it is an *integrative discipline*. Technology studies require an interdisciplinary approach. Recognizing this important aspect of technology studies, the New York State Education Department formed an interdisciplinary committee in 1991 to create a new set of MST learning standards. In March of 1996, the MST learning standards document was published (New York State Education Department, 1996).

Three of the seven major learning standards explicitly call for MST integration. The first standard recommends integration of the study of mathematical analysis, scientific inquiry, and engineering design. One way of achieving this standard is the study of technological systems (how they are designed and how they work). For this approach, relevant mathematics analysis and scientific inquiry are introduced as needed to learn how systems are designed and how they operate. The sixth standard focuses on unifying concepts that connect the three disciplines. Finally, the seventh standard recommends student engagement in interdisciplinary studies and technology and society problem-solving activities. The specific language of these three MST learning standards are as follows:

> Standard 1: Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.
>
> Standard 6: Students will understand the relationship and common themes that connect mathematics, science, and technology and apply the themes to these and other areas of learning.
>
> Standard 7: Students will apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions. (New York State Education Department, 1996, p. 1)

Currently, drafts of new national Standards for Technology Education are being reviewed. Designers of the new standards have recognized the importance of going beyond MST integration. One of the three universals of technology education is *contexts* and is explained in the following manner: "Technology exists in the context of particular human activities that have been categorized in the Standards as informational, physical, biological, and chemical" (International Technology Education Association, 1998).

The Standards for Technology Education draft document provides a framework for the study of technological knowledge and process in the context of real-world systems and problems. Genuine technological literacy can only be developed by providing students with opportunities to learn MST concepts in the context of real systems and problems that have meaning for them.

References

International Technology Education Association. (1998). *Standards for technology education*. Reston, VA: Author.

New York State Education Department. (1996). *Learning standards for mathematics, science, and technology*. Albany, NY: Author.

Shamos, M. (1998). Call for technological literacy. *Journal of College Science, 12*(6), 367.

Dr. Liao is a Professor in the Department of Technology and Society at State University of New York (SUNY) at Stony Brook. He is a member-at-large of Epsilon Pi Tau.

2. Is the Integrated Curriculum the Answer?

by Tom Loveland

The need for curriculum change is briefly reviewed. Some pilot integrated curriculum efforts, with emphasis on an effort in Florida, are described, and challenges and recommendations related to these are offered.

CHANGE

Secondary school statistics over the last 80 years have revealed some startling trends. High school entrance rates have gone from 50% in 1950 to 95% in 1980 and high school graduation rates have gone from 10% in 1900 to 73% in 1980 (Department of Curriculum, Instruction, and Assessment, 1996). Standards and methods of instruction remained relatively static during these years. Specialized instructors lectured to whole classes and assigned work out of textbooks. While this method of subject-centered curriculum and teacher-centered instruction is familiar to most Americans, students today are markedly different and require new ways of being reached.

Changing school demographics are well documented. There are increasing numbers of students living in single-parent households. Many of these families are living in poverty. Many students have non-English-speaking parents. In the 1940s, nonscholastic classroom problems included talking, chewing gum, making noise, and running in the halls. In the 1990s, the problems are drug abuse, rape, assault, and suicide.

Demographics are just one reason for schools to change. Other compelling reasons include legislative mandates, work requirements of new workers, competition from charter schools, and refinements in learning theory. Goal 3 of Florida's Blueprint 2000 states that "students successfully compete at the highest levels nationally and internationally, and are prepared to make well-reasoned, thoughtful, and healthy lifelong decisions" (Bureau of Curriculum, Instruction, and Assessment, 1995, p. 30). The Secretary's Commission on Achieving Necessary Skills report of 1991 identified the following five competencies and three foundation skills that graduating high school students will need to succeed in the workplace:

Competencies:

1. Resources: identifies, organizes, plans, and allocates resources.
2. Interpersonal: works with others.
3. Information: acquires and uses information.
4. Systems: understands complex interrelationships.
5. Technology: works with a variety of technologies.

Foundations:

1. Basic skills: reads, writes, performs arithmetic and mathematical operations, listens, and speaks.
2. Thinking skills: thinks creatively, makes decisions, solves problems, visualizes, knows how to learn, and reasons.
3. Personal qualities: displays responsibility, self-esteem, sociability, self-management, integrity, and honesty.

In 1996 the Florida legislature passed several laws that allowed for public funding of charter and private schools. Some charter schools will be linked with businesses, providing technology and expertise that standard public schools will find difficult to match. The final compelling reason for a change in curriculum and instruction techniques comes from studies in learning principles. Gardner's theory of multiple intelligences breaks learners into seven categories including verbal/linguistic, logical/mathematical, visual/spatial, and others. Not all learning styles can be affected by an autocratic teacher/lecturer with rigid curriculum barriers (Gardner, 1995).

The usual secondary school curriculum is delivered in distinct 50-minute blocks of specific content areas. Teachers are certified as specialists in their content areas, and students are expected to study the content areas separate from their other classes. The problem with this delivery system is that it bears little resemblance to the real world. People link and use all of their skills as they move about the day solving problems. With the explosion of information, increasing legislative mandates, fragmented schedules, and a lack of applied knowledge in the school curriculum, an interdisciplinary approach to a curriculum offers a feasible solution.

INTERDISCIPLINARY CURRICULUM—ADVANTAGES AND OBSTACLES

An interdisciplinary curriculum is "a knowledge view and curriculum ap-