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ABSTRACT

In the past 15 years a new curriculum field known as "Science, Technology, and Society" or STS has been established, first in higher education and since 1982 in K-12 education. The first section of this review charts the development of the STS field since the late 1960s. Throughout the 1960s and 1970s a group of writers, called STS prophets, focused attention upon the effects of science and technology on our society. The ideas of the STS prophets were assimilated in university interdisciplinary courses that urged a "social process" view of science and technology. The second section accounts for the extension of STS into K-12 education in the period of the "excellence reports" and the attempt to rebuild science education. The primary goal that has emerged for STS education is frequently spoken of as "scientific and technological literacy." The third section considers how this form of literacy has been tied to participation as a citizen in our democratic society. Because of their lack of STS education, citizens are unable to understand, or to participate in an informed way regarding, many issues on the public agenda. To counter this crisis, established forms or other possible forms of citizen participation should be selected for special emphasis in education. A number of suggestions are summarized. The final section considers the practicability of educational reforms proposed by STS educators. Appended are 63 notes. (MLF)

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WORKING PAPER:

"Science, Technology, and Society" Education and Citizen Participation

by

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CENTER FOR PHILOSOPHY AND PUBLIC POLICY
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"Science, Technology, and Society" Education and Citizen Participation

Introduction

In the past fifteen years a new curriculum field known as "Science, Technology, and Society" or STS has been established, first in higher education and since 1982 in K-12 education. The STS field initially developed from the insights of several prophetic independent scholars, whose voices struck a sympathetic chord among progressive students and faculty members in the nation's universities. In the past five years the field has been extended into elementary and secondary education and has been consolidating its basic principles and curriculum practices at all educational levels.

In the first section of this review I chart the development of the STS field since the late 1960s. Then I account for its extension into K-12 education in the period of the "excellence reports" and its development in the post-report climate. The primary goal that has emerged for STS education is frequently spoken of as "scientific and technological literacy." In the third section I consider how this form of literacy has been tied to participation as a citizen in our democratic society. In the final section I consider the practicability of educational reforms proposed by STS educators.

I. Three Stages in the Development of STS

<u>Stage One: STS Prophets</u>

Americans have long enjoyed a romance with technology, from plain old "yankee ingenuity" to the industrial inventiveness typified by Henry Ford and Thomas Edison. The ideology of progress through technological development sustained the nation throughout most of its first two hundred years. Statesman Adlai E. Stevenson exemplified this positive attitude in a symposium in the early 1960s, when he touted "the basic miracle of modern technology" as a

> magic wand which gives us what we desire. Don't let us miss the miracle by underestimating this fabulous new tool. We can have what we want. This is the astonishing fact of the modern scientific and technological economy. This is the triumph we hail today.[1]

Even as Stevenson spoke, the romance had begun to go sour. Technological development became widely perceived as involving costs as well as benefits. Rachel Carson first alerted the general public to the costs of technology when she argued in <u>Silent Spring</u> that our natural world was a complex system held in subtle balance, which chemical pesticides could disturb with unanticipated and devastating consequences.[2]

Since the early 1960s the world has been struck by one "techno-shock" after another: thalidomide babies, toxic shock from tampons, oil spills, napalm and Agent Orange in Viet Nam, the dalkon shield tragedies, Three Mile Island, the Challenger explosion, Chernobyl. By the mid 1970s such "techno-shocks" had provoked a "techno-crisis," a profound reevaluation of our technological culture. The noted biologist C. H. Waddington expressed this well:

> If things go unexpectedly wrong once or twice, that is, one might say rather paradoxically, only to be expected; but recently they have been going wrong so often and in so many contexts, that many people are beginning to feel they must be thinking in some wrong way about how the world works.[3]

Waddington located the error in the attempt to understand techniques in terms of simple causal sequences, a causing b, which in turn causes c. This way of thinking, he noted, is benign when a causes b and very little else, and when each cause in the chain is relatively feeble. But our new technological means are so powerful that it is no longer adequate to "concentrate on the primary effects and neglect all secondary influences." He added:

> The scale of very many of the impacts of mankind on the world surrounding him is now so great that they go right below the surface of things. At the deeper level, we find that most aspects of life and its interaction with its surroundings are connected into complexes.... We need nowadays to be able to think not just about simple processes but about complex systems.[4]

Throughout the 1960s and '70s similar ideas were expressed by such writers as Jacques Ellul, Buckminster Fuller, Ivan Illich, E. F. Shumacher, Theodore Roszak, William Irwin Thompson, and other scholars at the margin of mainstream intellectual life. For simplicity I will refer to these authors as "STS prophets," because as a group they focused attention upon the impacts of science and technology on our society.

To understand the development of STS education it is important to note that these writers, despite significant differences in their analyses of technology in society, shared several important themes:

(1) a rejection of "normal" disciplinary approaches to their topics, and indeed a rejection of the organization of intellectual life in academic disciplines;

(2) a rejection of the secular "scientism" which had dominated work in all intellectual disciplines including the humanities throughout the twentieth century; the STS prophets all spoke from either an explicitly religious viewpoint or one that acknowledged the cardinal importance of religious and spiritual values;

(3) a fundamental rejection of mainstream educational institutions, a theme developed most extensively by Illich but shared by the others. This rejection went beyond a call for educational reform and extended to a critique of education in industrial society.

Stage Two: Grassroots STS in Higher Education

The STS prophets did not intend their insights about the impact of technology on society to form a new field of study. Nonetheless, these insights quite predictably had a profound impact on university life in the tumultuous period of the late 1960s and early 1970s. For many the Vietnam war came to symbolize the anti-life effects of a technologically driven culture, and the anti-technology theme was joined to anti-war protest. On one campus after another, frequently in sympathy with the student protest movement, groups of faculty and graduate students from the humanities (frequently philosophers) and engineering formed to study technology in its social context. As Stephen H. Cutcliffe notes,

> The tenor of the overwhelming majority of the (STS) literature was anti-establishment and anti-technology in tone, and this was reflected in much of the first generation of STS coursework, which was directed toward educating science and engineering students about the "true" societal impact of their work.[5]

Study groups exploring the social impacts of technology thus became integral components of a culture of protest which also included "free universities," "back to nature" communes (with ecological and anti-technological values derived from the Whole Earth Catalog and Mother Earth News), and a wave of experiments in sexual liberation, urged on by such philosophers of eros as Herbert Marcuse, Norman O. Brown, and Paul Goodman.

After the Kent State student tragedy, this broader "counter-culture" receded on the campuses, but STS remained as a "grassroots" movement cutting across traditional categories of scholarship and slowly giving birth to new trends within the disciplines.[6] The ideas of the STS prophets were assimilated in interdisciplinary courses which urged a "social process" view of science and technology; these fields were said to be shaped by social values which in turn were reshaped by new scientific discoveries and technological innovations. This social process view was taken to imply that individuals and groups could alter the course of scientific and technological development. STS analyses pointed to leverage points for redirecting technology and urged students to assume responsibility for the future development of technology.

Commenting on these early days of STS in higher education, Langdon Winner observed, "What was envisioned at the beginning of this movement of scholars was a radical departure. Unlike normal academic fare, technology studies were to place a high premium on innovative approaches, interdisciplinary cooperation, the development of foresight, and utopian speculation."[7] But very early in the process, Winner expressed the worry that the STS movement would, like the counter-culture itself, fail to live up to its original promise -- that the "thrust of its activity [would] be conveniently reabsorbed into the normal flow of things."[8]

His worry was well grounded. During the 1970s STS and related ecological and environmental concerns increasingly became important components of an official public philosophy. The report Global 2000, which President Carter commissioned in 1977 and received in 1980, reflected these dominant concerns:

> If present trends continue, the world in 2000 will be more crowded, more polluted, less stable ecologically, and more vulnerable to disruption than the world we live in now. Serious stresses involving population, resources, and the environment are clearly visible ahead. Despite greater material output, the world's people will be poorer in many ways than they are today.[9]

As these concerns about the relations of technology, societal values, and environmental stress entered the academic, cultural, and political mainstream, the radical educational and cultural critique of the STS prophets was eclipsed. STS was becoming a "megatrend" within the higher education mainstream.

Stage Three: STS Consolidation

The third stage of technology studies coincides with the administration of Ronald Reagan. The driving concerns of this administration have been "high technology" as a spur to economic development. The appointment of James Watt as Secretary of the Interior announced to ecological activists that the official Washington, D.C., climate was no longer friendly. President Reagan and his associates have urged the nation to "stand tall" and adopt a competitive attitude in economic and military spheres. "Alternative" technologies and ecological concerns have been brushed aside. The administration's "high tech" emphasis generated a new policy agenda for education and training.

In K-12 education, policy discussion has been shaped by A Nation at Risk and the other "excellence reports," which identify gaps between our educational achievement and that of other nations and call for a return to the basics, with science and technology identified as "new basics."

In higher education a dominant trend has been the development of "new liberal arts." Technology and quantitative aspects of problem solving have entered the core curriculum for general students, promoted by generous grants from the Sloan Foundation to more than twenty leading liberal arts colleges; recently such programs have been established at many other institutions. Rather than reflecting critically on technology, this new wave of science and technology studies has increasingly been training in technology for liberal arts students, for example, using case studies to illustrate engineering approaches to problem solving and bringing quantitative methods to bear on the liberal arts. STS prophet Jacques Ellul had anticipated these developments, asserting that contemporary education

> is oriented towards the creation of individuals ... who conform to the structure and needs of the technical group. [When this transformation is complete] the intelligensia will no longer be a model, a conscience, or an animating intellectual spirit for the group, even in the sense of performing a critical function .... education will no longer be an unpredictable and exciting adventure in human enlightenment, but an exercise in conformity and an apprenticeship to whatever gadgetry is useful in a technical world.[10]

II. The School Improvement Reports and STS Education

In the 1970s and early 1980s, the K-12 science education community faced a crisis. It was failing to recruit talented teachers and to maintain quality standards in science classrooms throughout the nation. As the number of secondary school students declined, tenured non-science teachers were reassigned to science classrooms, often displacing qualified younger science teachers. Job opportunities for science-trained individuals in industry expanded, as did the salary differential between industry and education, and the number of science education graduates declined by 67 percent. Student participation in secondary science courses also declined and remained vastly unequal, with women and minori students underserved.[11]

In making their claim for resources to rebuild science education, policy leaders sought to make relevant connections with the public policy agenda. The goals of science education were reexamined, and a new emphasis was given to science for citizenship in our technologically dominated and ecologically vulnerable world. Organizational leaders, university-based science educators, and other education policymakers worked together to shape this new posture for school science.

Project Synthesis

In 1981 Project Synthesis, a National Science Foundation-sponsored reexamination of the science education mission, was completed. In the previous wave of curriculum reforms, following the launching of Sputnik, technology and applied science had been eliminated from the science curriculum and relegated to industrial arts, health, home economics, and social studies. The agenda of the science education policy shapers of the post-Sputnik period was to construct a science curriculum reflecting the working methods, experiences, understandings, and values of leaders in the scientific disciplines. The science curriculum would provide the most enriched learning experiences for the most promising students, who might aspire to careers in science or engineering.

This trend was reversed in Project Synthesis, which included a Science, Technology, and Society working group and incorporated STS goals into its final report.[12] These included an understanding of: energy problems from a personal perspective, population dynamics, human engineering, environmental quality, alternatives for utilization of natural resources, the effects of alternative technologies, and decision-making regarding the impacts of technology.

In terms reflecting the ecological concerns and technological ambivalences of the late 1960s and 1970s, the report went on to assert that students and teachers should be able to

- acknowledge the ambiguities of science and develop a mechanism to accommodate these so that future scientists see the potential pitfalls of science in society;

- analyse various troublesome elements of science and relate these to students' future careers; and

- give examples of how scientific and technological advances have been used and abused by society.

Project Synthesis projected a new role for the science educator as guardian of the ecosystem of our fragile planet against a potentially destructive technological system.

STS: Science Education for the 1980s

In the following year, 1982, the National Science Teachers Association (NSTA) published a position paper, "STS -- Science Education for the 80's."[13] With the Project Synthesis report providing general direction, the NSTA paper endorsed STS approaches to science learning in the middle and upper secondary years, with the goal of enabling students to

° use science concepts and processes in making responsible value judgments and everyday decisions;

° realize that society controls science and technology through the allocation of resources;

° recognize the limitations as well as the usefulness of science and technology in advancing human welfare;

° understand the applications of technology and the decisions entailed in the use of technology;

° have sufficient knowledge and experience to appreciate the worthiness of research and technological development; and

° know reliable sources of scientific and technological information and use these sources in the process of decision-making.

The Paideia Proposal and High School

Although not issued by the science education community, Adler's Paideia Proposal and Boyer's High School also influenced science education policy discussions at this time.[14]

The Paideia Proposal, issued by Mortimer Adler on behalf of the Paideia group, offered a vision of quality education for all Americans based on a synthesis of the liberal arts and progressive educational traditions. The report divided teaching-learning activities into three groups:

(1) acquisition of organized subject matter by didactic instruction and textbooks,

(2) the development of intellectual skills by means of coaching, exercises, and supervised practice, and

(3) enlarged understanding of ideas and values, through the study of original texts, socratic questioning, and active participation in discussion.

In the first group, Adler prescribed organized teaching of the scientific disciplines, with an emphasis on their interconnections. The second group included science and technology process skills, such as problem solving, observing, and measuring. Here Adler emphasized the active performance of students in laboratory and field-based settings, with the teacher acting as coach. The third group included a direct study of classical and contemporary works in science and technology, with an emphasis on enhancing powers of reading, critical thinking, and speaking.

Adler argued that knowledge should be presented in the context of social issues:

> Our country faces many insistently urgent problems, on the solutions of which its prosperity and even its survival depend -- the threat of nuclear war, the shrinking of essential resources and supplies of

> energy, the pollution or spoilation of the environment, the spiraling of inflation accompanied by the spread of unemployment.[15]

He added that the solution of such problems requires both an enlightened leadership and an educated citizenry with a broad understanding of science and technology.

Prepared by Ernest Boyer for the Carnegie Foundation for the Advancement of Teaching, High School charged that the nation's secondary schools lack a coherent mission and expressed the conviction that "the time for renewing education has arrived."[16] The report states four general goals for secondary education. Each student should:

(1) develop the capacity to think critically and communicate effectively,

(2) learn about self, the human heritage, and the world community,

(3) prepare for further education and work, and

(4) fulfill social and civic obligations through school and community service.

Boyer conceived of science as a process of discovery which "transcends the disciplines," a view he hoped would assist specialists and non-specialists alike in understanding the larger meaning of science. Becoming a "responsible citizen in the last decade of the twentieth century means that everyone must become scientifically literate."[17]

High School distinguished technology from science and recommended a one-semester course on technology, which would include both science and technology and the ethical and social issues related to them. This course would promote "technological literacy," a term which included an understanding of the important role of computers in society but was distinct from "computer literacy."

> The great urgency is not "computer literacy" but "technology literacy," the need for the students to see how society is being reshaped by our inventions, just as tools of earlier eras changed the course of history. The challenge is not learning how to use the latest piece of hardware, but asking when and why it should be used.[18]

High School proposed two innovations which could conveniently be connected to technology studies: a unit in community service, during which students learn about community problems at first hand and contribute to their melioration, and a written senior independent project addressing a contemporary social problem.

The Excellence Reports

Such was the science education policy climate when A Nation at Risk appeared in April 1983, followed by several dozen high-level reports.

Comprehensive summaries of thirty-three "excellence reports" are available.[19] In what follows I concentrate on the policy statements regarding science and technology in several of the most influential reports, which collectively shaped the mandate for STS education in the schools. It is important to note the contrast between ecological and technological development themes in these reports.

1. A Nation at Risk

Prepared by the National Commission on Excellence in Education, A Nation at Risk: The Imperative for Educational Reform warned that the nation is "drowning in a rising tide of mediocrity."[20] As a nation we are far behind our economic and military competitors on school achievement measures. To regain our competitive edge, we need to make profound improvements in basic studies. The report identified five "new basics," including science, math, and computer science.

The report recommended initiating a required third year of science as well as expanding science content beyond the traditional knowledge of science methods and concepts to include the social and environmental implications of scientific and technological development. It recommended reducing the shortage of qualified science and mathematics teachers by allowing properly prepared non-teacher professionals from industry to teach and by promoting programs to train and retrain teachers in these fields.

2. Making the Grade

Issued by the Twentieth Century Fund Task Force on Federal Elementary and Secondary Education Policy, Making the Grade argued that for our economic well-being, the educational system must ensure the availability of large numbers of skilled and capable individuals, without whom "we cannot sustain a complex and competitive economy."[21]

The report noted that only those trained in science and mathematics can maintain our economy and understand our world; consequently it emphasized "programs to develop basic scientific literacy for all citizens" as well as programs to provide advanced training in science and mathematics for secondary school students.

It urged the federal government to take responsibility for funding scientific literacy efforts, so that all citizens can participate meaningfully in decisions about topics such as radiation, pollution, and nuclear energy.

3. Action for Excellence

Action for Excellence, issued by the Task Force on Education for Economic Growth of the Education Commission of the States, focused on the lack of appropriate preparation given youth for the high technology employment needs of our society.[22] The report noted a shift in employment from labor- and resource-intensive to "knowledge-intensive" jobs.

> The skills many of our nation's workers need include: analysis and evaluation, computer literacy, problem solving, critical thinking and decision making, communication, organization and reference, ability to synthesize, creativity, ability to apply concepts in a wide range of situations.[23]

Hence schools should emphasize higher-order problem solving and analytic skills. Mathematics and science requirements should be strengthened, while electives are reduced or eliminated. Senior teachers should be trained or retrained in mathematics, science, and computer science and schools restructured from bureaucracies to collegial organizations.

4. Academic Preparation for College

The report of the Educational Equality Project of the College Board, Academic Preparation for College, focused on the skills students need to acquire in high school in order to take advantage of higher education.[24]

The report drew a distinction between science, which it conceives as a major intellectual achievement of civilization "useful and rewarding in its own right," and technology, which is a major determinant of social change. Students must study and understand both science and technology, because in order to address today's complex social issues intelligently citizens need to evaluate the benefits and risks of scientific and technological developments and methods.

The report recommended that upon entering college students should have detailed knowledge of at least one field of science -- either one of the traditional scientific disciplines or one of the new interdisciplinary fields (e.g., STS).

5. Educating Americans for the Twenty-First Century

The National Science Board's Commission on Pre-College Education in Mathematics, Science, and Technology issued Educating Americans for the Twenty-First Century: A Plan of Action for Improving Mathematics, Science and Technology Education for All Americans So That Their Achievement Is the Best in the World by 1995.[25] Not surprisingly, the NSB's Commission, with strong representation from government, industry, and science education, offered the most comprehensive review of science education, the most specific recommendations, and the largest synthesis of competing (ecological vs. technological development) themes. Although the basic premise of the report was that the declining quality of science, mathematics, and technology education harms the country's productive capacity, its standard of living, and its standing as a world power, the report expressed ecological concerns as well. It made these recommendations:

o The science curriculum must be rethought, updated, and reorganized, bringing in the areas of technology and engineering:

o The number of science topics covered should be drastically reduced and directed at an integration within each discipline and with other sciences, technology, and the social sciences.

o In biology, the curriculum should move toward a conceptual framework "in harmony with understanding oneself and ... supportive of the national and global welfare." General biology should emphasize biological knowledge in a social and ecological context.

o In chemistry "the social and human relevance of chemistry should be emphasized. Problem-solving skills and application of scientific processes should be continually developed.

o In physics, the "relevance of the understanding which physics provides for present and future problems and opportunities of our civilization should be constantly demonstrated and emphasized.

o In technology and engineering, high technology has added a dimension of knowledge needed for confronting world affairs. It is important for the young to be able to "understand and appreciate what science and technology are, and what they can and cannot do for society...."

o Technology and social issues should be integrated within the science curriculum, rather than forming the basis of a separate new course. "The study of technology should be used as a way of unifying the teaching of science at the secondary level."

o Teaching methods should deemphasize lectures in favor of activities in problem solving, modeling, and estimating, using probability and statistics.

From The Project Synthesis Report to Educating Americans for the Twenty-First Century, ecological and high technology development themes competed in K-12 science and technology education policy. Advocates of each pushed for technology in the science curriculum, but with conflicting interpretations and conflicting purposes. In the post-report climate they have achieved something of a rhetorical stalemate. Pro-attitudes and con-attitudes to high technology development have neutralized each other, and curriculum reform efforts have been organized around the technology assessment process. Students use the scientific and quantitative knowledge and skill they acquire to examine proposed technological innovations, balancing pros and cons, and coming to a personal judgment. They may also engage in action to influence decision-makers. In this way they are to acquire "scientific and technological literacy" for participation in the democratic decision-making process.

III. Technological Literacy for Citizen Participation

The phrase "scientific and technological literacy" has been used to name a key educational goal in various policy analyses and excellence reports. These policy statements agree that there should be minimum standards of science and technology learning for all students and that the study of science should be connected to the study of technology and its social consequences.

Beyond this minimum content, the term "scientific and technological literacy" has become a slogan around which various groups have rallied to promote their specific and conflicting objectives in the educational policy process process.[26]

Many reports speak of scientific and technological literacy as necessary for democratic citizen participation in our age of complex technology-dominated public issues. But what concept of "participation" does this imply, and how is scientific and technological literacy supposed to make it possible? Stephen Cutcliffe notes that we are now "entering a phase where STS may help to shape the public response and involvement in decision-making ... both by providing an awareness of the public's intimate involvement and by offering suggestions regarding the specific role that it has to play."[27] But he does not provide a specific map of this process, indicating that this remains a pressing task for the STS community:

> While we seem to have accepted the idea that the public has a right to participate in science and technology decision-making it still remains to analyse what mechanisms are most appropriate to the task. In this STS may be able to make its greatest contribution.[28]

As Cutcliffe indicates, the STS education community at this time lacks a definitive analysis of citizen participation. Because it has not identified the specific tools by which citizens are to affect technological decisions, its educational goals and means are not yet sharply focused.

Recently David Matthews of the Kettering Foundation spoke about "civic intelligence."[29] Citing Astin's data on the "me-ism" of contemporary young people interested only in themselves, Matthews suggested that teachers can combat this neglect of public issues simply because they talk with young people.

> Talk is "doing" in a democracy. Whom we talk to, how we talk, and what we talk about create the political community. Political talk ... is the kind of talk that serves both to develop and to exercise civic intelligence.... A dialogue is a conversation in which we "word" our way all the way through an issue -- with others. Teaching, in many ways, is leading a dialogue.[30]

While this is a good starting point, it leaves several questions unanswered: why are young people neglecting public issues, what forms are prescribed for their participation, and what kinds of political dialogues in schools will promote these? If young people are rejecting the public sphere in large numbers, it is likely that there are roadblocks to significant action. Before we begin our classroom dialogues, we must explore what these roadblocks might be. Many analysts, in the STS community and elsewhere, think the problem resides in the fact that public issues are now dominated by technology, and citizens feel powerless to participate in resolving them.

The "Crisis" in Democracy

In our increasingly technological world, citizens are unable to understand, or to participate in an informed way regarding, many issues on the public agenda. This is so because such issues (a) have a scientific base, (b) involve powerful new technologies with long-term and uncertain effects, including subtle inter-relationships and unanticipated side effects, (c) require analysis using sophisticated technologies of information processing, including (d) cost-benefit analyses with implicit social and ethical values, and (e) involve data that are not available to the public, because they are classified or merely withheld from the public or distorted by technocratic elites.

Kenneth Prewitt argues that the domination of the political agenda by technological issues has created a "crisis in democracy," and that the concern for scientific literacy

> raises in a fresh light an ancient issue for democratic theory and practice. Because the average citizen lives a life far removed from the political, economic, cultural, and technical centers that give direction to society, it has always been a ... challenge to ensure that the rights bestowed by democracy will be meaningfully exercised.[31]

But this challenge intensifies when the lay public confronts a political agenda "fashioned by technical processes that only the experts can understand," such as the restriction of genetic engineering or the mounting of a strategic defense in space.

Earlier analyses of this "crisis" offered by Michael and Coates are in fundamental agreement.[32] Michael notes that as public problems become increasingly complex, they demand more long-range planning. This in turn requires computer forecasts and sophisticated modeling techniques, which concentrate decision-making power in technocratic elites. Methods of forecasting are fallible, and political considerations pertaining to the preservation and extension of power will deeply influence decisions. But these two facts can be covered up:

> Computer-based options, will, by virtue of their source, carry great weight.... The overwhelming complexity incorporated into the derivation of options will make it excessively difficult to know in what ways the politician is covering up conceptual and data limitations in the computer program.[33]

The concerned citizen will face long-term decisions regarding powerful technological means and will know that he is unskilled in manipulating and evaluating the information from which the computer-based options are derived. To intervene effectively, the citizen will need both access to the data and computer programs and knowledge of sophisticated procedures of decision-making and data analysis.

Coates maintains that in our age a combination of economic and technological forces produces a web of increasingly complex and inter-related problems which foster bureaucratization. This centralizes decision-making power in the hands of technocratic elites, putting a premium on education, information, expert knowledge, and hence specialization. But this

> induces a number of qualities inimical to the basic concepts of democracy and a free society. Bureaucracies tend to be secretive, self-serving, non-imaginative, non-risk-taking, and susceptible to functional lying.... In their relationships with the public, bureaucracies withhold certain kinds of unpalatable information or deliver information in such a way that it distorts facts.[34]

In assessing new technologies, the technocratic experts are ill equipped to deal with large but uncertain future risks, which alert dormant publics and so can weaken technocrats' present decision-making power. They are always tempted to "pretend not to hear, or hope the bad news will go away."[35]

Citizen Participation and Its Educational Prerequisites

To counter this crisis, what forms should citizen participation take? There are many established forms of citizen participation in our society, and new ones are frequently proposed to handle new needs. Individuals vote for decision-makers and on referenda on specific issues; they attempt to influence decision-makers through personal correspondence or membership in public interest groups. Members of such groups can influence decision-makers through lobbying, organizing protests, engaging in civil dis-obedience, pressing law suits, testifying in hearings, and serving on various advisory boards. While all of these are options, only some are likely to be effective or attractive to large numbers of citizens. Which among these established forms of participation, or other possible forms, should be selected for special emphasis in education, and what knowledge and skill requirements do these impose?

Michael, without indicating specific forms of participation, proposes to resolve the crisis by (1) opening up the information base of decision-making to citizens, and (2) creating a new group of professional specialists who, in assisting citizen interveners, can

> see the issue writ large, who can play with the data, who see what is and what is not in a computer program, who can invent alternative programs, who can sense the ethical and social problems and opportunities implicit in the ... options.[36]

Coates would not leave the problems of democratic society in the hands of still more professional specialists. He provides an analysis of forms of participation, identifying three traditional means: the law suit, lobbying, and testifying at public hearings. He argues that each is inadequate as a tool for expressing the public's interest in technologically dominated issues. The span of responsibility of the courts is not "congruent with the domain of real-world impacts" of new technologies. Powerful special interests can out-lobby the public interest, while administrative and legislative hearings are often overly circumscribed, preventing an airing of important issues and perspectives.

By contrast with these traditional procedures for citizen participation,

> technology assessment is a class of policy studies which systematically examine the effects on society that may occur when a technology is introduced, extended, or modified with special emphasis on those consequences that are unintended, indirect, or delayed.[37]

Because technology assessments involve future forecasts, they are fallible, and the technocratic elites are, for reasons indicated earlier, ill equipped to face the full range of results, often burying the "bad news." Citizen participants can focus their efforts on this process, working through public interest groups. They can influence decisions by cooperating with, and occasionally by contending in adversary proceedings against, the technocratic bureaucracies.

For public interest groups to obtain significant influence, activist members will need to be "informed in areas of complex scientific and technological matters."[38]

> To interface with the technical experts and impact their decisions, the representatives of the public must themselves be knowledgeable in substantive matters. The educational process will be de-manding over sustained periods.[39]

While Coates did not suggest educational means, Prewitt's notion of "scientific savvy" is relevant. This "savvy," which Prewitt takes to be the primary goal of school science education, will "connect today's citizen with the public life of his community in as meaningful a way as did the scientific lore of the hunting, fishing, gathering, harvesting, and farming cultures that preceded modern society."[40]

Prewitt notes that "from the perspective of democratic practice, the notion of scientific literacy does not start with science itself," but rather consists of an understanding of the impact of science and technology on public life. Although this understanding would be "enriched by substantive knowledge of science, it would not be co-terminus with it."[41] It would be organized around three themes:

a) the political process. Science as it enters the political process is not merely "knowledge for its own sake," but inextricably tied to commercial, strategic, and bureaucratic purposes, and scientific literacy involves an understanding of these non-scientific purposes of science.

b) policymaking. A scientifically literate people would understand two things about policymaking: first, that the various scenarios of he future with which the policy process must contend are themselves often consequences of developments in science and technology; and second, that our projections of what these consequences may be are derived from science-based forecasts. Literate citizens will need to appreciate how such forecasts are made, that they are frequently open to doubt, and that the techniques on which they rely are themselves scientifically questionable.

(c) social change. Science and technology are major determinants of social change. A scientifically literate citizen would understand three principles regarding the social impact of science and technology. First, such impacts involve trade-offs between costs and benefits; second, in interdependent systems, it is not possible to deal with any large component without disturbing the others; and third, any large technological intervention will inevitably have unintended second-order consequences.

A model of citizen participation has been provided by Jon Miller, who notes that the traditional idea of science literacy involved two dimensions -- an understanding of the norms and methods of scientific practice, and knowledge of major scientific concepts. But, he adds:

> If scientific literacy is to become truly relevant to our contemporary situation, one additional dimension must be added: awareness of the impact of science and technology on society and the policy choices that must inevitably emerge.[42]

Building on the work of Gabriel Almond, Miller develops a pyramid model of participation. At the pinnacle are the decision-makers. Beneath them are various non-governmental policy leaders, or "elites," who interact with policymakers and often exchange roles with them. The "attentive" public -- that group interested in a given policy area and attempting to remain informed -- makes up a third layer. When decision-makers and policy leaders disagree among themselves, or when a consensus of policy leaders is not shared by decision-makers, appeal may be made to the attentive public to join in the political process and attempt to influence the decision-makers by communications, protests, etc.

At the base of the pyramid lies the non-attentive public. The non-attentives on any issue have little interest in the relevant science policy and a low level of relevant scientific knowledge. However, when they are unhappy about the direction policy is taking they can exercise a "political veto."[43]

In short, attentives influence decisions when there is no clear consensus among the community of decision-makers and policy leaders, and non-attentives attain influence when in sufficient numbers they become unhappy about the drift of policy. Only 2 to 3 percent of the non-attentives and fewer than 30 percent of the attentives have any basic scientific understanding on any given issue. Yet both groups have in recent years obtained considerable influence.

The importance of the attentives, most of whom must rely on science journalists and public interest group communications to acquire their basic scientific ideas, is growing as the consensus of decision-makers and policy shapers is eroding on major issues, but as Miller sees it:

> The situation is a fragile one Given the large numbers in this group who are dependent upon "translators," the personality or philosophical perspective of the translator may become as important -- if not more so -- than the substance of the scientific arguments.[44]

The non-attentives are also gaining in influence because of the increasing number of public referenda on issues related to science and technology, such as nuclear power, fluoridation, laetrile, and recombinant DNA. Given the current state of science literacy it is obvious that they will make uninformed judgments on these issues.

Miller's point is that a better understanding of both science and its social impacts would improve the performance of both the attentive and non-attentive publics in their specific roles in the democratic process. Attentives, while inevitably swayed by philosophical and ideological perspectives, would be less subject to ideological bias if they were more scientifically literate -- more comfortable digging into the scientific and technological matters at issue.

Two other implications are worth exploring. First, with the sense of helplessness reduced as citizens' scientific and technological "self-concept" (their sense that they <u>can</u> dig in and relevantly inform themselves) improves, there may be a larger reservoir in the community from which to recruit attentives. Second, a rising level of literacy among the attentives might exert an upward pressure on the translators, who would know that they could no longer substitute ideology for scientific and technological substance. This in turn would put a further upward pressure on the scientific community to improve their communications with the translators, forcing them to move beyond questionable public relations ploys.

If public education were effective in promoting scientific literacy, the remaining inattentives would at the very least be somewhat less open to irrational influences. This would improve their performance on referenda. It would also tend to curb media images of science and technology as either "saviors" or "devils," and hence would reduce the wild swings in the public's willingness to support funding for research and development.

<u>The Technology Tribunal</u>

The authors discussed so far share a "liberal" analysis, in that they take for granted the capitalist political-economic framework, with its inequalities of decision-making power, and try to moderate these inequalities through acceptable forms of political participation.

Shrader-Frechette seeks to reduce these inequalities in power still further, arguing that decisions on technology-dominated issues can be made by a tribunal of intelligent, non-expert citizens.[45] Without advocating specific forms or operating procedures, she supports the potential for such a tribunal. She considers the possibility of giving large groups of ordinary citizens, instructed via television by contending experts in an adversarial setting under rules of procedure, the final word on technology-dominated public issues.

Citizenship in the Pseudo-government of Technology

All of these analyses of "citizen participation" have focused on governmental decisions relating to technology. But decisions shaping and limiting life choices are not made only by government bodies. As Michael Goldhaber has noted, the institution of technology itself is "inherently political": it "channels and focuses human actions with the same fixity and force as laws established by sovereign governments -- such as those determining speed limits, drinking ages, or time zones."[46] This is because technology implies standardization: uniform, repeatable ways of doing things, utilizing standard objects and standard units. These standards don't simply "pop into existence." Rather, they are the result of formal and informal consensus building and negotiation among technologists, scientists, industralists, and even workers.

Goldhaber asserts that in a modern, technological society, these decision-making processes affect everyday life profoundly. If we neglect these processes and concentrate only on governmental decisions, then "political activity can only become increasingly irrelevant as a means of controlling what shapes our lives."[47] He calls technology the "pseudo-government" of modern society and insists upon democratic participation in the decision-making process of that institution, primarily through the labor unions.

For Goldhaber, democratic participation requires that each person have a right to be heard on matters affecting his or her life. This in turn requires that opportunities to form an opinion, which means information, leisure, privacy, and a venue for discussion, be available to all.

> Democracy loses its meaning if a society loses its commitment to equality, if information is concentrated in too few hands, if issues are decided in such technical form that most people are unable (or imagine themselves to be unable) to understand what is being argued....[48]

He offers a set of inter-related proposals for ensuring democratic participation in technology. These include social impact statements for inventions and proposed innovations, and guaranteed rights to a voice in technological decisions for factory workers to spread knowledge of, and power over, private sector innovation. Goldhaber's analysis challenges fundamental assumptions about limits on citizen participation and appropriate forms of power sharing in a modern technological democracy.

IV. STS Educational Reforms

What educational reforms does the STS community propose to promote citizen participation? Are these reforms possible, and will they effectively promote participation? To simplify, I will discuss reform under four headings: curriculum units and modules, curriculum reorganization, radical critical analysis, and de-schooling.

Curriculum Units and Modules

The main lines of STS curriculum reform are intended to change the science curriculum in two ways. First, they add technology and engineering content to traditional, disci-pline-based science content. Second, they place science and technology in their social and political context. Issues involving technological innovation are selected for analysis of societal impacts. Students engage in technology assessments, exploring direct and indirect, positive and negative consequences of various alternative decisions. They form personal judgments and may participate in either simulated or real-time citizen action to influence decisions, typically along established democratic lines.

STS units may be "tacked on" to the existing curriculum with relatively little disruption, in two ways:

(1) STS infusion. STS units or modules may be infused into discipline-based science courses. Such units may be limited to a single lesson or may extend to several days or even weeks, without forcing reorganization of the remaining curriculum content. In these units STS concepts and principles may be taught and illustrated. Didactic lessons may be reinforced and deepened through building STS skills. Students may conduct issue analyses, simulate decision-making and policy-shaping contexts, and engage in simulated or real-time citizen action projects: writing to or visiting a representative, joining an advocacy group, engaging in an environmental event or a protest meeting to exert influence on a decision-maker. Teachers may act as coaches or may facilitate issue analyses leading to deeper levels of interpretation and evaluation. Many modules, as well as elective interdisciplinary courses built from then, have been developed.[49]

(2) S-STS (Science through Science, Technology, and Society) Required Courses. Some "excellence reports" call for a required third-year science course. Many states legislated this requirement in the aftermath of the reports, and these new required courses are built from STS units. Aimed at students who would otherwise choose to avoid course work in the physical sciences, many of whom are "science and math phobic," these new required courses are organized around such topics as acid rain, nuclear waste, strategic defense, and global technological development, instead of traditional science disciplines. Addressing these issues in familiar and nontechnical terms, the units provide op-portunities for assessment of alternative technologies and simulated or real-time decision-making and social action, as well as some basic scientific concepts and facts, presented with some quantitative exercises.

The proposed benefits of S-STS courses are these:

o Science-avoiding students, required to take these courses, will acquire some additional science and technology concepts as well as quantitative reasoning and problem-solving skills.

o Learning will be easier because curriculum content is placed in the context of familiar community issues and is hence related to the out-of-school experiences of the learner.

o Course work is linked to students' future roles as citizen participants, influencing their destinies through democratic processes.

S-STS courses are being developed throughout the United States and Canada and already exist in several Western European countries and Great Britain.

Curriculum Reorganization

A thorough reorganization of the science curriculum was proposed in Educating Americans for the Twenty-First Century. Fewer topics should be included in the disciplinary science courses, and these topics should be studied in greater depth, integrating all the natural sciences, the social sciences, technology, and the socio-political and environmental contexts.

A reform of this depth would require major changes in pre-service and in-service teacher preparation, school organization, textbooks and curriculum materials, and achievement test items and operational procedures. The current science teacher corps is committed to a single discipline approach to science teaching, and to lecture-demonstration and laboratory methods of instruction. While they may be willing to infuse off-the-shelf STS modules into existing courses, they may resist a complete reorganization of the curriculum. An integrated STS curriculum that combined the efforts of science teachers and teachers in mathematics, social studies, and technology would require new administrative procedures and might encounter administrative roadblocks, especially if the goals and methods are not widely understood and supported by the public.

Curriculum materials and textbooks for year-long courses in the scientific disciplines reflecting an STS approach have been produced in the Netherlands. These materials are being translated into English, but may not be suitable in their present form for American students. Modular STS units are being produced at a rapid rate in the United States and Britain, but comprehensive textbooks for courses in the science disciplines are not being prepared at this time. Because of its "issues" approach to curriculum organization, the STS community has decried reliance on textbooks. Nonetheless, science teaching generally relies heavily on textbooks, and the widespread implementation of STS at this time will require them.

Current achievement tests reflect discipline-based science education goals (methods and concepts). The citizen participation goals of STS education pose special problems for test construction. But if these goals are not reflected on achievement tests, the practices that promote them will not attract achievement-oriented teachers.

It is safe to predict that a thorough reorganization of the disciplinary science curriculum along lines proposed by the STS community will at the very least be difficult to accomplish.

Radical Critical Analysis

Some educators have raised serious objections to the usual STS approaches to both citizen participation and technology.

Wood believes that citizen participation itself should be the focus of study.[50] He distinguishes between participatory democratic practices and a contemporary "protectionist" trend in democratic theory which seeks to justify the protection of technocratic decision-makers from popular challenge (on the basis of the "ignorance" of the masses vs. the "expertise" of technocrats.) He claims that contemporary democratic practice is locked within this "protectionist" mode and states three conditions for genuine citizen participation:

> First, the participants must be in the position of decision-maker rather than decision influencer; second, all participants must be in possession of or have access to the requisite information on which decisions can be reached; and third, full participation requires equal power on the part of participants to determine the outcome.[51]

Democracy functions best, in Wood's view, when it approaches such a participatory ideal. For then citizens do not merely choose between elites, but rather "transform themselves through debate and contestation over public issues,"[52] gaining in the process a greater sense of political efficacy, the knowledge and skill needed for self-governance, and ultimately more effective and efficient decision-making leading to an enhanced social and technological environment.

Wood criticizes "citizenship transmission" and "social science" approaches to civic education for their implicit acceptance of "protectionist" trends. The "citizenship transmission" model endorses only such participatory activities as voting, letter writing, and interest group formation, which tacitly assume the existence of decision- making elites. Wood argues that these established forms of citizen participation leave citizens powerless and that educational practices pointing in this direction promote cynicism and withdrawal.

The "social science" approach appears to place students in more active and creative decision-making roles, but by taking the technology assessment model for granted, the "deck is stacked in favor of technocratic solutions proposed by experts."[53] When participation takes place in the context of technology assessment:

> Social problems are not resolved on an historical, political or normative terrain over which varying notions of right and wrong are put forth outside of objective scientific knowledge. Instead, students face a cookbook approach in which only certain knowledge is legitimate and solutions to problematic situations are judged on their technical rather than humane merits.[54]

As an alternative, Wood proposes the direct study of citizen participation in technological issues. Taking the nuclear freeze as an illustrative case, he indicates how such study can bring the issue of participation into focus, because it shows many forms of participation to be "decried as not really within the rules of the game, and denied either legitimacy or usefulness."[55]

> What teachers need to do is demonstrate to students that while participation is legitimated in our cultural heritage, our current

limited sense of democracy functions to both discredit and occasionally even stop participation.[56]

The purpose of studying the nuclear freeze is not to encourage students to make a pro or con decision, based on a rational assessment, but rather "to demonstrate how participation is actually subverted in our current democratic structure."[57]

Winner argues that by emphasizing technological innovation and assessment, STS educators systematically exclude "intensive criticism of the fundamental ideas concerning the technological character of our civilization."[58] Focusing on innovation and assessment issues restricts attention to future opportunities for positive action, while "existing technologies and the social systems which support them" fade into a taken-for-granted background. The innovation/assessment mode is thus "drastically one-sided," for even if the world never saw another change, advance, breakthrough or startling innovation, fundamental questions must still be faced involving the "basic relationships between man and technology, and the nature of the modern technological civilization,"[59] about the role of technology in our culture and in our very identities.[60]

He notes that the early literature of the technology and society movement recognized the need for such fundamental inquiries, and he calls for a renewal of such foundational study, under the label "technology criticism." The first branch would be a philosophical anthropology which generates a "sweeping reappraisal of the identity of Western man as he appears in the technological society." The second would be a practical reexamination of the "specific socio-technical configurations which this society contains and their consequences for the way we live." These studies would lead to the ability to draw the line and say "no," the "courage to recognize and call attention to the untenable."[61] The possibility of altering the character of the human through genetic surgery, for example, is not merely another "choice" to be rationally analyzed in terms of its "costs" and "benefits." In seeking a standpoint to draw the line, we shall want to "have a firm grasp on the idea of who we are, how we got that way, and what we would like to become."[62]

STS and De-Schooling

The prescriptions of Wood and Winner may meet resistance in many conservative educational institutions. But however radical in content, these prescriptions fit within the formal framework of teaching and learning in classrooms. The STS prophets might raise still deeper questions. While rejecting neither schools nor university studies per se, they prescribed a more diverse mix of legitimate learning experiences, in the context of a life governed by ethical and religious rather than merely technical values.

We can make this idea more concrete by considering the Amish, who have been successful in creating and preserving just such a life. Taking advantage of new technological developments, they have first subjected them to community evaluation to determine their compatibility with the ethical, social, and spiritual principles of the life they have chosen. Significantly, they reject secondary education (regarding it as mere socialization in the scientific and technical knowledge and commercial values of our materialist civilization) and replace it with a mixture of quasi-apprenticeships and adult work responsibilities. Acceptance within the community and access to full adult status are based on commitment and competence, not on compulsory curricula or paper credentials.

The Amish provide one example of a "de-schooled" society, which we should seek to understand, rather than romanticize or reject as irrelevant We should keep in mind that the Amish have, in Winner's words, had the "courage to say no," long before the issue was genetic surgery to alter the fundamental character of human beings. Winner's "technological criticism" may lead us, too, to prescribe limits to schooling. By comparison, any reforms within the school curriculum are of minor importance. STS educators guided by the insights of the prophets now need to be thinking through a long-term social strategy for education and citizen participation, within which curriculum reform is perceived as merely an initial step.[63] Guiding values and goals, as well as transitional processes and stages, should now be proposed and debated.

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