Integrating the History and Nature of Science and Technology in Science and Social Studies Curriculum

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The Importance of Understanding The History and Nature of Science and Technology

The decade of the 1980s was a period of pressure for and movement towards educational reform. During the early 1980s, numerous reports focused attention on the failure of education in general, and science and mathematics education in particular, to prepare American students for the 21st century. These efforts, in turn, influenced calls for reform in the fields of science and social studies education. Several trends have particular relevance for the teaching of the history and nature of science and technology. First, there is a push for the general improvement of scientific literacy. Second, there is a resurgence of interest in history instruction. And third, the trend toward the integration of science-technology-society themes into contemporary school programs. Authors such as Bertrand Russell and C. P. Snow addressed the importance of understanding science and society connections in their books *The Impact of Science on Society* (Russell, *1951)* and *The Two Cultures* (Snow, 1962). These insights, however, had little influence on school programs. The situation in which individuals neither perceive nor understand connections between science and society is partially due to the fact that we do not teach about those connections. Presenting students with the historical influences of science on society and society on science could help fulfill the goal of citizenship.

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In *Educating Americans for the 21st Century,* the National Science Board summerizes the reasons for this emphasis on science and technology in a social context.

> Science and technology are integral parts of today's world. Technology, which grows out of scientific discovery, has changed and will continue to change our society. Utilization of science in the solution of practical problems has resulted in complex social issues that must be intelligently addressed by all citizens. Students must be prepared to understand technological innovation, the productivity of technology, the impact of the products of technology on the quality of life, and the need for critical evolution of societal matters involving the consequences of technology (NSB, 1983, p. 44).

This quotation highlights the need for students to understand the nature of both science and technology; it especially emphasizes technology. The term "scientific and technological literacy" express the goal of understanding science and technology.

The National Science Teachers Association (NSTA) position statement "Science-Technology-Society: Science Education for the 1980s" describes several attributes of scientific and technologic literacy. According to NSTA, students should be able to

- Understand how society influences science and technology, as well as how science and technology influence society.
- Understand that the generation of scientific knowledge depends upon the inquiry process and upon conceptual theories.
- Recognize the origin of science and understand that scientific knowledge is tentative, and subject to change as evidence accumulates. (NSTA, 1982, p. 1).

Many science educators agree that technologically and scientifically literate people must understand something of the history and nature of science and technology (Showalter, 1974; Duschl, 1985; Bybee, 1986; Hurd, 1987; Garrison & Bentley, 1990). Project 2061, an effort by education in science, technology, and mathematics, believes that such knowledge is critical to not only scientific and technologic literacy, but cultural literacy as well. The following about coverage of the history of science and technology in American schools is from *Science for all Americans* (AAAS, 1989).

> There are two principal reasons for including some knowledge of history among the recommendations. One reason is that generalizations about how the scientific enterprise operates would be empty without concrete examples. Consider, for example, the proposition that new ideas are limited by the context in which they are conceived; are often rejected by the scientific establishment; sometimes spring from unexpected findings; and usually grow slowly, through contributions from many different investigators. Without historical examples, these generalizations would be no more than slogans . . . A second reason is that some episodes in the history of the scientific endeavor are of surpassing significance to our cultural heritage. Such episodes certainly include Galileo's role in changing our perception of our place in the universe; Newton's demonstration that the same laws apply to motion in the heavens and on earth; Darwin's long observations of the variety and relatedness of life forms that led to his postulating a mechanism for how they came about; Lyell's identification of infectious disease with tiny organisms that could be seen only with a microscope. These stories stand among the milestones of the development of all thought in western civilization (AAAS, 1989, p.111).

Hickman, Patrick, and Bybee provide further support for the notion that understanding the nature and history of science and technology is an element of cultural literacy. They assert that "some fundamental connections between science, technology, and society were established in the canons for scientific investigation and definition of the American social order," making science and technology "a conceptual heritage in the historical documents out of which this country was born and which continue to influence our social development" (Hickman, Patrick, & Bybee, 1987, pp. 2-3). Such a view would undoubtedly be supported by the advocates of a stronger educational emphasis on history and philosophy (Adler, 1982; Ravitch & Finn, 1987; Bloom, 1987; Hirsch, 1987; Cheney, 1987).

Social studies educators view teaching about the history and nature of science and technology through another lens—the need for students to become competent decision makers in the personal and civic arenas (Bragaw & Hartoonian, 1988). Today's citizens are not only affected by science-based developments, they are increasingly called upon, through their participation in the democratic political process, to affect public policy concerning the development and application of science and technology.

Given this situation, it is important for people to understand science as a key element in intellectual history—the achievements of the human mind (Ronan, 1982). Furthermore, studying the history of science and technology will help young citizens recognize factors influencing innovation and act accordingly when confronting them (Burke, 1978). Similarly, some knowledge of the history of technology is necessary to avoid the pitfalls of policies shaped by "technological utopianism—the hope of a better tomorrow through purely technological solutions" (Corn, 1986). Melvin Kranzberg has summarized the importance of this subject for developing rational decision making as follows

> Clearly we are living in a scientific and technological age. Well, then, how did it get to be that way? If we could learn how it got to be that way, we might possibly be able to deal effectively with problems caused by the advance of science and technology and, conversely, to deal with problems that science and technology might help resolve (quoted in Post, 1989, p. 36).

A 1980 report by The Commission on the Humanities included this statement in The Humanities in American Life.

> The humanities are an important measure of the values and aspirations of any society. Intensity and breadth in the perception of life and power and richness in works of the imagination betoken a people alive as moral and aesthetic beings, citizens in the fullest sense. They can use their scientific and technical achievements responsibly because they see the connections among science, technology, and humanity (p. 3).

The Commission on the Humanities made an explicit connection between instruction in the humanities and science and technology. The report emphasizes the creative connections between science, technology, and the humanities and highlights the historical context of these connections

> Scientific models can sharpen and give insights into the characteristics of information… .Social and ethical questions are intrinsic to science and technology. In these respects, science and technology have been a domain of the humanities in

> Western culture since its Greek origins. . . . This Commission needs not to elaborate the fact that throughout history science and technology have had enormous impact on the way people work, live, and die (pp. 14, 16).

The Commission concludes its discussion with the recommendation that

> Courses in humanities should probe connections between the humanities and other fields of knowledge. For example, humanistic questions are inherent in—and should foster an awareness of—the moral dimensions of science and technology. Teachers and students should consider the human purposes of scientific discovery and scientific invention.

A 1988 report prepared by the Bradley Commission on History in Schools, *Building A History Curriculum: Guidelines for Teaching History in Schools*, gave some recognition of the importance of science and technology in a list of vital themes and narratives. One of six themes was human interaction with the environment. That theme was described as

> The relationships among geography, technology, and their effects on economic, social, and political developments. The choices made possible by climates, resources, and location, and the effect of culture and human values on such choices. The gains and losses of technological change. The central role of agriculture. The effects of disease, and disease fighting on plants, animals, and human beings (p. 10).

Note the clear emphasis on science and technology-related social issues. While this emphasis is commendable, there is still a need for recognizing the importance of science and technology as human endeavors that influence, and are influenced by culture.

Given that understanding the history and nature of science and technology is widely regarded as contributing to scientific and technological literacy, to cultural literacy, and to the ability to make reasoned decisions, one would think that science and social studies curricula would have numerous descriptions of the development of major ideas from science and clarifying examples of the contributions of science and technology to society. Such is not the case, however, as we point out in the next section.

History and Nature of Science and Technology in the Current Curriculum

Research related to the status of the history and nature of science and technology in the curriculum indicates that few materials and little time are devoted to helping students develop an understanding of or appreciation for the history and nature of science and technology (Harms & Yager, 1981). Four specific areas can be examined for evidence regarding this issue: student and teacher understanding of the subject, curriculum guidelines, studies of actual classroom practice, and current instructional materials.

Student and Teacher Understanding

Researchers have documented the inadequate understanding of science and technology by *both* students and teachers (Mead & Metrauz, 1957; Cooley & Klopfer, 1963; Carey & Strauss, 1968; Lavach, 1969; Carey & Strauss, 1970; Mackey, 1971; Billeh & Hasan, 1975; Bady, 1979; Rubba et al., 1981; Patrick & Remby, 1984; Lederman O’Malley, 1990). Very importantly, Lederman (1989) has confirmed the effect of teachers’ language on students' conception of the nature of science. Equally important, some studies (Patrick & Remy, 1984) showed that students feel a lack of control over public issues related to science and technology.

Few studies have been conducted on the history and nature of science. One notable study (Lederman, 1986) found a slightly higher level of understanding than the articles cited above. Ravitch and Finn's (1987) recent assessment of 17-year-old students' knowledge of history contained 16 clusters (subscales), one of which was a 10 item cluster on the history of science and technology. Interestingly, this was one of only two clusters on which students had a mean score of more than 70% (71.3%). This finding may not mean that understanding of the history of science and technology is adequate, however, since Ravitch and Finn's questions asked generally for recall of factual information rather than any understanding of the complexity of the creative enterprise, the interconnectedness of developments in science and technology, and the causes or effects of particular developments.

Curriculum Guidelines

A review of 27 state curriculum guidelines in science indicated that slightly less than half of the guides called for the study of the history of science and technology. Examination of state and local social studies curriculum guides show little emphasis on the history of science and technology.

In the new *History-Social Science Framework for California Public Schools* (1988), which many observers expect to have a significant impact on social studies nationwide, the importance of intellectual history, often neglected in school history courses, is stressed. Science and technology are listed as two aspects of culture to be studied in historical perspective. The course descriptions provided in this document give little specific attention to the history of science and technology, however.

There is also a new *Science Framework for California Public Schools* (1990). Compared to earlier *Science Frameworks,* the 1990 *Science Framework* has several significant changes including an emphasis on the nature of science. Although the history of science and the nature and history of technology are not prominent, science-technology-society is clearly a prominent theme. Both the *History-Social Science Framework* (1988), and the *Science Framework* (1990), offer potential for incorporating information on the history of science and technology into the curriculum, they fall short by providing little guidance about the content and pedagogy for incorporating the history of science and technology.

Classroom Practice

Empirical research on classroom practice, though sparse, reveals a pattern of underemphasis on the history and nature of science and technology. For example, a study by Mitman and others (1987) showed that seventh-grade life science teachers spent minimal time addressing material pertinent to the history and nature of science. The authors' analysis of students' academic assignments showed a similar underemphasis. Likewise, in a three-year ethnography of six high schools, Guthrie and Leventhal (n.d.) found that teachers gave primary attention to facts, methods, and attitudes. Components of science literacy, such as history and philosophy, were not an integral part of the curriculum. Finally, a survey of Wisconsin social studies and science teachers (Barman et al., 1982) found that respondents favored an integration of social studies and science. They also agreed that an interdisciplinary approach should emphasize the history and nature of science. However, most of the respondents were undecided about their commitment to actually initiating programs to encourage such integration.

Education about the nature of scientific methods generally takes the form of memorizing a series of steps in the method and involving students in laboratory activities that mimic those steps. These approaches are inadequate for two reasons. The former approach trivializes the human dimensions of scientific investigation and confuses the protocol for reporting research with the actual research procedures. The latter approach inappropriately represents the nature of science because the use of laboratory activities in most science teaching merely confirms material presented in the textbooks.

These problems in actual classroom practice are likely related to teachers' lack of knowledge about the history of nature of science and technology. In 1964, James Rutherford stated that

> science teachers must come to understand just how inquiry is in fact conducted in the sciences. Until science teachers have acquired a rather thorough grounding in the history and philosophy of the sciences they teach, this kind of understanding will elude them, in which event not much progress toward the teaching of science as inquiry can be expected (p. 84).

More recent research indicates that indeed inquiry is not a widely implemented goal of science teaching (Welch et al. 1981; Weiss, 1977, 1987). Furthermore, teachers' documented lack of knowledge about the history and nature of science and technology (Russell, 1981; Wagner, 1983; Duschl, 1985;1988) makes it difficult—for them to provide background and elaboration on these topics during instruction. As Schulman (1986) has noted

> Teachers must not only be capable of defining for students the accepted truths in a domain. They must be able to explain why a particular proposition is deemed warranted, why it is worth knowing, and how it relates to other propositions, both within the discipline and without, both in theory and in practice (p. 9).

Shulman's statement indicates that science and social studies teachers should be able to present the major ideas of their discipline, the historical context in which those ideas originated, and the processes by which they were developed. For example, recent historical and philosophical analysis of scientific progress indicates that scientific knowledge is constructed by communities of scholars. The contravening notion that science is a steady accumulation of "better" knowledge, suffers from what S. J. Gould calls the "bias of progress" (Gould, 1987). A more conservative view holds that scientific knowledge evolves through revision by communities of scholars (Toulmin, 1972, 1982). In a more revolutionary view, scientific knowledge changes as dominant paradigms are replaced by subordinate paradigms. This replacement occurs as new approaches to problems produce results that the dominant paradigms do not explain (Kuhn, 1962, 1977; Lakatos & Musgrave, 1970; Feyeraband, 1975). There seems, however, to be some question about the validity of paradigm shifts in the biological sciences (Herscher, 1988). A paraphrase from a 1960 article by Joseph Schwab simplifies the philosophical point and connects this discussion to Shulman's quotation: teachers should know "what scientists do." It appears that teachers have misconceptions about what scientists do. We would add engineers and technologists to the science theme. The consequence of their misunderstanding is an underemphasis and misrepresentation of the history and nature of science and technology in classroom practice. Are curriculum materials a help? Unfortunately, they are not. We support this assertion in the following section.

Curriculum Materials

Since no studies of actual classroom practice related to this topic in social studies are available, examination of social studies textbooks may be the best indicator of the status of history and nature of science and technology in the social studies curriculum. This supposition is supported by data indicating that social studies teachers rely heavily on curriculum materials especially basal textbooks, as the foundations of instruction in their classrooms (see, for example Patrick & Hawke, 1982).

An analysis of current basal textbooks for secondary U.S. history, world history, and U.S. government courses reveals very modest attention to the history of science and technology. U.S. history textbooks, for example, typically mention the Industrial Revolution; great inventors, such as Thomas Edison, the Wright brothers, and Alexander Graham Bell; and space technologies. Attention to these topics covers about 15 pages—less than 2% of the total.

Several textbooks treat the theme of scientific or technological development as a sidebar feature, with one or two pages in each chronological unit focusing on different aspects of discovery or technological progress. Set apart as isolated and optional readings at the end of units, the excerpts and their subject area-technology are perceived by students as interesting and diverting information that is essentially extraneous to history.

Government texts present even less coverage of the history and nature of science and technology; indeed, most government texts examined include virtually no coverage of these topics. They do not look at the impact of scientific or technological developments on the process of governing, despite the impact these developments have had. In addition, while policy issues with technological dimensions are covered, there is little or no discussion of how the technology developed over time or of policy decisions made at earlier stages in its development. Rarely, if ever, are analogies drawn between contemporary policy issues and historical issues.

Exacerbating the problem with social studies textbooks is the lack of supplementary materials on the history of science and technology. While materials on science-related social issues are proliferating, virtually no materials provide a coherent look at issues in a historical context.

In the history of science education, there are few efforts to develop materials that directly teach the history and nature of science and technology. James Bryant Conant introduced history of science cases into the curriculum at Harvard University in the late 1940s and 1950s. Conant argued that individuals could understand the methods of science by examining how science progressed historically. Leopold Klopfer (1969) extended Conant's ideas and developed "History of Science Cases" for the secondary school. In addition, Klopfer and Watson (1987) presented strategies for teaching about the history of science. Two other programs directed at introducing history to science teaching were initiated at Harvard University, *The Project Physics Course* developed by F. G. Rutherford, G. Holton, and F. Watson (1970) and the "History of Modern Science" program developed by Stephen Brush (1984). Although there are significant attempts to introduce history into science programs, one finds little or no evidence of them in current school curricula (Weiss, 1977, 1987). Nor have other materials incorporated the approaches the above-cited materials exemplified.

While educators agree that understanding issues in history and nature of science and technology is critical to development of scientifically literate citizens, little, if any, instructional material is available for teacher use in this area. Moreover, most curriculum guides do not require teaching of the history and nature of science and technology, and teachers are not well prepared in this area. In the classroom, a laboratory or hands-on approach is often used to represent the nature of science and vignettes of scientists to represent the history of science. Nowhere is the student likely to encounter a cohesive view of the ways in which the intellectual development of the sciences and the resolution of problems by technology shaped history and were in turn shaped by it. No conceptual framework that describes teaching and learning strategies that would more accurately reflect key themes in the history and nature of science and technology is available to guide improvements.

A place to begin is with the clarification of scientific and technological literacy. We propose the following major categories of understanding:

1. The scientifically literate person understands the nature of modern science, the nature of scientific explanation, and the limits and possibilities of science.

2. The technologically literate person understands the nature of technology, the nature of technological solutions to human problems and the limitations and possibilities of technology.

3. The scientifically and technologically literate person understand thatthe natures of science and technology as well as their interrelationships have changed over time.

4. The scientifically and technologically literate person understands that science and technology are products of the cultures within which they develop.

5. The scientifically and technologically literate person understands that the roles and effects of science and technology have differed in different cultures and in different groups within these cultures.

6. The scientifically and technologically literate person understands that technology and science are human activities that have creative, affective, and ethical dimensions.

7. The scientifically and technologically literate person bases decisions on scientific and technological knowledge and processes.

Toward the Integration of History and the Nature of Science and Technology in School Curricula

Several problems exist relative to teaching the history and nature of science and technology. First, there are no specific descriptions of scientific and technological literacy as these pertain to the history and nature of science and technology. Second, no conceptual framework exists that describes teaching and learning strategies for the history and nature of science and technology. Third, teacher understanding of content and pedagogy is weak. Several authors (Russell, 1981; Wagner, 1983; Duschl, 1985, 1988, 1989) have delineated these needs and problems.

The National Science Foundation (NSF), therefore, has funded the Biological Sciences Curriculum Study (BSCS) and the Social Science Education Consortium (SSEC) to design, develop, and disseminate a conceptual framework for integrating the history and nature of science and technology in school science and social studies programs. The framework will identify major themes related to the history and nature of science and technology, delineate a scope and sequence for developing student understanding of those themes, and provide recommendations for implementing the scope and sequence into current science and social studies programs, K-12. National, state, and local groups will be able to use the conceptual framework in program planning and in developing educational materials that introduce the history and nature of science and technology to students at grades K-12.

To support the framework, the project will prepare and disseminate an additional resource. The project will develop a teacher education resource book to help teachers restructure, revise, and adapt, extant curriculum and instruction to include the history and nature of science and technology.

The BSCS and SSEC project, "Integrating the History and Nature of Science and Technology in School Science and Social Studies Programs," addresses two important problems through the development of these materials. First, the conceptual framework will provide a general background and approach for integrating the history and nature of science and technology in school programs K-12. Second,
the conceptual framework will provide a background and orientation for pre and in-service education in both science and social studies, thus establishing a *broader base* and increasing the teacher's background for teaching about history and nature of science and technology.

The proposed BSCS and SSEC materials will emphasize

- the integration of the concepts of the history and nature of science and technology into school science and social studies programs K-12.
- the contributions of women and minorities.
- activity-based approaches for science and social studies.
- an accurate presentation of the disciplines of both science and technology.
- an introduction to the nature of science and technology.

Conclusion

The history and nature of science and technology have a place in school programs, especially science and social studies education. Using the characteristics of scientific and technologic literacy as a complement to other goals is a first step. A conceptual framework such as the one we propose is another important step. A full program on either the history or philosophy of science and technology has no home in current school science or social studies programs. However, a conceptual framework with recommendations for supplementing and enhancing current programs is an achievable innovation. This innovation will clarify the place of history and nature of science and technology. In addition, teacher preparation programs can incorporate the conceptual framework into their efforts to improve the quality of future science and social studies teachers.

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Integrating the history and nature of science and technology in science and social studies curriculum. Rodger W. Bybee, Janet C. Powell, James D. Ellis, James R. Giese, Lynn Parisi & Laurel Singleton. Science Education 75 (1):143-155 (1991).Â Nahum Kipnis - 1996 - Science and Education, Kluwer Academic Publishers 5 (3):277-292.details. The paper describes the author's experience in using the history of science in teaching physics to science teachers. It was found that history becomes more useful to teachers when explicitly combined with 'investigative' experimentation, which, in turn. can benefit from various uses of the history of science. The impact of science and technology on our lives will continue to grow. Consequently, scientific and technological literacy for all has become the overarching objective of science and technology education throughout the world.Â An understanding of the nature of technology includes knowing the following: what technology is, in its broadest terms (much more than the knowledge and skills related to computers and their applications) how technology and science are interrelated how thinking about technologyâ€™s benefits, costs, and risks can contribute to using it wisely.Â They also help students to integrate scientific and technological knowledge with knowledge in other subject areas, such as mathematics and social studies. Integrating the history and nature of science and technology in science and social studies curriculum. Article. Jan 1991.Â Later this year, a new Handbook of Research in Science Education will be published by Lawrence Erlbaum and Associates (edited by Sandra Abell and Norman G. Lederman). As one might expect, there will be a chapter on nature of science. The chapter will represent the fourth systematic review of research on nature of science (Abd-El-Khalick & Lederman, 2000; Lederman, 1992; Meichtry, 1992). What follows is a brief review of the history of research in the field and some speculations about WHAT research the future may hold. View. Show abstract.