DOCUMENT RESUME

ED 293 705 SE 049 059

AUTHOR	Waks, Leonard J., Ed.
TITLE	Technological Literacy. Proceedings of the National Science, Technology and Society (STS) Conference (2nd, Washington, D.C., February 6-8, 1987).
PUB DATE	87
NOTE	374p.; Drawings, charts, and some small print may not reproduce well.
AVAILABLE FROM	STS Press, 102 Materials Research Laboratory, The Pennsylvania State University, University Park, PA 16802.
PUB TYPE	Collected Works - Conference Proceedings (021)
JOURNAL CIT	Bulletin of Science, Technology & Society; v7 n1-2 1987
EDRS PRICE	MF01/PC15 Plus Postage.
DESCRIPTORS	*College Science; *Educational Technology; *Elementary School Science; Elementary Secondary Education; Environmental Education; Higher Education; *Science and Society; Science Curriculum; Science Education; *Secondary School Science; Social Studies; *Technological Literacy; Technology

ABSTRACT

This document contains 59 papers presented at a recent national conference dealing with the relationships among science, technology, and society (STS), with a particular emphasis on technological literacy. The papers deal with such topics as: (1) the concepts and frameworks of technological literacy; (2) STS and technological literacy at the higher education level; (3) STS and technological literacy in K-12 education; (4) technological literacy and women; (5) innovations in educational technology; and (6) challenges and critiques of STS and technological literacy. Introductory remarks by George Bugliarello and Rustum Roy, and an afterword by Leonard J. Waks are included. (TW)

BULLETIN OF SCIENCE, TECHNOLOGY & SOCIETY

The Materials Research Laboratory
The Pennsylvania State University
University Park, PA 16802 USA

Editorial Office: *Bulletin of Science, Technology & Society*, Materials Research Laboratory, University Park, PA 16802 USA. Telephone (814) 865-1137.

Publishing, Subscription, and Advertising Office: STS Press. Materials Research Laboratory, University Park, PA 16802 USA. Telephone (814) 865-1137.

Published bimonthly. Annual subscription rate (1985) $85 00 for libraries and other multiple-reader institutions, two-year rate (1985-86) $161 50 Professional rate (1985) $30.00. Special Educator s rate (1985) $25.00. Prices include postage. Air mail subscriptions extra.

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TECHNOLOGICAL LITERACY

Proceedings of the Second National Science, Technology and Society (STS) Conference

Organized by

Science Through Science, Technology and Society Project

of The Pennsylvania State University

in cooperation with

Contemporary Liberal Arts Core Curriculum

Polytechnic University (New York)

Edited by Leonard J. Waks

BULLETIN OF
SCIENCE, TECHNOLOGY & SOCIETY

Volume 7, Numbers 1 and 2 1987

Bull. Sci. Tech. Soc., Vol. 7, pp. 1-2, 1987. Printed in the USA.
0270-4676/87

TECHNOLOGY LITERACY - THE ESSENTIAL TASK

OPENING REMARKS

George Bugliarello

Last year, in Baltimore, we had a most successful first conference. It was a strong clarion call by Rustum Roy, echoed and reinforced by all participants as to the need in our society for greater technological literacy. The events that have occurred in the intervening year underscore again, dramatically, the urgency of attacking the lack of widespread technology literacy in our country.

This has been the year of Chernobyl, the year of the dramatic, if elusive, arms reduction proposals at Reykjavik, the year in which the administration has proposed to invest six billion dollars in a supercollider, the year in which the dismantling of our industry because of competition from abroad has continued at an accelerated pace in spite of a weak dollar, and the year in which the size of the AIDS epidemic has been revealed in its tragic dimensions, posing tremendous social and ethical health care dilemmas for the entire world.

In each one of these events, the need for technological literacy in order to draw intelligent conclusions, make intelligent public choices and develop intelligent policies is quite pressing.

The great strength of our country has two foundations: our form of government, and our technology. In our schools -- from elementary schools to universities -- we have done a good job in developing and communicating an understanding of our form of government -- how it works, the choices we can make, and how we can go about making such choices. But a similar understanding of technology is missing among the public at large. As a result, technology is mythologized, and much too much left to the experts, without that level of public involvement that is essential in a democratic society to deal intelligently with technology. The debate in the wake of the Challenger disaster has shown how even the media failed, before the disaster, to ask intelligent questions.

The same thing may be occurring now with the decision to develop the six billion dollar supercollider. For instance, it is fair to say that a debate as to why forego a 50-50 collaboration with other countries -- or a debate as to how the supercollider ranks in terms of alternative uses of six billion dollars for science (for instance, what $6 billion could do for science education) -- has been lacking. Another crucially important facet of technological literacy in which we are terribly deficient is the preparation in our secondary schools of a workforce suitable for the increasingly sophisticated technological environment of the school and the office.

Thus, the task in front of us is immensely important, and immensely urgent. The focus of this conference is particularly on a very key question for our society -- the issue of technology and imagination. How can we, for instance, maintain and enhance our individuality and creativity while competing technologically with other societies that are successful because they are more monolithic and conformistic? How can we preserve the greatness of our ideals and the coexistence of great diversities of views, and yet have a successful and competitive technology?

So, we certainly have our work cut out for us. Let us all wish each other success, and let us hope that a consensus and a coalition will begin to emerge, as to how to further technological literacy.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 3-8, 1987. Printed in the USA.
0270-4676/87

STS: MANAGING THE COMMONS OF HUMAN EDUCATION

Rustum Roy

STS: Connections to the Major Disciplinary Areas

The community of persons who gather under the rubric of Science, Technology and Society have chosen the theme of "technological literacy" as the focus of their meetings. This year that theme is continued and subtitled "Technology and the Imagination." Next year the theme is already in view as "Technology, Democracy and Development." STS would appear to be linked to all the highest goals of education and citizenship!! In this short introduction, I wish to address the twin questions, of how the overall STS movement is connected to these major societal goals, and how it is served by technological literacy.

Some 15 years ago, Garrett Hardin wrote a perceptive and widely debated article "The Tragedy of the Commons." In it Hardin explained how property or facilities which are shared or held in common, tend to be neglected and gradually run down. Indeed, beyond neglect, in Hardin's agricultural metaphor, shareholders in the commons tend to take advantage of this access and overgraze the commons while preserving their own property. The same phenomenon is evident in education. The tragedy of General Education is a perfect example of the "Tragedy of the Commons." All the centripetal forces of reward and recognition force professionals to look inward, to preserve and conserve their own disciplinary bases, while neglecting the inter-disciplinary commons. Indeed Hardin's metaphor is even more closely matched to the relation between discipines and their part in General Education. Beyond neglect, there is a parallel to "overgrazing" the commons. It is very common to find departments justifying their budgets on the basis of the large number of student credit hours 'earned' in their 'service' courses--i.e. their general education. Yet these budgets are disproportionately allocated to the specialist components of the discipline, often doing research on esoterica. Increased budget allocation, research time or money for improving the General Education courses (i.e. maintaining the commons) are typically minuscule.

It is the failure to determine clearly and define the distinctive content of general education which has led to the cycles of attention and neglect of General Education in American education. Because there has not, in the past, been a distinctive or characteristic subject matter at the core of general education, there is not a professional structure to serve as the continuing on-going guardians or managers of this intellectual commons. Today, it is becoming clear that within our colleges and schools, STS is becoming that intellectual foundation of what is called General Education. What else other than what is universally being called "STS" can form the core (not of course all) of General Education at this twilight of the twentieth century? A century which will be remembered as the inflection point in the influence, impact, nay, domination of the human condition by technology and science. The evidence of this realization is all around us: The burgeoning of STS departments, programs, courses in colleges and secondary schools. The "New Liberal Arts" programs by that or several other names all aim to invest liberal learning with a deeper understanding of S/T.

If we grant then that what has emerged in the last decade is the realization that STS is starting to create an intellectual framework of General Education, there remains the question of how STS is integrated into the formal world of schooling with its artificial but nevertheless all-too-real disciplines. I find the schema in Figure 1 helpful at this point. Each discipline separated from the other by walls, has increasingly come to recognize that there is a "commons" as much in education as in traditional agriculture. Figure 1a shows the situation obtaining in many universities today. The students in any discipline must now base their total general education on the offerings at the points of other disciplinary pieces of pie. This situation has produced not only scientific and technological illiterates but absolutely no integration of learning from history with technology, or literature and science, or social sciences with the arts; which the disciplines, by common agreement, assign to the commons. In Figure 1b there is depicted an emerging role for STS as it stands today. Within the central area STS is both forming a core and fuzzing the boundaries between disciplines. Moreover, there is little question that as the single-lifetime career wanes, General Education's share of the total pie will become even larger. The question facing the academic world is how it will manage this new intellectual commons in the near future. What I am developing here is that for the first time in modern history, the managers of the commons are not specialist representatives of their disciplines teaching their specialties at a "lower level to non-majors." The core area representing STS, does not mean teaching English to engineers or vice versa. Nor is STS merely a mixture of disciplinary topics. It has clearly emerged as something rather different, a "proto-discipline" created by the interaction among several disciplines and with purposely fuzzy interfaces with all such disciplines. In this model the disciplines do not provide all the content of general education. Rather, the disciplines manage the commons by contributing some of their members to bring their viewpoint to the interactive learning of a new subject matter; STS, which crystallizes at the core of General Education. It is appropriate to show STS as the core, because it is the result of new societally generated centripetal forces which force the interactions.

The emerging STS community may therefore be perceived as persons holding dual citizenship. They bear the linguistic stamp of the discipline of their formal education, but they have each chosen to learn a new language--that of STS. They are "technologically literate." It should be clear that the "litera" of technology are not at all the same as the "litera" of formal science. Many--perhaps most--scientists, and many engineers are, by this definition, technologically illiterate also because they do not understand the position and processes of connection of engineering and science with society. The multi-disciplinary character of the STS community is essential because that is what makes them acceptable--each to their respective disciplines--as guardians and managers of the commons. It is also essential for the healthy development of the content of STS itself.

Figure 1c is an attempt to show in schematic form a desirable model for the future relations between the major traditional academic areas and STS as the distinctive and core content of General Education and the interdisciplinary boundaries further weakened. The central claim of this approach is that when science and engineering subjects are, for example, connected to history or sociology or the arts, the general learner absorbs them at a deeper level. That is the "Science-through-STS" approach. The watered-down disciplinary course alternative of Figure 1a has failed and it is not clear how it can be altered in some new way. Figure 1c offers an attainable goal with the boundaries between disciplines growing increasingly fuzzy and penetrable and STS, created by the ongoing interdisciplinary community managing the commons, providing substantive core subject matter for General Education.

"Technology Literacy"--the Language of STS

Every discipline develops a certain minimal threshold of learning that we call literacy. Last year at this conference I tried to describe this level in the symbol "TC^3": Technological Comfort, Competence and Control. I claimed that Technological Literacy

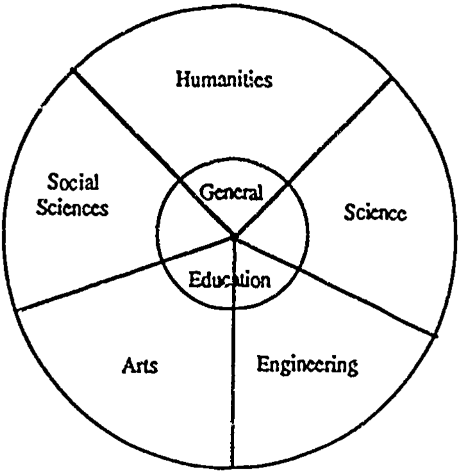

Fig. 1a. *"Classical picture of relation of General Education to the disciplines. A typical engineering student would include the courses within the dotted line perimeter. The disciplinary boundaries continue within General Education.*

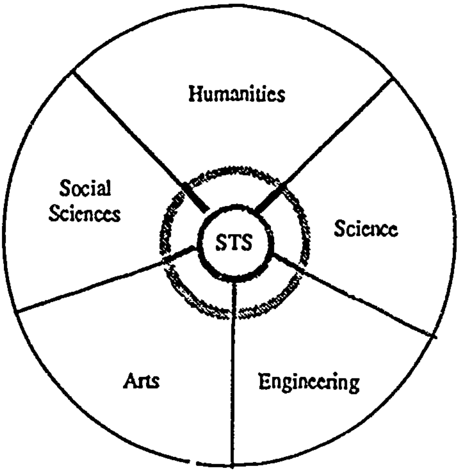

Fig 1b. *Emerging new relationships. Note that STS is forming as a core within General Education, and in addition the boundaries between disciplines in General Education are more permeable.*

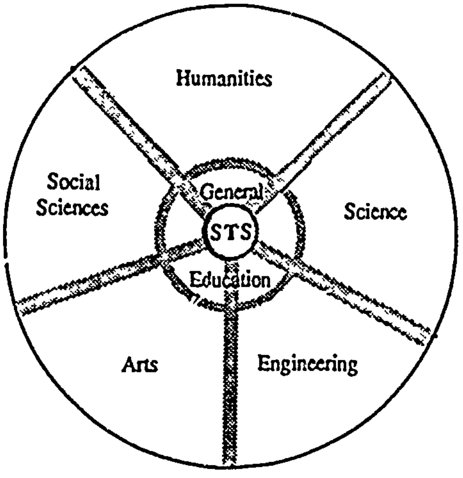

Fig. 1c. *A possible and desirable future; with much more overlap and permeability between disciplines, and STS at the intellectual core of General Education totally permeable to all disciplines.*

allowed one to become more comfortable in our technological milieu; Technological Literacy made one competent in one's work whatever it be in the societal context we find ourselves in; and, finally Technological Literacy implies that one has some sense of control over the choices which shape one's life. STS as part of General Education has developed a certain set of basic learnings, its fundamental axioms, the understanding of which is essential to delving deeper into the field. Such topics form the subject matter content of Technological Literacy, and become the language by which STS is recognized and taught, especially to the "general student."

Schooling Versus Conviviality

Having so defined STS and Technological Literacy the question that we must also address is: How does one become more than literate, indeed STS educated? Is making STS into a discipline and specializing in it possible or would it destroy the STS character as defined above? If the very connectedness to experience is necessary to retaining an STS character, then "schooling" in the sense it was used by Ivan Illich in his book "De-schooling Society" is surely not moving in the direction of more STS. I recall here that Illich, however, pointed out that some of the technological educational aids could be worse than traditional schools. He writes:

> Alternative devices for the production and marketing of mass education are technically more feasible and ethically less tolerable than compulsory graded schools. Such new educational arrangements are now on the verge of replacing traditional school systems in rich and in poor countries. They are potentially more effective in the conditioning of job-holders and consumers in an industrial economy. They are therefore more attractive for the management of present societies, more seductive for the people, and insidiously destructive of fundamental values.

In Figure 2, I have attempted to pictoralize the relationship between the two choices that the structures shown in Figure 1 now face as more education is demanded for all. What I have labelled the "schooling" direction requires much more specialization--in an attempt presumably to fit the needs of the job market of a "high-tech" society; i.e. one moves from 2b to 2c. This demand inevitably reinforces the rigidification of the discipline boundaries, and even if STS is taught, it too becomes a separate discipline; and the special character described for it in Figure 1c is lost. The alternative future could be in the direction of what I have labelled "conviviality"--living together--taken from Illich's "Tools for Conviviality." Here is how Illich--in 1975--described his views:

> I here submit the concept of a multidimensional balance of human life which can serve as a framework for evaluating man's relation to his tools.
>
> To formulate a theory about a future society both very modern and not dominated by industry, it will be necessary to recognize natural scales and limits.
>
> Once these limits are recognied, it becomes possible to articulate the triadic relationship between persons, tools, and a new collectivity. *Such a society, in which modern technologies serve politically interrelated individuals rather than managers, I will call "convivial."*

Convivial learning is "holistic" learning. It is learning where everything is connected to everything else. In the limit, all the so-called disciplinary bits of learning lose their identity because they all interact with and enrich each other, and where the boundaries between abstract knowledge and experience are equally transparent. That surely is what all stable traditional cultures had attained. It surely is what the very rare genuinely educated,

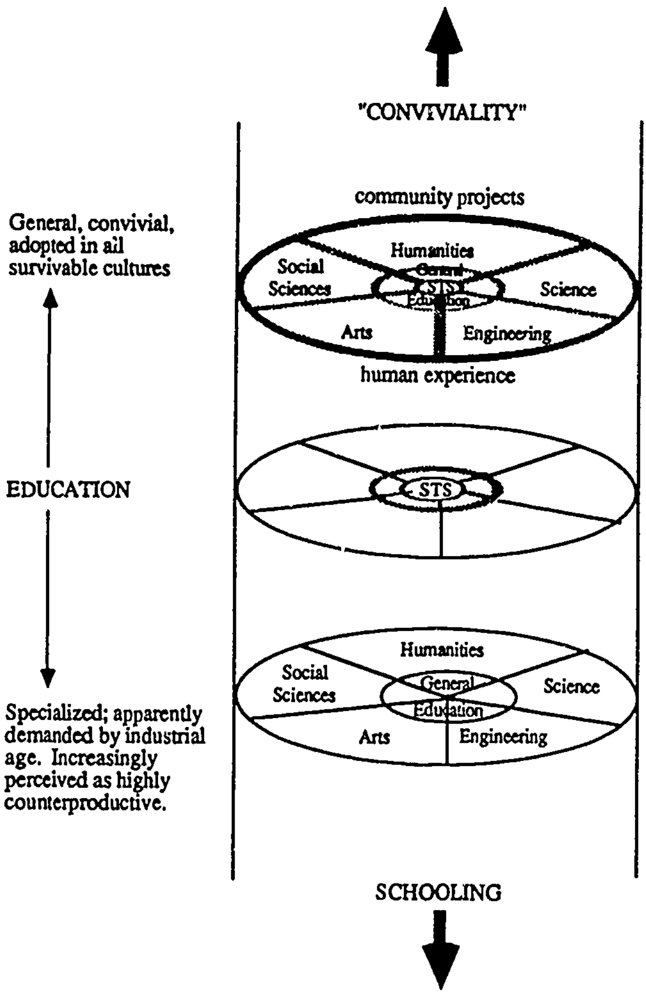

Fig. 2a *"STS" as the core of experience/learning, with very weak demarcation between disciplines and connections to society via experience.*

Fig. 2b *STS as the core of General Education commons of other human learning areas, and disciplines allowing for interdisciplinary overlap.*

Fig. 2c *General Education squeezed out. Rigid boundaries between disciplines.*

persons even in our high-tech culture have also attained. But we note that, in today's world, such an integrated person cannot be conceived of who has not come to terms with STS.

The sketch of Figure 2 also helps us see that different cultures--middle class midwesterners and innercity poor in America, African tribal, or Japanese high tech--are at different levels on the "schooling conviviality" axis. Tribal cultures would be higher than 2c on the vertical axis, with very little internal structure. "Appropriate education" for any population would match the mix of general and special education and the mix of experience and abstraction to fit the context. The STS content and its nature and the content of technological literacy would also change with this context.

The application of Figure 2 to the present crisis in mathematics and science education in the U.S. is that it helps us recognize that the problem simply cannot be solved by reverting to more "schooling." Whatever technique is used: more calculus courses, or an extra course in science cannot work and are irrelevant in any case. From an operational viewpoint the solution is in a different direction. Connectedness to experience is one key theme, cooperative hands-on projects are another. The new approach is characterized by puncturing, penetrating and lowering the disciplinary walls. Even more importantly it is characterized by the co-mingling of disciplinarians to form a new community, dedicated to the creation of an intellectual core for General Education and guarding the commons of the wide varieties of optimum human education.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 9-13, 1987. Printed in the USA.
0270-4676/87

A NATION REFLECTS: THE MODERNIZATION OF SCIENCE EDUCATION

Paul DeHart Hurd

The ferment for the reform of science education in American schools has never been greater. Never has the vision of what ought to be done been so clear. And never has an effort for educational reform been so befuddled, politicized, misdirected, superficial, and counter-productive.

My comments are directed at current efforts to reform the school science curriculum. It is my belief that a viable reform has its roots deeply embedded in the evolution of western civilization, the nation's history, and the cumulative achievements of science and technology. The tendency in the United States is to regard any demand for educational reform as a "crisis" and then proceed to deal with its symptoms, instead of searching for the intellectual insights that might change the aims of science education from what they are now. Since 1980 the reform movement in science education has been propelled mostly by indictment (teachers are unqualified, students unmotivated, test scores too low, parents disinterested and more): by political mandates for improvement (over 700 state laws and regulations in a three-year period): by slogans (quality, excellence, rigor, equity--all undefined) and by an overload of uninformed rhetoric. It is little wonder that the efforts to reform science education have achieved little more than to create confusion.

The issue of curriculum reform in science is intimately associated with the historical evolution of the sociology of knowledge in the sciences and technology and its influence on the culture. The potential of science in the culture was a concern of Francis Bacon. In 1620 Bacon wrote that the "ideal of human service is the ultimate goal of scientific effort," and its purpose is to equip the intellect for a "better and more perfect use of human reason" (1). To achieve these ends he would choose educational subject mater "which has the most for the welfare of man."

In 1668, a group of scientists and amateurs founded "The Royal Society for Promoting Practice Knowledge." Their purpose was to have a place where ideas could be exchanged, findings of experiments reported, and scientific views from other countries collected. Members of the society were facing an information crisis that was as serious to them as the 60,000 journals in science and technical fields now present to us.

In 1747 Benjamin Franklin and a few associates organized the American Philosophical Society. The purpose of the society, like that of the Royal Society, was to "promote useful knowledge" . . . "and improve the common stock of knowledge" among the American colonies through regular meetings, correspondence, and the establishment of a library. The library was to house a collection of scientific "experience, observations, and experiments . . . which if well-examined, pursued and improved, might produce discoveries to the advantage of some or all the British plantations, or to the benefit of mankind in general" (2).

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Leon R. Kass notes that the American republic is "the first regime explicitly to embrace scientific and technical progress and officially to claim its importance for the public good. The United States constitution, which is silent on education and morality, speaks up about scientific progress. It does so in defining the powers of Congress (Article 1, Section 8)" (3).

> The Congress shall have power . . . to promote the progress of science and useful arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries.

These statutes which we think of largely as protecting so-called intellectual property, were in the first instance thought of as useful to scientific and technical progress.

In 1798, Thomas Jefferson stated that the "sciences are keys to the treasures of nature" and "hands must be trained to use them wisely," . . . "knowledge can be practical as well as scholarly" (4). Jefferson invited DuPont de Nemours to survey, among other subjects, the teaching of science in the primary and secondary schools and the universities of the nation and make recommendations for improvements. Among DuPont de Nemours' recommendations were these: 1) Between the ages of ten and 17 students were to study "fourteen true sciences of which the great part are not yet taught in the colleges of Europe; 2) the natural sciences were to be thought of as "only branches of one science;" and 3) principles of the mechanical arts were to be widely taught. Teachers rejected the recommendations because there were no textbooks available. Jefferson asked Congress to appropriate money to have science textbooks written that stressed "natural history and mechanics" beginning in the primary schools. Congress turned down Jefferson's request for funds and America's first effort to develop a science/technology curriculum ended. Ironically a few years later, in 1805, Jefferson was awarded a gold medal by the society for agriculture for his design of a ploughshare that offered the lest resistance to soil: a technological achievement of considerable importance.

Steven Van Rensselaer, in 1824, founded an institution of higher education to encourage the application of "science to common purposes of life" and to foster "the application of experimental chemistry, philosophy, and natural history to agriculture, domestic economy, the arts and manufacturing" (5). Van Rensselaer was strongly convinced that a more productive economy in the United States was rooted in scientific research and its application in agriculture and industry.

In 1861, a Boston committee representing the associated institutions of sciences and arts, recognized that the time had come to consider "the happy influence of science culture on the industry and the civilization of nations . . . and for the cooperation of intelligent culture with industrial pursuits" recognizing that "material prosperity and intellectual advancement are inseparately associated" (7). "To secure the great industrial and education levels alluded to, it is proposed to establish . . . an institution devoted to the practical arts and sciences, to be called the Massachusetts Institute of Technology, having the triple organization of a society of arts, a museum or conservatory of arts, and a school of industrial science and art."

The committee then outlined an educational plan for the diffusion of practical knowledge and its technological uses through each of the proposed divisions of M.I.T. For example, the educational value of the museum of science and technology "would be best served if the arrangement of exhibits showed the successive changes of objects wrought upon them by the application of science, or mechanical skill."

The M.I.T. committee not only defined an institutional structure, but a rationale, curriculum goals, and instructional strategies for a science, technology, and society program at the collegiate level. There is no record, however, that this new context for the teaching of science had any impact on secondary school science.

In 1862 the Congress of the United States passed the Morrill Act, to develop colleges "for the benefit of agriculture and the mechanical arts" (6). Research was to replace observation and experience, leading to a science of agriculture. After a half century of struggle the nation now had a govemment-sponsored institution, the land grant university, dedicated to fostering research and its application for the purpose of advancing our major industry, that of agriculture.

I have described in another essay, efforts during the 20th century to generate a general education science, technology, society curriculum for use in schools (8). Here I will only highlight the major reform movements. As a response to the new industrial age in the United States around 1905 a series of practical courses in science were introduced into high schools. These courses bore such titles as "toy physics" and "civic biology." Industrial processes were added to the conventional chemistry textbooks such as the manufacturing processes for sulfuric and nitric acids, separation of minerals from ores, and various ways of making steel. These courses survived only a few years and then gave way to the discipline-bound courses they were designed to replace.

Declining enrollments in high school science courses brought the issue of more relevant science to the fore again in 1915. This time the new courses bore the titles of household physics, household chemistry and civic oiology. A general science course emphasizing a few basic principles from physics, chemistry, geology and biology along with applications in technology, industry, and everyday affairs made its appearance. The subject matter featured the airplane, automobile, radio, plant and animal breeding, control of communicable diseases, telescopes and astronomy, and the safe use of electrical appliances, among other topics. The course was introduced at the ninth grade to motivate students for pursuing more science in high school. Over the next fifty years general science became the most popular science course in the precollege curriculum. The high school courses in "household" science disappeared from the curriculum in a matter of three or four years.

Reflecting a general education movement in the sciences at the university level during the 1930s, efforts were again made to develop courses in a similar philosophical vein for secondary schools. Curriculum models for precollege science courses focused on the selection of subject matter related to the basic aspects of living so as "to promote fullest possible realization of personal potentialities and the most effective participation in a democratic society" (9). A few courses described as "consumer science" found their way into schools. The onset of World War II brought the movement to an abrupt halt under pressures from the scientific community "to get back to fundamentals" in school science if national needs were to be met.

The precollege science curriculum improvement movement that began after Sputnik in the 1950s and continued through the 1960s was designed to portray science as it was known by researches. The result was discipline-bound courses unrelated to individual and social affairs and without reference to concepts of technology.

Since 1980 over fifty national committee reports have been published calling for a new vision of science education in the schools. The most widely distributed report, A Nation at Risk, developed by the National Commission on Excellence in Education, describes science as a "new basic" in education that should form part of a common curriculum core for all students. The committee recommended that a knowledge of the humanities be "harnessed to science and technology if the latter are to remain creative and humane, just as the humanities need to be informed by science and technology if they are to remain relevant to the human condition" (10).

The panel on science of the National Research Council argues that "literacy in science as an objective of American education is fully as urgent as basic skills in the three R's" (11). The panel stresses the importance of science knowledge "useful for one's own well-being and knowledge useful for good citizenship."

Educating Americans for the 21st Century is a report to the National Science Board by the Commission on Precollege Education in Mathematics, Science, and Technology (12). The commission encouraged identifying new instructional goals along with a supporting curriculum relating science education to the quality of living and the resolution of social issues. The commission wanted students to "be able to make informed choices regarding their own health and life-styles based on evidence and reasonable personal preferences, after taking into consideration short- and long-term risks and benefits of different decisions. They should also be prepared to make similarly informed choices in the social and political arenas" (12). The commission added "the greater the degree to which all the sciences and technology can be integrated in new curricular approaches, the broader understanding in these fields will be" (13).

The Committee for Economic Development, representing business interests, titled their report on educational reform, Investing in Our Children (14). The committee stressed the importance of elementary school education and noted it is not now in harmony with the character of today's world. To meet the demands of a changing society children should have more opportunities to develop such cognitive abilities as priority setting, problem solving, decision making, effective communication, learning, and logical reasoning as well as a common fund of knowledge.

The task force of the Twentieth Century Fund emphasizes the increasing need for scientific literacy for all citizens so they may be able to participate intelligently in political decisions and controversial issues that have a dimension in science or technology (15).

The National Science Teachers Association has taken the position that precollege science should be taught in a science/technology/society context that considers the welfare of individuals (16). Furthermore, skills and attitudes essential for the proper use of knowledge are to be emphasized in every grade and for all students.

Where are we now in science education? About where we were in colonial days. The avalanche of reports on the condition of science education in the U.S. today differ little in their recommendations for reform from those of the past two centuries. At different periods in our history thoughtful groups of scientists, engineers, and citizens have recommended a comprehensive reconceptualization of school science that translates into human capacities for dealing with change, for extending knowledge and its comprehension throughout life and for assuming civic responsibilities. What has been sought is a science curriculum that considers the interconnectedness of human beings, natural phenomena, advancements in science and technology, the quality of life and the economic progress of the nation. What the national panels, commissions, and committees have found in today's schools is a science curriculum that fails to recognize the image and ethos of modern science, recent shifts in many aspects of our culture and changes in our economy and the work place.

Just at the moment when science and technology are historically in the best position to advance human welfare and the common good, just at the moment when we have national support for a revitalization of science education, we are unable to marshall the intellectual forces for doing so (17). There has been little progress in defining a unified science and technology curriculum that recognizes we have "a shared cultural heritage, a shared agenda of urgent contemporary problems, and a shared future that cannot be ignored" (18). Before we can expect changes in science education, scholars in science and technology policy, in the history and sociology of science and technology, in research and innovation, together with humanists, teachers and educators must work harmoniously together. Then in the spirit of mutual tolerance and respect they must work to identify the over-arching framework, integrative themes, cognitive skills and the knowledge base essential for a viable science, technology, society curriculum.

The synthesis required for this endeavor is not something that teachers in the elementary and secondary schools working alone can carry out in their free hours, the responsibility lies with the science and engineering communities. It is the task of the scientists and engineers to build the essential bridge between their endeavors and those of science education in the schools.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 14-24, 1987. Printed in the USA.
0270-4676/87

BEYOND LITERACY TOWARDS FLUENCY CURRICULUM INTEGRATION FOR THE INFORMATION AGE

Irwin J. Hoffman

It defies common sense that contemporary issues do not pervade the education of America's youngsters. An understanding of the controversial and often life-threatening dilemmas of our society is essential for our students to become informed citizens and, as a consequence, a knowledgeable electorate. These current problems are of pervasive concern, and most of them are imbedded in the controversy. The diverse subjects taught in a comprehensive high school could individually make their own contribution to an intelligent understanding of life in our complex society. The controversies can be presented within the context of each discipline so that the rubric of the subject matter can be presented while the course contributes to the "warp and woof" of an overall understanding of modern society. The "glue," holding together this integrated curriculum, is the computer.

There will be a paradigm shift in the framework used to deliver education. Goals will change from regurgitative knowledge to generative knowledge. Educators will be concerned with how students learn rather than what they learn. Methods will change. Naisbitt, in his book Megatrends pointed out that ownership, team-work and networking constitute a new methodclogy that produces results in successful Information Age enterprises. Educators will have to utilize these new techniques as they modify and update the curriculum.

Networking will extend learning experiences beyond local sites. Already Robert Tinker of Cambridge has established an activity-oriented large-scale science activity. Geographically separated groups of students are collecting acid rain for analysis. It is not hard to see the value of a computer network as a catalyst to this activity. Foreign language students at George Washington High School in Denver are using the Source (a public information utility) to send letters to pen pals in foreign countries using their Spanish, German and French word processors. Telecommunications and satellites facilitate this activity in our "increasingly shrinking" world.

The six headings presented below (box) are suggested as topical guidelines under which the pressing issues of contemporary society could be studied and for which a new educational framework could be designed. They are designed to provoke a discussion regarding alternatives to our current educational delivery system. Technology has made it possible to seriously consider such modifications. Horizontal and vertical integrated articulation of learning is now possible and the education establishment should "plumb" the depths of this potential.

A creative K-12 curriculum developed around the dilemmas of our society would provide a strong basic education for children. Reading, writing, arithmetic and technological skills could be mastered in any context. Students should be prepared for modern society by studying the basic tenants of each discipline (contextually) within an infrastructure of modular curricular offerings that present a total treatment of each issue.

THE SHRINKING WORLD -	TRAVEL, COMMUNICATION, TERRORISM, OTHER LANGUAGES, OTHER CULTURES
ENVIRONMENTAL ISSUES -	POLLUTION, EROSION, DECLINE OF NATURAL RESOURCES, INSTITUTIONAL RESPONSIBILITIES, INFRASTRUCTURE, OZONE DEPLETION
MORAL ISSUES -	GENETIC ENGINEERING, DRUG INGESTION, IMPACT OF RELIGIONS, HUNGER, PREJUDICE, AGING, POLITICS, MEDICAL CARE, FAMILY STRUCTURE CHANGES, AIDS, SURROGATE MOTHERHOOD, TEST-TUBE BABIES
TECHNOLOGICAL ISSUES -	MICRO CHIP, LASER BEAMS, FIBER OPTICS, SPACE EXPLORATION, CHANGING WORK PLACE, CONSUMERISM, INFORMATION AGE, SDI, TECHNICAL READING AND WRITING
RECREATION -	LEISURE TIME, APPRECIATION OF ART AND MUSIC, FITNESS
FUTURISM -	CHANGE IN VELOCITY: PAST HISTORY → PRESENT WORLD → IMMINENT FUTURE

Teacher education will be changed as new teachers are prepared to teach within these infrastructures. The universities will eschew their customary (inherited) departmentalization of man's cognitive forays and develop new ways to "package" knowledge. For instance a university might have a department of Environmental Issues. Within this department science, technology, mathematics, social science, art, music, etc., would be oriented to prepare all students, including prospective teachers, to intelligently analyze the issues that impact on the world's environment. The power of mathematics and science as an interpreter of phenomena will be given to everyone, while the abstract structure of these disciplines will only be offered to those who are capable of understanding it. No longer will mathematicians and scientists impoverish (intellectually) the non-scientifically inclined by postponing (withholding?) such analyses until a student has reached a specific level of expertise in their fields. Instruction will change so that the question so often asked, "What good will algebra do me?" will become "When do I get to study the rules of algebra? I see what it can do." The use of the power inherent in these subjects will motivate the study of the subjects. An example of extending this power downward is found in using spread sheets on the computer. A non-algebraically oriented student could study any application that requires exponentiation on a computerized spread sheet without an in-depth knowledge of algebra. Half-life, growth of bacteria, investments and many other applications of mathematics requiring a knowledge of exponents and logarithms would be available to students who would never study these subjects.

The elementary school of the future will staff itself with a faculty whose college degrees might include majors in the topics listed above. The former Physical Education majors will become Recreation majors with an understanding of how recreation impacts the environment, an awareness of the values of art, literature and music as leisure-time activities. Physical Education majors will become part of the academic faculty instead of existing in the twilight zone of academia.

Naisbitt observed changes in the operation of the corporate world. The academic world will respond to the same forces. An exciting spirit in the education enterprise will gestate as students and teachers network, material is developed in projects undertaken by student teams, and ownership of the curriculum happens at the grass-roots level of practicing teachers. The authoritarian model of education will gradually disappear as the effectiveness of this new technology becomes apparent. Students who lag behind in required skills will find remediation available in sophisticated CAI programs, replete with adaptive testing and administrative procedures. The colleges will be forced to accommodate the changed demands for their "product."

Efforts in this direction are already taking place around the country. The teacher-developed "PIC" program in Jefferson County, Colorado, is producing an integrated curriculum for grades 1 and 2. Jefferson County's "Topics in Science," program integrates the sciences for grades 6 and 7. Teachers in the school district of Fort Collins, Colorado, are developing an integrated high school science program, called "Project Engineering." This program, also, could be redesigned to require parallel units in business, mathematics, English, social science, art and industrial art. All of the above programs encourage students to work in teams and provide networking opportunities for students and teachers alike. The outstanding curriculum in the Denver Public Schools magnet computer laboratory at George Washington High School uses the computer to integrate social science (questionnaire design and data collection), mathematics, English, and computer science in a popular class called Technical English. This course emphasizes networking, team-work and student ownership, undergirded by integrated software that includes a word processor, a spreadsheet, a data base, report generation, and a graphics package.

The University of Chicago is piloting a major new mathematics curriculum called UCSMP, "The University of Chicago School Mathematics Project." Dr. Usiskin, an author of this program, indicates that some of this new mathematics curriculum comes from the social studies and business communities. Except, the social studies and business departments are unaware that this curriculum is being tested in their school. Mathematics teacher are the sole owners of this curriculum modification, even with its purported applications to the real world. Interdisciplinary integration is not often a requirement of grant-offering institutions or a priority of principal investigators.

In the late '70s the National Science Foundation (NSF) supported research called "Project Synthesis." The results of this study proposed an integrated science curriculum, still not a synthesis with the other humanities, but nevertheless a start. The Congressional mandate of the NSF only provides funds to support research that is totally related to the advancement of the science curriculum. Congress should mandate the Foundation to pursue research that develops an integration of science, mathematics and technology across the entire curriculum. Scientists must not only compute, they must read and write critically and understand the social consequences of their work.

The scientific literature abounds with schemes for a unified curriculum that promotes scientific and technological synthesis in the curriculum. Why does this literature ignore the necessity of bringing in the humanities? Roger Bybee of BSCS, located in Colorado Springs, Colorado, has established a whole conceptual framework (Appendix A) under which a unified science program could be taught. One could easily envision an entire integrated curriculum under this framework.

Many scientific disciplines are suggesting modifications within their area of concern. The advocates of modernization within the mathematics curriculum are suggesting changes that recognize the value of the calculator and computer. Mathematicians point out that the division algorithm, except for single digits, is no longer necessary. The National Council of Teachers of Mathematics (NCTM) and the Mathematics Science Education Board (MSEB) suggest that calculators be part of instruction from early primary school. At least four states are including calculator items in their standardized tests for next year. The

College Board has instructed the Educational Testing Service to develop a mathematics level 2 test that requires the use of the calculator. The NCTM is advocating changes in geometry and the development of high school courses in finite mathematics. However, like the science people, mathematicians are not suggesting that mathematics unify with the other humanities.

It seems to me that the suggestions for change in the mathematics and science curricula have an implicit agenda for a totally integrated curriculum. Yet advocates of these changes are so entrenched in their own interests that these suggested modifications stop short of a truly appropriate, integrated education. Mathematics, science and the other humanities should be taught as servants of each other, not as masters of their own fiefdom. The curriculum for this education should stress the dependency each discipline has on the other. Learning activities should be correlated between disciplines.

Mathematicians and scientists are not solely to blame. Rarely do I see suggestions of curriculum modifications in English and social science that advocate a partnership with mathematics and science. Each discipline seems to exist in an isolated relationship, whereas in reality they are completely symbiotic. English teachers must teach technical reading and technical writing. Instructors who are involved in teaching students to write research papers must address the new methods of collecting data in data bases and analyzing this data with application programs such as graph generation, spread sheets, and word processors. Librarians who restrict their instruction to card catalogues and do not include the library electronic search routines with modems and computers are doing their students a distinct disservice.

In my opinion the year 2000 will see a change in the K-12 curriculum, demonstrating the symbiotic relationship among all subjects. Students will no longer study any field as a subject in its own right, but will study all disciplines as an application toward understanding contemporary issues in society. The K-12 curriculum will produce citizens who: (1) comprehend the problems of their time; (2) participate in the dynamic vocational and avocational evolution; and (3) read, write, compute and communicate effectively in the Information Age. Instruction in the next century will discard the outmoded remnants of a curriculum developed by the pressing needs of the Agricultural and Industrial Ages.

Twenty-first century instruction will be graduated to reflect the natural skills of the students. The subject matter studied at all levels will reflect the society students will join. For instance, all students might study problems related to retirement. In a mathematics application, those students who are capable of mastering algebra will examine investment issues with equations, logarithms, exponentiation and the rule of 70. Students who are not as capable, mathematically, will study the growth of investments with application computer programs, calculators, spreadsheets or the analysis of pre-printed tables. At the same time the social science classes will discuss the problems of retirement, social security, IRAs and Keogh plans. Social Science classes might also discuss the history of FICA, the depression and other issues that bring investment growth into perspective for the students. English classes will provide students with research, reading and writing skills appropriate to this subject. A combined English, art and social science project might involve creating a brochure for a nursing home.

Higher education will have the responsibility of taking those students who are "turned on" by a discipline and making specialized scholars of them. Students will still enter college with the algebra, geometry and trigonometry necessary to study higher subjects; however, they will have studied these subjects within the context of societal issues. The training of teachers will be modified to reflect the changes in methods of instruction. Colleges must develop better writing skills in mathematics and science teachers. Teachers of English and social science will have to be taught the roles of mathematics and science as descriptors of their disciplines. The use of the computer must to be effectively taught in all areas of teacher preparation. Lip service to the use of this tool must be replaced with an effort to produce genuine competence in the use of application software. Universities will have to train administrators to work in a networking environment. There will be many changes. The Information Age will make its demands and we must respond!

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Appendix A

This is a list of what is presently an intra-disciplinary set of topics that should become an inter-disciplinary set of academic "tools" that examine the issues of our time.

(The * indicates a computer or calculator is useful or necessary.)

I. MATHEMATICS AS A TOOL IN UNDERSTANDING THE ISSUES OF OUR TIME

- EXPONENTIATION

  *RADIOACTIVE DECAY-NUCLEAR WASTE

  *INVESTMENTS - IRA, CD

  *DEPLETION OF NATURAL RESOURCES - OIL, GAS, COAL

  *GROWTH - POPULATION, DISEASE

- STATISTICS

  READ DESCRIPTIONS OF DATA CRITICALLY

  *DESCRIBE DATA INTELLIGENTLY

  CONVERSANT WITH VOCABULARY

  *GRAPHIC INTERPRETATIONS AND DESIGN

  *DATA COLLECTION

  *PORTRAYAL OF DATA - STATISTICS

  TECHNICAL READING - INTERPRETATION OF PICTORIAL DATA

- PERMUTATIONS, COMBINATIONS, AND PROBABILITY

  *GENETICS

  *PROBABILITY - LOTTERIES, OCCURRENCES OF EVENTS

  *BASIC RESEARCH - CHEMISTRY, PHYSICS, OTHER SCIENCES

- ARITHMETIC IN ALTERNATE BASES

  *FOUNDATIONS OF MATHEMATICAL NOTATION - PLACE VALUE

- CALCULATOR USE

  *ALL AREAS OF COMPUTATION - RPN, AOS, MEMORY USE

  *BALANCING CHECK BOOKS

  *PAYROLL DEDUCTIONS - TAXES - FRINGE BENEFITS - INS.

  *MORTGAGE

  *DRILL AND PRACTICE

- SCIENTIFIC NOTATION AND MEASUREMENT

  *ESTIMATION AND APPROXIMATION

  *EYEBALLING CALCULATIONS

  *CHECKING ON ACCURACY OF CALCULATOR

  *LARGE NUMBERS - SPACE, SCIENCE

  *MEASUREMENT - LIGHT YEARS, ASTRONOMICAL UNITS

  *SMALL NUMBERS - SPACE, SCIENCE

  *MEASUREMENT - MICROSECONDS, NANOSECONDS, PICOSECONDS

  RULERS FOR PATTERN MAKING, INDUSTRIAL ART IN CONTEXT - SO IT IS MEANINGFUL

  *TIME - LIGHT YEARS, CLOCKTIME (HOURS - NANOSECONDS)

  *DIFFERENT UNITS - ORDINARY, NOT SO ORDINARY ASTRONOMICAL UNITS, BAUD RATES, ETC.

  TOOLS - CHANGING A TIRE

  *UNITS DESCRIBING CONTAMINATION

  *POLLUTION OF THE AIR, LAND AND WATER

  *NOISE POLLUTION

  *TOXICITY

- PROBLEM SOLVING

  *REAL PROBLEMS - OWNED BY STUDENT

  *WORKING AS A TEAM

  *ORAL AND WRITTEN EXPOSITION OF PROBLEM AND SOLUTION

II. SCIENCE AS A TOOL IN UNDERSTANDING THE ISSUES OF OUR TIME

METEOROLOGY

*INVERSIONS - BROWN CLOUD

UPSLOPE, DOWNSLOPE

TURBULENCE

MOUNTAIN WAVE

FRONTS

CONVECTIVE CLOUDS

WEATHER WARNINGS - WATCHES, ALERTS, ETC.

- PHYSICS/CHEMISTRY/BIOLOGY

*HALF LIFE

*RADIOACTIVITY

*ENVIRONMENTAL ISSUES

*GREENHOUSE EFFECT

*NUCLEAR WINTER

*BROWN CLOUD - AUTO EMISSIONS, SMOKESTACKS, FIREPLACES, INVERSIONS, PRESSURE GRADIENTS

*WATER POLLUTION

*INDUSTRIAL POLLUTION

*FOOD CHAIN TOXICITY - CHEMICAL WASTE, BULLETS SPRAYING, DRUGS AND FOOD ANIMALS, POISONING "PESTS"

TAMPERING WITH NATURAL BALANCES - KILLING PREDATORS, FOREST FIRES, KILLING OFF GROUND COVER, AGRICULTURE (DUST BOWL)

*ROLE OF PLANT LIFE

*ENVIRONMENTAL IMPACT - POLLUTION, CONSTRUCTION

*OXYGEN SOURCE

*SCIENTIFIC METHODS OF INVESTIGATION

*SPECTROGRAPHIC ANALYSIS

*INFRARED ANALYSIS

*SOUND ANALYSIS

*NEW TECHNOLOGIES RESHAPING OUR WORLD

*FIBER OPTICS

*MICRO CHIP

*LASER BEAM

III. SOCIAL SCIENCE HELPS IN UNDERSTANDING THE ISSUES OF OUR TIME

TOPOGRAPHY AS IT AFFECTS CLIMATE

*ECONOMICS

*SYSTEMS - CAPITALISM, SOCIALISM, COMMUNISM

*SCARCITY

*SUPPLY - DEMAND

*CONSUMER EDUCATION - SKILLS FOR LIVING BANKING, SAVING, INSURANCE, TAXATION, BUYING, MORTGAGES

*GEOGRAPHY

MAP READING

CULTURES/RACES/COMPARATIVE RELIGIONS

IV. ENGLISH AS A TOOL IN UNDERSTANDING THE ISSUES OF OUR TIME

READING SKILLS

READ CRITICALLY - AUTHORS' BIASES

READING RATES (VIS-A-VIS MATERIAL DIFFERENCES)

READ PLANS/DIRECTIONS FOR ASSEMBLING PRODUCTS

READING VOCABULARY

UNDERSTAND COMMON TECHNOLOGIES - NEWSPAPERS

COMMON "BUREAUCRATEZE"

COMMON JARGON (CHANGING THE ENGLISH LANGUAGE)

EMPHATHETIC READING - DEVELOPING UNDERSTANDING OF EMOTIONS

ADD READING MATERIAL THAT DESCRIBES CONTEMPORARY SOCIETY - MEGATRENDS, CENTENNIAL, ENCOURAGE DISCRETIONARY READING

HIGH TECH - HIGH TOUCH INTERESTS

WRITING

*CRITICAL ANALYSIS - INCLUDING TECHNICAL WRITING

*PROBLEM SOLVING

*MODERN METHODS OF LITERATURE SEARCH

ORAL COMMUNICATION

GEAR PRESENTATION TO AUDIENCE

LEARN TO USE NEW TECHNOLOGIES

*GRAPHICS

OVERHEADS

SLIDES

*INTERACTIVE VIDEO DISK TECHNOLOGY

A Conceptual Framework for Knowledge, Skills and Values of Scientific and Technologic Literacy.

ACQUISITION OF KNOWLEDGE	UTILIZATION OF LEARNING SKILLS	DEVELOPMENT OF VALUES & IDEAS
related to	based on	about
SCIENCE AND TECHNOLOGY	SCIENTIFIC AND TECHNOLOGY INQUIRY	SCIENCE AND TECHNOLOGY IN SOCIETY
in three areas of emphasis	means of active participation	through study of
PERSONAL MATTERS	INFORMATION GATHERING	LOCAL ISSUES
CIVIC CONCERNS	PROBLEM SOLVING	PUBLIC POLICIES
CULTURAL PERSPECTIVES	DECISION MAKING	GLOBAL PROBLEMS

The table was taken from a lecture by Roger Bybee.

Appendix B

Examples of modules for the integration of the curriculum.

I. Environmental Issues

A. Pollution
1. Water pollution
   a. Oil spills
   b. Agriculture
   c. Industrial waste
2. Land pollution
   a. Land fills with toxic material
   b. Industrial waste
3. Air pollution
   a. Greenhouse effect
   b. Brown cloud
4. Noise pollution
   a. Travel
   b. Recreation
   c. Industry

Science: Ramifications on food chain, impact on wild life, effects on plantlife, chemistry of pollutants, chemistry and physics of preventive measures, public health, meteorology, toxicity, human physiology of hearing and breathing.

Mathematics: Computation techniques to understand the above. Graphs, collection of data, display of data, statistics, units of measurements, algebraic modeling, exponentiation, logarithms.

Social Studies: Geography, history, politics, analysis of societal problems, recreation, travel, industries that pollute, economics of these industries, reading and discussing environmental impact statements, kinds of jobs, kinds of education.

English: Methods of acquiring information, reading for information, critical reading, writing a survey of pertinent information, problem solving, debating, oral exposition, technical reading, technical writing, writing environmental impact studies.

Electives: Music, word processing, application software packages using databases, report generators and graphics (maybe writing original programs).

B. Infrastructure
1. Transportation
   a. Land
   b. Sea
   c. Air
2. Industry
   a. Public sector
   b. Private sector
3. Agriculture
4. Communications
   a. Telephone
   b. Television
   c. Radio
   d. Newspapers and magazines
   e. Electronic
   f. Satellite

5. Education
   a. Public thru higher education
   b. Private thru higher education
   c. Corporate
6. Government - local, state and national
   a. Policies
      i. Development
      ii. Administration and Implementation
7. Natural resources
   a. Energy
   b. Water

Science: Industrial arts such as drafting, and reading blueprints, understanding the physics of communication, transmission of signals, satellite trajectories, the botany of agriculture, the chemistry of fertilizing, fossil fuels, the physics of energy resources, the chemistry and physics that undergrid transportation systems, the science of water collection and storage, evaporation, radar, laser technology (USA Today printed by satellite transmission and laser printer).

Mathematics: The algebraic modeling of consumption of natural energy resources, the trigonometric and algebraic modeling that describes the frequencies, amplitudes and periods of signal transmissions, surveying, mathematical modeling for taxation, amortization tables, bonds and other financial instruments that pay for infrastructure funding programs, the computations that describe quantities of water flow.

Social Science: Studies of government, legislation, enforcement, bureaucracy, methods of collecting opinion data, analysis of data, economics of government and industry, descriptive tools used in economics, capitalism versus other alternatives, sharing of resources such as the Colorado rivers, mining of resources and the industries involved, financing education, kinds of jobs, kinds of education.

English: Research techniques vis a vis modem data bases and modems, writing position papers, research papers, impact studies, technical papers, editorials, journalistic articles, reading financial instruments, reading legislation, reading impact studies, reading technical documents, reading Centennial, reading about problems in agriculture.

Electives: Join clubs in political arena, support activities such as word processing, accounting and typing, shadowing professionals working in infrastructure activities, art instruction regarding colors in television and colors in printed material, position posters.

Bull. Sci. Tech. Soc., Vol. 7, pp. 25-27, 1987. Printed in the USA.
0270-4676/87

OUTSIDERS AND INSIDERS: SOCIAL FACTORS THAT DETERMINE SCIENCE AVOIDANCE AND ALIENATION

Sheila Tobias

This talk will address the common perception by some students that they are "outsiders" to science and must remain so because science and mathematics, the language of science, are seen as a series of domains from which they are socially or by their own self-imposition excluded.

One perception is that science and mathematics reside somehow as part of a "male domain," a problem already identified by Fennema, Tobias and others[1] for women in mathematics. Another is that science belongs to a "white-Anglo" domain which causes blacks and minority Hispanics in the United States to exclude themselves. A third is more general, a perception that science belongs to an "elite domain," one for only those of enormously high-scoring intelligence. A fourth--a variation on the last--is that science belongs only to people who have a "special gift" for the work. Whatever the "domain," students perceive mathematics and science to be non-verbal, non-humanistic in nature, exact answer oriented and, as a result, not very friendly to students who are not.[2]

Feelings of alienation, then, stem initially from perceptions of science as unfamiliar and forbidding. And these feelings manifest themselves both in science avoidance and concomitant anxiety about science (avoidance and anxiety being reciprocal) and also in students' perceptions that neither mathematics nor science has much utility intellectually or professionally for themselves.

This is compounded by a general unwillingness or inability of their nonscience instructors (especially, but not exclusively at the high school level) to make the connections between fields and, above all, to show them the utilities of science.

The other perspective of the outsider/insider approach is to seek from outsiders some insight into what makes science and mathematics difficult for ordinary students to learn.

From Perspective 1, I developed the math anxiety project beginning in 1975 which has been well documented elsewhere. In brief, 600 elite college students who had stopped studying mathematics in high school and who were determined not to study it again (40 percent male, 60 percent female) were counseled and given math anxiety reduction workshops at Wesleyan University in Connecticut. Of the 600, almost all survived a college-level calculus course within one or two years from the onset of their math anxiety reduction work.[3] From the project, the following problems were identified as blocking otherwise intelligent, highly motivated college students from mathematics at the college level:

I. Ideological Issues

1. That one either has or does not have a "mathematical mind" and that, as a result hard work is not particularly useful in learning mathematics.

2. That mathematics is a "malc" indeed a "white Anglo male" domain (see above).

3. That speed and accuracy are the most important aspects of mathematics; not persistence and insight. Right answers were seen to be more important in mathematics learning that "right understanding."

II. Classroom Styles

1. Timed tests.

2. Right answer orientation which left little room in class for debate and discussion which these students liked best.

3. Type of evaluation: narrow, right-answer oriented (see above), premature closure. (No opportunity to comment on a math problem and to explore its other meanings.)

4. Cheating paranoia: teacher's hostility and suspicion of students.

5. Hierarchic rigidity of the subject.

6. Inevitable competitiveness in class.

III. Verbal

1. Problems of "dialectical" use of familiar terms in different and more demanding ways.

2. Textbooks not discursive enough for good readers who depend on books for their information.

3. Problems with notation.

4. Overly compulsive searching for "meaning" of mathematical expressions.

The results of work on these issues with students in small groups with combined counseling and mathematics instruction was impressive. Once clear of their "blocks," students at this level were able to catch up with their age mates within 8-10 months.

After ten years of working in the math anxiety/math avoidance arena, I have now turned to focus on the "utility" argument and am writing a new book Succeed with Math for The College Board (July 1987)[4] that will offer mathematics for math-avoiders largely through applications. Typically applications are presented as an afterthought to the presentation of some mathematical principle in a text. In my book the mathematical principles are applications-driven which means that mathematics is taught (as I believe outsiders prefer to learn it) as it is needed to solve some real-world sets of problems.

In addition, I am employing the "outsider perspective" in a series of learning laboratories in which professors of science and/or mathematics presented a self-contained unit of material to a "class" of their colleagues from fields outside science. The Project called "Peer Perspectives on Science" is funded by the Rockefeller Foundation in 1986-87 and is reported elsewhere.[5]

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To be published by the College Board and distributed by the

MacMillan Company, July 1987

Succeed with Math
Every Student's Guide to Concerning Math Anxiety
by Sheila Tobias

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Bull. Sci. Tech. Soc., Vol. 7, pp. 28-35, 1987. Printed in the USA.
0270-4676/87

THE AUTONOMY OF TECHNOLOGY AS A CHALLENGE TO EDUCATION

Walter B. Waetjen

Technology is not just another casual concern to the educator, consumer or manufacturer. It affects every man, woman or child in one way or another. Consider how it would affect U.S. citizens in the year 2000 if we did nothing between now and then. There would be less productivity and economic growth in the United States than in Japan, Korea, Germany and other industrialized countries; there would be less manufacturing than in the countries mentioned; the U.S. trade imbalance will be far higher than at the present; the U.S. would be a debtor nation to a far greater extent than it is at the present time; there will be less money for the support of public education; there will be fewer students with greater needs; there will be more functional illiterates since we will be less able financially to help them; and, our standard of living as well as the quality of our lives will decrease.

Futurists tell us that manufacturing will provide only 11 percent of the jobs in the year 2000, down from 28 percent in 1980. Jobs related to agriculture will drop from 4 percent to 3 percent. The turn of the century will find the remaining 86 percent of the work force in the service sector, up from 68 percent in 1980.[1]

There are two generalizations to be drawn from the above: we are losing our technological edge as a nation and our educational system is apparently becoming less responsive to societal needs.

The problem seems to be that the United States has no game plan to sustain the impetus it achieved in technology. Our technological leadership and commercial success has been taken for granted, leading us not to appreciate the undergirdings that have supported our achievements. Those undergirdings are mandatory to maintaining our technological and educational leadership. The United States appears to be fighting the leadership battle on two fronts: the economic battle with countries in the Far East and the military struggle with the Russians. The anomaly is that we fight both of those battles with foot soldiers having the same background, namely, technology. Even worse is that we do not know which battle is more important to our national security.[2]

A major, but incomplete, solution to these problems is that we must start an educational revolution that would emphasize the major characteristics of our society. People from all levels of education will have to be responsible for creating a groundswell that will bring technology to its proper place in the total educative experience.

Schools are created by a people to perpetuate the important aspects of their society. Our society has three major characteristics: It is democratic by choice and persuasion; it is

[1] Marvin J. Cetron, "Getting Ready for the Jobs of the Future," The Futurist, June 1983.
[2] James Botkin, Dan Dimancescu and Roy Stata, Global Stakes: Future of Technology in America.

technological in nature; and it is an educated society. While we may quarrel with how well or poorly our educational institutions are performing their jobs, it is nonetheless a fact that we have learned from our forefathers that education is the keystone in the arch of democracy. That tenet places a great burden of responsibility on educators.

Our schools do a commendable job of inculcating democratic principles. They are taught as content and used in pedagogical practices. Democratic concepts are taught in such classes as history, economics, social studies, political science, and other subjects. We apply democratic principles and processes to a large extent in the way in which our schools operate. As a result we do an acceptable job of teaching our young people to become citizens of a democratic society. Of course, some people would like our schools and colleges to do more.

But whatever happened to technology? Where do we teach young people about the application of mathematical and scientific knowledge to the solution of problems? Where do we teach that frequently new technology springs directly from older technology--that it feeds on itself. We seem to skirt around the fringes of technology, being uncertain not only as to whether we should teach it, but how and where it should be taught. Some people would differ with this generalization citing as evidence the physics, mathematics, chemistry and biology courses that are offered in our schools. They make the assumption that science and technology are one and the same. Gies makes the following distinction between science versus technology:

> Technology is not to be confused with science. Science is what the universe, macrocosm and microcosm consists of--stars, planets, galaxies, cells, atoms, and particles. Technology is tools, machines, power, instrumentation, processes, techniques. Science is knowledge discovered, and being discovered by man. Technology is knowledge created, and being created by man.[3]

Simple logic dictates that if students don't learn about technology in school they will be illiterate about a fundamental part of their world. We cannot escape the fact that for students to live effectively in our world they must live with adequate technological information. There have been only a few direct attempts to teach technology and most of those have not been offered as general education. One that has been offered as general education is technology education, an advanced derivative of industrial arts. Through vocational education technology has been offered as occupational preparation at the secondary level and at the college level through engineering. But, one of the major premises of this paper is that technology must be offered as general education.

Why have we avoided, overlooked or ignored technology as general education in our schools even though it is such an ubiquitous activity and strong force in society at large? Some would claim that educators cling to a traditional curriculum which omits technology. Murchland advances another opinion as to why technology should be in the curriculum.

> Another formidable obstacle to clear thinking about technology is what might be called the "elitist thesis,' which holds that technology contradicts and often cancels out the egalitarian assumptions of democracy. Technological knowledge is the province of specialized elite, who know that citizens in general cannot know, who speak a language others cannot learn, and who have goals the public cannot discern. As a consequence, the flow of information is stopped up, and the populace finds itself in a position of reacting to decisions without their participation or consent. As government

[3] Joseph C. Gies, "Technology: A New Liberal Art?" AGB Reports 24, 1 (January/February 1982), pp. 17-20.

and business increasingly adopt these elitist manners of technology, society's malaise worsens.[4]

One must be careful not to believe that teaching democratic principles and technology are discrete activities. Separation of that kind has been the undoing of many attempts to construct a curriculum that is vibrant and that will inform and involve young people. Friedman cautions us not to separate technology and democracy in the curriculum when he says:

> For me, the most compelling reason for technological literacy is the survival of the democratic process . . . . Judgments concerning resources of our nation need to be made by an informed citizenry. Luddism will only strengthen the hand of the technocrats. The issues stretch from MX missile deployment to space travel and we, as a nation, are not prepared for participatory decision making. We need to confront these problems with the vast intelligence that they require.[5]

Technological Literacy

Technological literacy is a term that has a short history in the literature and as a result there is a paucity of information about it. An abiding difficulty with respect to the concept of technological literacy is that there are varying opinions with respect to both parts of that term; that is, there is no common agreement as to what is technology or literacy.

Some would posit that technology is product-oriented and is to be defined primarily in terms of products. Yet there are those who claim that technology is a social process. One of the later is Cutcliffe who argues that:

> Technology is a social process in which abstract economic, cultural, and social values shape, develop, and implement specific artifacts and techniques that emerge from the distinct problem-solving activity called engineering which is embedded in that process.[6]

There is little doubt that technology involves cognitive activities including social values and the application of these to a product. It should be noted that a high level of cognitive activity is involved in technology, a fact that is frequently overlooked, particularly by those in the humanities.

If there are numerous opinions as to how to define technology, there are an equal number with respect to the nature of literacy. Most of those definitions hold that literacy (of any kind) involves understanding and appreciation, that is, the learner comes to understand something and also to show an appreciation for it. Using the example of language, one must understand the language in order to be literate. Concurrently, one would learn to appreciate that the language enables us to remember the past, communicate with others, and to think. As important as those are, they fall short of the mark, for if one is fully literate it is necessary to be able to use the language. Individuals must be able to speak and write the language--not only to understand and appreciate it. Indeed, that quality is implicit when we describe a literate person.

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[4] Bernard Murchland, "Technology, Liberal Learning, and Civic Purpose," Liberal Education, 1982, Vol. 68, No. 4, p. 5.

[5] Edward Friedman, The Forum for Liberal Education, 1980, p. 2.

[6] Stephen H. Cutcliffe, "Technological Literacy for the Non-Technologist." In proceedings of the Technology Education Symposium II. Menomonie, Wisconsin: University of Wisconsin-Stout, 1981.

Technological literacy, then, means that a student must understand basic scientific concepts; know societal needs and moral constraints; be able to cognize the application of scientific principles to tools and materials; and, to a certain extent be able to utilize these tools and materials. A person having those characteristics could not qualify as an engineer; therefore, what we are talking about is technological literacy to be advanced through general education. An engineer, or any other kind of technologist, requires far more sophisticated knowledge.

It is necessary to think of technology in the broadest possible manner, presenting it to students as part of the fabric of human history as well as our daily existence and our shaping of the future. When students receive their high school diploma they should realize that technology must be followed over the course of their life and know what it means and how it is applied. They should be as familiar with microchips as they are with potato chips. Buchen in his exposition on a curriculum for the year 2000 makes a telling statement "... what is clearly needed is the creation of a new category of Technological Literacy as minimum knowledge required to be a reasonably educated or civilized human being. In fact, never before has the knowledge of machines been such an important condition for the knowledge of being human."[7]

To compound the problem of understanding what technological literacy is and of being assured that it is taken care of in the curriculum, we now have the term "computer literacy" that has gained some coinage. A recent tendency has been to think of computer literacy and technological literacy as synonyms. This writer is supportive of developing computer literacy, but for this paper it is assumed that computer literacy is an aspect of technological literacy, albeit an important aspect.

Curriculum Considerations

American education has had a long history of curriculum faddism. Upon discovery of a new idea or method of teaching educators have had a penchant for adding a new course to the curriculum. That is not being advocated here. What is advocated is an emphasis on technology in the curriculum as a whole.

The rationale for this emphasis recognizes that all curricula have integrators or recurring themes that run through the entire curriculum and help students relate bits and pieces of information. Symbols are integrators to be found throughout the curriculum and those are principally in two systems, words and numbers. They are the major conveyors of knowledge. Given the richness of technology in society it is not surprising that it affects every aspect of our lives; and, therefore it is convenient to think of technology as another curriculum integrator. Technology used in this context may be taught in many areas of the curriculum since no one profession or curriculum area has sole province to technology education. If a number of disciplines and professions teach technology education it is necessary to have an organizing theme or integrator to bind together all of the technological subjects. Further, if we really are concerned about and interested in having learners develop technological literacy, every school subject must make a contribution to it while retaining its unique content and teaching methodology. In a recent unpublished paper for Project 2061, James Johnson, Chair of the Technology Panel, speaks to this point:

[7] Irving H. Buchen, "Curriculum 2000: Futures Basics," Needs of Elementary and Secondary Education in the 1980's: A Compendium of Policy Papers, pp. 377-99, Washington, DC: Ninety-Sixth Congress, Second Session. Subcommittee on Elementary, Secondary and Vocational Education, Committee on Education and Labor, January, 1980, p. 388.

> The relationship between technology and the social order should be taught as an integral part of history and the social sciences and, in some cases, as pat of literature and art. There are many examples of how this can be done: the printing press as it affected the expansion of learning in Renaissance Europe, the impact of mass production technology on social organization in social science, and the role of technology in the development of cinematic/graphic art, as well as technology as a theme in art in the movie "Modern Times."[8]

Because technology has not been previously taught in the schools as it is being proposed here, there must be a curriculum infrastructure developed to support it. Technology will have to be integrated into the curriculum of the biological and physical sciences, the social sciences, and the arts. Too, it would seem that technology may be taught directly in some programs designated as "technology education" and be taught more indirectly in other programs. Undoubtedly, additional education in technology will have to be provided for teachers so that they can furnish the integrating concepts for students.

In an interesting discourse Murchland makes a unique observation about technology when he says:

> If one regards technology as a language (and not merely a tool) and technicism as a perversion of that language, then the function of education becomes clear. For the primary task of education is to train us in a responsible use of human languages .... Put simply, education s what enables us to create and control our symbolic worlds, including, of course, the world of technology. This is what literacy means.[9]

If technology is a language, as Murchland suggests, there is little doubt that the schools are caught between a heavy hammer and a hard anvil. The schools must do the job of teaching technology but are ill-prepared to do so.

Earlier, the comment was made that literacy by its very nature implies that a person must be able to do something. The example given was that of using language. The same can be said for technological literacy. In short, to be technologically literate a student must have the opportunity to develop rudimentary skills regarding tools, materials, and machines as well as to understand and appreciate how technology affects our lives. More advanced skills such as those obtained in vocational education or engineering may make a person more technologically literate but goes beyond what should be available as general education. In discussing general education Johnson makes the following point, "... USE OF THE TOOLS of technology should be part of the process. 'Tools' include the library, the laboratory, the shop, equipment, computers, the use of mathematics and diverse means for assisting the learning process, again at all levels."[10] What is being indicated is that for technological education to become a "minds on" experience for students there must also be a concurrent "hands on" experience.

There have been few occasions in the history of American education when students have had the opportunity for a hands-on approach when it came to learning anything about technology, or any other subject for that matter. The laboratory seems to be the ideal place for hands-on learning and would serve as the synthesizer or integrator of symbolic learning from other classrooms and other areas of the curriculum. Newman makes this point well when he states,

[8] James R. Johnson, unpublished report of the Technology Panel for Project 2061, American Association for the Advancement of Science, 1986.

[9] Murchland, p. 5.

[10] Johnson, p. 8.

> Activism (i.e., participation) also seems to be a particular help in encouraging students to synthesize and to make connections. A passive learning role leads the student toward a view of knowledge or concepts as individual pieces to be mastered and remembered, a loose-leaf binder of knowledge that can be readily added to or forgotten.[11]

In the act of teaching, students are typically presented with isolated facts and discrete courses. Then we abandon these students at the very point where they need the greatest help, which is synthesizing or integrating isolated ideas and concepts learned previously.

There is another compelling reason for using the laboratory for hands-on learning activities. That reason is rooted not in the field of technology but is directly related to the dynamics of human learning. For a long time it has been known that it is insufficient to learn something for the sake of passing an examination. Yet, that is what we do, even while recognizing that it is permanence of learning that is critical to human effectiveness and productivity. What good to teach students only so that they could pass an examination and then promptly forget what had been learned? Research on learning has demonstrated that the greater the number of human senses used in a learning task the more permanent the learning. Newman, again making a point about student activism in the classroom, implies that there be use of a wide range of human senses when he observes, "Activism even has a strong relationship to the retention of knowledge. . . .Active participation in class during discussions, class projects, etc., increases the overall retention by a significant factor."[12]

Thus, the hands-on, activism, or laboratory approach to technology education can be justified from a curriculum integration point of view as well as in terms of human learning. To use this technique does not require large outlays of monies for equipment of sophisticated machinery; but, it does require a new and different approach to teaching and use of new teaching materials. Here we cannot neglect the needs of teachers for they will require help in developing the teaching techniques and in identifying new teaching material.

Technologies to be Taught in the Curriculum

Were the world a simple place and technology applicable to only one area of human endeavor, such as agriculture, the task of the technology educator would be simplified. The fact of the matter is that ". . . science and technology are permeating the daily lives of Americans so deeply that we are barely conscious of how these forces influence the form, content, and direction of our lives."[13] Technology impacts the use and development of materials, communications, energy and its conversion, power transmission, agriculture, biomedicine, manufacturing, weather prediction and control, and computer technology. Should students, as part of their general education, understand the technology of each of these fields? If the answer is in the affirmative we have before us a curriculum revision process of great magnitude. If the answer is in the negative there is an equally perplexing problem and that is to decide which of the many technologies are necessary for students to learn as general education. Because either of those questions involves difficult decisions we should not avoid making them.

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[11] Frank Newman, "A Time for Rethinking," National Forum, Vol. 64, No. 2, Spring 1984, pp. 20-23.

[12] Ibid., p. 22.

[13] Gordon T. Bowden, "Becoming a Scientifically Literate Nation," Educational Record, Vol. 63, No. 4, Fall 1982, p. 5.

Enhancing Technological Literacy

As a form of general education, technological literacy should be taught from kindergarten through the baccalaureate degree. That would seem to require a great revision of the curriculum, but such may not be necessary. It is quite likely that technology is taught in ways not realized and which could become incorporated into a clearly defined technology education emphasis in curricula. Critics would say that achieving technological literacy would be constricting and in the nature of "careerism." The warning must be heeded. We must subscribe to technological literacy as a function of general education and not career education. The justification for this stance is that the consequences of literacy in any field of knowledge serves progressively to free the human mind from the tedium of memorizing every scrap of information. The technological literacy being proposed would be a liberating force which would not narrow one's education or narrow one's view of the world. A grassroots knowledge (literacy) of technology has the power to humanize students in much the same manner that the humanities do.

Our failing in dealing with technology is to look only at its benefits and much later realize there was a downside to the new technology. The downside is acid rain, job displacement, occupational diseases, and pollution of streams to mention but a few examples. An objective that we can strive to achieve as a technologically literate society is to consider the outcomes of new technologies thereby reducing the risks and increasing the benefits and making wise choices thereafter would be almost impossible to achieve without having young people develop literacy about technology. Moreover, those same young people would learn that technology is essential to growth since the population of the world is increasing at a rate that makes obsolete the old technologies that deal with meeting human needs. Equally important is that students learn that human needs are not restricted to creature comforts but include aspects of the affective realm, such as values. In this connection Murchland makes a relevant statement, "Everything a technologist does affects the quality of our lives and has some impact upon our values. Technological innovation destroys old values and makes possible new ones; it alters the circumstances in which our choices are made."[14]

Colleges and universities are typically slower than elementary and secondary schools to undertake curriculum innovation. An exception to this generalization is the new liberal arts program funded by the Sloan Foundation in 1982. This program involves funding of a number of liberal arts colleges to teach quantitative reasoning and technology as a set of "new" liberal arts. These were not meant to displace anything from the old liberal arts but to infuse technological modes of thought into existing courses. Presumably, the jury is still out on the degree to which the experiment has succeeded, but it has been reported that the single-most troublesome problem of this innovative program is technology itself--what it is, how to teach it to liberal arts students, and why to teach it at all. This program indicates that technology can be taught as general education but it will take a considerable amount of creative thinking to determine how it is to be taught properly and the materials that are effective in its teaching.

Recommendations

Americans have always expected a great deal of their educational institutions. The Land Grant Act was expected to give the United States a strong position in agriculture and engineering--and it did. The curriculum reform (math and science) that occurred after the Russians launched Sputnik was expected to give us a leadership position in space exploration--and it did. We should now expect to revamp our schools so that they will promote technology education. The task will be long, but not impossible. The following recommendations may make accomplishment of the task easier.

[14]Murchland, p. 5

(1) In every way possible it will be necessary to have technological literacy and technology education recognized and accepted as legitimate fields of study in general education. At the present time there is a small minority of educators, business persons and industrialists who have that awareness. Now that same group must become much more vocal and raise the consciousness of more people to the need for technology education.

Not the least of needs is to stimulate research activity. The research might focus on curriculum designs that incorporate aspects of technology. Additionally, research might be undertaken to determine how students learn to be technologically literate in carefully designed situations. Such research could reveal how to teach for technological literacy, materials that are effective, and what are reasonable levels of literacy to be expected in given situations.

(2) It would be prudent to launch a large-scale technology education program at the baccalaureate level for non-engineering students i.e., as general education. Such a program should involve faculties in the arts and sciences and those in teacher education. There are two reasons for this recommendation. First, technology education is much more likely to be implemented in the elementary and secondary schools if it came from the collegiate institutions. Whether that's right or wrong is immaterial, it's the way curriculum change occurs. second, and more importantly, teacher education and arts and sciences faculty are the people who will be training the teachers of tomorrow. If those pre-service teachers experience technology as part of their baccalaureate general education it is reasonable to expect that they will be predisposed--even eager--to teach technology education when they take positions in elementary and secondary schools.

(3) It is imperative that people at all levels of education, from business and industry, and from the various professional associations join forces to solve the technology education dilemma. People from such organizations as the American Association for the Advancement of Science, National Science Foundation, National Science Teachers Association, International Technology Education Association, National Association of Manufacturers, and the Association for Supervision and Curriculum Development should convene frequently to discuss how they might cooperatively launch technology education programs. Each organization should be prepared to identify what it can contribute uniquely to the development of a technology education curriculum and its implementation. The fact is that developing technological literacy transcends any one educational organization or discipline. Technophobia may be encountered in which one group's attitudes about technology may be in conflict with another group's attitude but this can be minimized if there is agreement that technology education must be implemented.

The foregoing recommendations can be put into action if it is accepted that technological literacy would improve the quality of life for all individuals, would improve our productivity as a nation, make our schools more reflective of society, and enhance the economic position of the United States by the year 2000.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 36-38, 1987. Printed in the USA.
0270-4676/87

SCIENCE AND TECHNOLOGY IN EVERYDAY LIFE

Floretta Dukes McKenzie

February is Black History month; thus it is fitting that I quote Dr. Martin Luther King, Jr., who so well described the alienation that humans can feel when they are not comfortable with technology. Although thought of primarily as a civil rights activist, Dr. King said: "Gargantuan industry and government, woven into an intricate computerized mechanism, [can] leave the person outside. The sense of participation is lost, the feeling that ordinary individuals influence important decisions vanishes, and man becomes separated and diminished. . . . This process produces alienation--perhaps the most pervasive and insidious development in contemporary society."

These words were written by Dr. King 20 years ago and capture well the discomfort too many of us have. However, I believe that many people have become less fearful of science and its application to our lives, technology. I do think that we welcome with open arms new products related to convenience, leisure and entertainment, while we still find ourselves wary about technology in what we think is its purest form, "as Big Brother." We are as a society still not digesting and assessing technical information enough to make better decisions for us as individuals, organizations, communities, nations, and as a planet.

The high tech explosion of today is one of the most exciting, albeit awesome, topics of discussion. I am pleased to share with you my thinking about the technological impact on public education.

Although education is often criticized for lagging behind the rest of society in its response to innovations, technological literacy must be promoted for all.

I am pleased to report that many of us in public education are working feverishly to keep pace with the rest of society in coping with the information age, and are attempting to better prepare our students for a future destined to be even more steeped in technological sophistication.

New Educational Technologies

I would like to share with you my perception of some components of new technology most applicable to the education of our students. These factors, directly and indirectly, affect the bottom line: if we can improve the instructional delivery, increase the time teachers have available to instruct, we will have increased our odds for success--if we can also improve the quality of teaching through technology.

Math and science teachers are scarce, and even among the ones available, there are good, better, best. Instructional t.v., videotapes, discs, computerized instructional materials, all make for more even quality.

In the many school systems, computer technology has become widely accepted and has been met by enthusiastic students of all ages. The computer has been introduced in a wide range of student matter areas from spelling to English literature, from elementary arithmetic to physics.

As participants in a national validation study, our school system introduced 1,500 five- and six-year-olds to a computer-assisted approach to learning reading and writing. At the secondary level, in cooperation with a major computer company, we helped develop a state-of-the-art literacy program now available nationally.

Our experience indicates that each of these computerized applications provides reinforcement to the teacher-student relationship by increasing the motivational dimensions of the instruction process:

- learning at one's own pace
- initiating learning on one's own
- learning in privacy
- choosing content of interest
- having fun with learning.

Impact of technology in our everyday lives has been more pervasive; for example, in 1983, the compact disc player was introduced. In less than 4 years, 850,000 households have one. We bought these quite eagerly, without the realization that the compact disc has been and will continue to be used not only for music but for visual images and computer storage too. This acceptance in recreational areas does make way for more practical uses, it is true; but we are going to have to as a society realize that technology (or the lack of it) is a part of our lives that affects us, like it or not, in every room of our home, our school, our workplace, in health, in government, at the store, on the streets (when it snows, remember?). We might as well understand it and control it in our behalf.

After all, there once were only two things of which we can be certain: death and taxes. Now there are four. Third, technology is here to stay; and fourth, people resist change unless motivated strongly by a need to change.

There are 23 million Americans who use a computer at work but don't have one at home. Of these people, 91% admit that the computer has increased productivity on their jobs, yet they have not found it necessary to have at home. I don't want to get into psychological motives and underlying neuroses, but it is odd that the major reason people have cited for buying a home computer is for "educational material for a child." How unselfish! Or how afraid?!

Parents want a learning edge for their children and they are also aware of the thinking behind George Orwell's line in Animal Farm, "All animals are equal, but some animals are more equal than others." Understanding and connectedness with technology will make some of us more equal than others. As public educators, we want to ensure that the number of citizens "more equal" to the task of utilizing technology increases--especially those responsible for the education of many poor, minority and female students.

Teacher will have to address anxieties with math and science. We have to convince ourselves that we are living in what one social scientist (Barbara Ward) termed a "technosphere." Then we will be able to transfer this orientation to our students, both in the pre-K through 12th grades and in the adult education classes. Scientists will need to stop talking to each other and learn to talk to the rest of us in terms we can understand and implement.

One thing we must remember is that people are motivated by needs: "Survival, power, and love, to name just a few. If a particular need is strong enough, barriers that resist change often come tumbling down." Typists learn word processing because if they don't, they won't be in demand. Regrettable, but true in the world as we know and live it.

Science, Technology and Social Issues

In our school system, we recognized this human phenomenon and embraced a course called "Science and Social Issues." We made it optional but very desirable since it satisfies the Carnegie unit requirements for the second science course.

In the preface to the curriculum, we state that "the social issues course is designed to help students become scientifically literate; i.e., to enable them to make rational and constructive decisions regarding various social and environmental problems. It is further designed to make students aware of man's dual role as both creator and controller of the problems which affect his external and internal environment."

This last sentence is very important because the very problems raised or caused by technology must not be ignored by the rest of society nor the developers of this technology. Everyone must be aware of the costs we pay for growth.

We in public education have only scratched the surface of the technological realm. We continue to need the help of scientists, engineers, and industrial leaders, as well as social scientists and humanists, if we are to make a significant breakthrough.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 39-41, 1987. Published in the USA.
0270-4676/87

STS AND TECHNOLOGICAL LITERACY: HIGHER EDUCATION

INTRODUCTION

Carl Mitcham

"History, if viewed as a repository for more than anecdote or chronology, could produce a decisive transformation in the image of science by which we are now possessed." That opening sentence of Thomas Kuhn's The Structure of Scientific Revolutions (1962) states the bsis for a new way of thinking about science. Previous images of science, Kuhn argued, had been derived mainly from finished scientific achievements. Established laws and theories had been subjected to a kind of structural analysis. What had been left out was the reality of science in the process of historical development. At the basis of Kuhn's new paradigm for understnding science is a determination to take this history seriously.

One way of summarizing what is going on in the STS movement at the higher education level is as a natural extension of Kuhn's work. STS studies extend Kuhn in two ways: by moving from science to include technology, and by taking seriously not just history but education. Kuhn had, of course, already implicitly included some aspects of technology (in his consideration of the important influence of experimental apparatus and his discussion of progress) and explicitly given attention to education. But in the latter case he is only concerned with the education of scientists, not the general populous, and with scientific pedagogy as a passive purveyor of the non-historical perspective he wants to argue against. He does not let the educational experience enter into his understanding of the science-technology-society relationship. But how non-scientists and non-engineers learn about science and technology and how learning about science and technology influence and are influenced by society -- these factors also need to be taken seriously in formulating our images and understanding of science and technology.

The STS concern with science and technology education exhibits, however, two sides. On the one side is the effort to increase scientific and technological literacy as a kind of promotion of science and technology. Science and technology are key factors in contemporary society. They must be promoted and supported if society is to prosper, and they must be understood by those who would be effective citizens in such a scientific and technologically oriented society. The origin of STS studies in this sense is not as recent as some might think. The great French Encyclopedia, in its attempt to make science and technology more widely available through the popularization of scientific knowledge and technical practice is in some sense a classic STS text.

On the other side of the STS coin, however, is an effort to bring the social sciences and the humanities to bear on science and technology in ways which have not been previously done -- at least not in general education. Science and technology are historically dependent on certain kinds of societies and cultures; science and technology in turn tend to influence societies and cultures to take on certain forms. Yet science and technology may not themselves be the highest forms of society to culture. Science and technology further raise important ethical, political, aesthetic -- and even epistemological, metaphysical, and theological -- questions that neither science nor technology can answer for themselves. The attempt to face up to these issues, especially pedagogically, is an equally important aspect of the STS movement -- and one that might be said to have roots as deep as Socrates' concern for understanding and delimiting the scientific cosmologies of Anaxagoras and the rhetoric technologies of the sophists.

The thirteen papers in the higher education section of the present proceedings illustrate differential aspects of the STS movement so outlined. Stephen Cutcliffe opens with a broad historical overview of STS education emphasizing the pedagogical and critical dimensions of the field -- and to some extent the need to educate scientists and technologists not about science and technology but about the social, historical, and humanities dimensions of experience. Little is said about the promotion of scientific and technological literacy in the technical sense. Wayne Norman, however, provides a case study of how to turn a psychology course into one that develops literacy in systems theory, cybernetics, and information theory -- as an avenue for introducing technological literacy into the social sciences. Gary Weaver follows with a paper stressing, from a more theoretical perspective, how an understanding of the STS relationship influences education -- and vice versa.

The first three papers thus clearly illustrate the STS attempt to take education seriously as well as the two sides of the STS coin. Each of the next four papers highlights some aspect of the STS-education relationship, but with a stress on the technology literacy side of the coin. Eugene Schultz argues the crucial importance of technological literacy in a third world context. Theodore Ducas, James Grant, and Alan Shuchat provide a second case study using the education for more informed participation in medical decision making as a means to increase technological literacy. Thomas Liao and David Ferguson address the issue of computer literacy with a third case study of a course for liberal arts students. And Corrine Caldwell considers the special technological literacy needs of community college science faculty members.

All four papers tend to highlight the need to bring technology into the liberal arts, but not to the exclusion of bringing the liberal arts to bear on technology. In the second instance, especially, medical decisions are finally not technical ones, but moral ones. In the last instance, STS courses may well be the best way to bring the liberal arts into the curriculum of the community college student in a meaningful way.

The four papers emphasizing religious perspectives are a welcome departure from many previous STS discussions. Religion does have a legitimate contribution to make to the STS educational agenda, and the papers by James Miller, James Salmon, Brent Waters, and Robert Brungs emphasize this in four distinct ways. Miller considers the contribution campus ministries can make to STS education. Salmon, adopting the case study approach, reflects on a particular course in which he presented STS issues to teachers of religion. Waters argues that the churches should support scientific and technical education, but not in a way that cowtows to either science or technology. And Brungs suggests an intimate connection between science, technology, and Christianity. In a sense these four papers balance the previous four by emphasizing the non-technical side of the STS education agenda.

Finally, the two papers on technological literacy and communication point up the importance of STS education in relation to that perennial problem in higher education: how to help students to become more effectively literate. Both papers are case studies of situations at engineering schools. Barbara Olds (Colorado School of Mines) describes how literacy in a linguistic sense is crucial to engineers -- and one program developed for teaching it within a technical context. William Pfieffer (Southern College of Technology) points out the importance of language literacy to promoting technology literacy.

In sum, the thirteen papers in this section present a broad range of issues in and approaches to ST3, and thus provide an effective introduction to what c .n and needs to be done to take education seriously in the STS field.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 42-48, 1987. Printed in the USA.
0270-4676/87

TECHNOLOGY STUDIES AND THE LIBERAL ARTS AT LEHIGH UNIVERSITY

Stephen H. Cutcliffe

The Emergence of STS as an Academic Field

The field of science, technology and society studies emerged at the same time as the widespread social upheavals of the 1960s and early 1970s. Public interest in such areas as consumerism, civil rights, the environment, together with protests against the Vietnam War, multi-national corporations, nuclear power, etc., set the tone for much of the general context of the period. Within this context there emerged a critique of the idea of progress, a critique quite radical by American standards. Following a collapse in the late 1960s of a twenty year-long, direct translation of science and technology into economic prosperity for the American working class, there emerged the recognition that it was also becoming necessary to cope in practical ways with an accumulated burden of negative impacts of science and technology. The passage of the Clean Air and Water Acts (1970, 1972) and the establishment of the Environmental Protection Agency (1969) and the Occupational Safety and Health Administration (1970) were reactions to this new perception. Cognate changes in the approaches of a number of academic disciplines also took place during this period. The history of science and of technology and the philosophy of science, and the beginnings, at least in this country, of the philosophy of technology and the sociology of science and technology reflected a shift from internalist-oriented subdisciplines to progressively more externalist sociologically-oriented interpretations. I believe the shift reflected the same intellectual and social forces that also precipitated STS. This was certainly the case with Lehigh's STS Program, which was originally created in 1972 under the name Humanities Perspectives on Technology.

Voices began to raise doubts about the beneficence of science and technology, began to question whether science and technology were the unalloyed blessings that society had generally come to believe they were. Intellectuals from a variety of perspectives suggested that there were negative externalities associated with those blessings long assumed to be the primary legacy of science and technology. Rachel Carson's Silent Spring (1962) raised serious questions about the hazards associated with chemical insecticides such as DDT and in many ways helped to crystalize the current environmental movement. John Kenneth Galbraith in The

Affluent Society (1958) and The New Industrial State (1967) suggested that in the industrial state economic power had shifted from consumers and the marketplace to a "technostructure" within the corporation that controlled technology for the sake of the growth of the organization. Galbraith warned of the instability of an economy keyed to production for its own sake, rather than true consumer needs.

Other books such as Jacques Ellul's The Technological Society (trans. 1964), Lewis Mumford's two volume The Myth of the Machine (1967 and 1970); Theodore Rozsak's The Making of a Counter Culture (1969) and Where the Wasteland Ends (1972); and Alvin Toffler's Future Shock (1970) --to name but a few --extended to the public and to the academic world the argument that science and technology were inherently value-laden and often, if not always, problematic in terms of societal impact. But perhaps the most influential intellectual precursor of the STS movement was C.P. Snow's 1959 Rede Lecture at Notre Dame in which he alleged that there existed a widening split between "two (non-communicating) cultures" in our society, one composed of scientists, the other of humanists, in the process creating a metaphor that shaped (and still shapes) discourse within the STS field.

The tenor of the overwhelming majority of the early 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. Many of the earliest STS courses and curriculum programs emerged at institutions with engineering colleges and sometimes within those colleges themselves. Not unexpectedly, liberal arts students were just as interested in such questions, and very quickly a second generation of STS coursework emerged, indifferently aimed at all students. This second generation took as its approach a social process interpretation of science and of technology in which both were seen as shaped and influenced by societal values, which were, in turn, affected by impacts upon them deriving from scientific knowledge and technological innovations. In the last five years, approximately, the STS community has moved beyond this social context analysis of science and technology, to the design of courses and programs aimed at developing "literacy" on the part of liberal arts students in technology, rather than about technology (in a similar sense to what is expected of liberal arts students vis-a-vis science and mathematics).

In a parallel way to this three-phase development of STS coursework, there have been three stages of faculty involvement. In the first years a number of science and engineering faculty were quite extensively involved, while during the second phase increasing numbers of social science and humanities faculty identified themselves with the social context aspects of the STS field. Most recently, science and engineering faculty seem to be attracted into STS to teach liberal arts students <u>in</u> science and engineering.

Approximately fifteen years of STS-oriented coursework has thus been devoted in the main to taking a detailed look at the value-laden, societal context of science and especially of technology. Whereas initially this examination was often highly critical, more recently the pendulum has swung back somewhat. The anti-establishment, anti-technology stance has been complemented by a more positive attitude that seeks to elucidate the key cultural values that support technological achievement. Yet in both cases what has emerged is an increasingly broad consensus that while science and technology do bring us numerous positive benefits, they also carry with them certain negative impacts, some of which are perhaps unforeseeable, but all of which reflect the values, views, and visions of those in a position to make decisions regarding the scientific and technological expertise within their domain.

The central mission of the STS field to date, then, has been to convey a social process interpretation of science and technology. Traditionally, science has been viewed as that body of theoretical knowledge concerned with natural phenomena and attempts to provide a coherent account of physical and biological objects and events through observation and experiment. That these bodies of knowledge are influenced by societal contexts in terms of their conceptual frameworks, theoretical models, and funding decisions selectively to support research, has increasingly come to be accepted by sociologists of science and is today virtually a commonplace. Defining technology is somewhat more complex. Traditionally, definitions of technology have centered around the end-products of engineering problem-solving, with, in the last hundred years, direct input from scientific research as well. Increasingly, however, scholars of the social impact of "technology" have taken the term to refer to the complex of social, value-based processes through which the work of the engineer is channeled into society through society's financial, legal, and political institutions, and as a general rule often with little direct input from engineers themselves. Thus, technology is different from engineering, a term that refers to the specific activity that generates particular artifacts and technologies. It is also much more than applied science, although it certainly draws upon scientific knowledge and methodology. In turn, of course, science and technology affect these same values and the society that holds them. Hopefully STS can explicate these relationships fully both for engineering and for liberal arts students.

At the same time we are now beginning to move into a phase where STS may help to shape public response and involvement in decision-making regarding scientific and technological change both by providing an awareness of the public's intimate involvement and by offering suggestions regarding the specific role that it has to play. STS studies is a reflection of living in an age in which we are trying to exert stronger and more deliberate social and political control of science and technology. 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 determine what mechanisms are most appropriate to the task. In this STS may be able to make its greatest contribution.

The Crucial Question

Given the recognition of scientific and technological issues, as complex social enterprises, how should the STS field seek to explicate science, technology, and their societal relationships? This is the crucial STS question, the answer to which STS education ought to be organized around.

It is precisely this complex set of relationships and interactions that good STS programming should present to all students. To do so successfully means developing an understanding, both generally and in specific instances, about what values are, how people come to hold them, and how values evolve. It means understanding the genesis and function of societal institutions in the political, economic, and cultural realms. It means understanding in some general sense the internal essence and operation of science and technology--a familiarity with scientific and technological reasoning, with major current concepts and methodologies, with design and modelling strategies in the disciplines being studied. It also requires a holistic understanding of the complex interactions among these diverse components. And if this were not enough to give pause, it also implies the study of these complexities as reflected in art, literature, philosophy, and history as well as through contemporary political, economic, and sociological analyses.

To do all this requires interdisciplinarity--an interdisciplinarity that can be achieved through a multiplicity of perspectives in a single faculty member, through team-teaching, or through a host of other techniques, but always with an eye toward the holistic complex of interrelationships. This is not as forbidding as it might seem, because STS does not need to make its students into expert scientists or engineers, so much as it needs to make them seriously aware of the <u>relationships</u> between science, technology, and society--an understanding that can be achieved in a general way at the level of theory and supported by specific and appropriate case studies judiciously chosen to reflect the issues or questions at hand. STS further aims to teach its students how to seek out relevant and important information on a given subject, analyze and evaluate it, and in the end come to a decision regarding appropriate action. In the process of dealing with such issues, students can reflect on the values embedded in the science and engineering involved and ultimately recognize that their own final decision is likewise inherently value-based.

Although in its formative years STS was often highly critical of science and of technology, today we have come to understand their richness and complexity, the opportunities they offer as well as the dangers they pose. To rest upon our laurels, however, would not only be to miss an opportunity for further understanding, but to fail to meet our expanded obligation to society. Merely to assume that more education in instead of about science and technology is enough to solve our problems in this area would be an equally empty response; it would fail to take account of the inherent value-laden structure of science and technology, the social context. What is called for instead is an increasingly sophisticated understanding of the inside workings of science and engineering, yet one that places that understanding in the context of the social process interpretation of science and technology. For only when "science and technology literacy" is understood in this broader context can there be any real hope of effectively shaping our future world by conscious public control so that scientific and technological processes truly benefit humankind. Such is at once the hope for STS and its greatest opportunity.

STS at Lehigh University.

"To create educational experiences which bring humanistic perspective to the application and evaluation of technology." With this goal in mind Lehigh Unviersity in 1972 launched a major interdisciplinary curriculum development project entitled Humanities Perspectives on Technology and later renamed the Science, Technology, and Society Program. Like many other nascent science, technology, and society activities, Lehigh's STS Program arose in part out of the widespread social upheavals of the 1960s and early 1970s. As the STS field began to coalesce and as the Lehigh program matured it became commonplace to view science and technology from the perspective of a social process interpretation. Thus, the STS Program at Lehigh serves as a common ground from which to explore the relations between ideas, machines, and values.

The STS Program includes over 50 courses, offering approximately 20 each semester. Topics range from the nature of scientific theories to the nature of the nuclear power industry, from the history of the machine in America to medical ethics, from the politics of oil to the economics of environmentalism, and from the influence of technology on art, music, and literature to the influence of philosophy and religion on science and technology.

Lehigh's STS courses are divided into four "tracks" within which courses with a common conceptual orientation are clustered:

1. science, technology and society --courses analyzing the economics, the national and international politics, and the social policy implications of research and innovation;

2. science, technology and human values --courses dealing with the ethical, philosophical, and religious impacts of the products of science and technology;

3. engineering and society --courses specially designed for students not majoring in science or engineering, treating applied science and engineering as elements in the social process determining their practice;

4. science, technology, and Western culture --courses dealing with the history and sociology of science and technology.

Students who are particularly interested may take a minor in Science, Technology and Society Studies. The minor consists of eighteen hours of course work including the introductory "Technology and Human Values" and five more courses, four of which must be in a single track. The minor program is open to students from all colleges and provides a way to help focus STS studies. While the absolute number of students electing to minor in STS is not overly large, approximately 25% of all Lehigh undergraduates do take at least one STS course before graduating. Currently we are in the early stages of exploring the feasibility of offering an undergraduate major in STS studies at Lehigh, as well as the somewhat more distant possibility of a Masters-level STS program.

From a variety of perspectives then, Lehigh's STS courses provide a vehicle for entering into a systematic confrontation with some of the major issues of our time involving the exercise of deliberate social and political control over science and technology. For example, are science and technology autonomous forces to which we must adapt and into whose hands the future is given, or are they derivative, expressing prevailing social, economic and even religious commitments for which we are responsible? Are science and engineering objective activities, keyed to facts and logic and immutable laws of nature, or do they embody subjective value judgments reflecting ultimately political decisions?

In conjunction with its STS curricular activities, Lehigh has also established a Technology Studies Resource Center. The TSRC is engaged in the creation and dissemination of materials and programming that will lead to a more useful understanding of technology on the part of a wide range of audiences, especially their understanding of the mutual interaction of technology and social institutions and values. The Center serves as a focus for academics from all disciplines to collaborate in pursuing research and educational opportunities in technology studies, on and off campus, with academic colleagues and in conjunction with non-academic sponsors. TSRC activities fall into several areas: the development and dissemination of resource materials, professional development programming, and educational programming.

The Center publishes the Science, Technology and Society Curriculum Development Newsletter which includes short articles on the theoretical and speculative aspects of curriculum development, in-depth course descriptions, reviews of texts and audio-visual materials, and an annotated bibliography of current books and articles in the STS field.

The Center also sponsors a Regional Colloquium in Technology Studies, the proceedings of which are published in a Working Papers Series. The Colloquium offers scholars within a reasonable distance of Lehigh the opportunity to gather periodically to hear about and to discuss current research in the field.

The Center also serves as a clearinghouse for information on people, curricula, and materials resources in technology studies. This includes the collection and distribution of model course syllabi. The integration of technology studies material into existing secondary school curricula and the development of better courses in science and mathematics in cooperation with regional teachers is also an important function of the Center.

Finally, the STS Program and the TSRC together have recently embarked upon the publication of a new series of works entitled Research in Technology Studies. The goal of the series is to produce theme volumes consisting of essays centered around important topics such as Technology and the Ideology of Progress. The TSRC thus complements the curricular focus of the STS Program by providing a range of professional development and service functions for the national, even international, STS community.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 49-54, 1987. Printed in the USA.
0270-4676/87

INFUSING TECHNOLOGY INTO THE LIBERAL ARTS

Wayne D. Norman

I would guess that most participants at the Science, Technology, Society Conferences recognize the legitimacy and even the need for including the study of technology in the liberal arts curriculum. However, sensing a need and recognizing legitimacy are not the same as explaining how one actually goes about integrating technology into the liberal arts in a manner that does justice to the study of technology and preserves the integrity of the liberal arts approach to education. Add to this the constraints that many small colleges and universities experience, such as small budgets, limited resources and average students and the problem of meaningful integration becomes acute.

I will present some of the work conducted at Northwestern College under the Council of Independent College's "Technology in the Liberal Arts Project." In addition, I will suggest some guidelines for infusing the liberal arts curriculum at mainstream colleges and universities with technology studies. As a general rule we do well to keep in mind three points: (1) that to properly understand technology one must understand certain technical aspects and the characteristic methodologies used by practitioners in that field; (2) that the effects of technology on culture nneds o be assessed on a case-by-case basis; and (3) that technological change is the result of technological innovation plus the expression of society's values.

The introduction of technology into a course, any course, can, and in fact must, preserve the liberal arts perspective of that course. Aside from its emphasis on teaching students to think critically, to communicate, to become acquainted with the great thinkers of a culture's past, the liberal arts curriculum examines the world and our place in it. That world may be natural, social or technological and the focus may be on the individual, on communities, societies or cultures. In any case, liberal arts educators, whether sociologists, historians, philosophers or literary critics must develop questions they find meaningful to their academic disciplines. Unless the inclusion of technology into a course is of interest to the educator it will be a hollow exercise aimed at sticking yet something else into an already overcrowded curriculum. These two requirements - preserving a liberal arts approach and developing meaningful disciplinary questions about technology - demand a radical infusion of technology into the liberal arts curriculum. Courses which compartmentalize liberal arts questions and technical aspects of technology should be avoided.

During the Spring semester, 1986 I offered Physiological Pyschology: An Informatics Approach. Rather than teach the course from a traditional perspective, I reorganized the themes in the course in order to accomplish three things: (1) to raise questions of a general philosophical nature about the topic, in this case, "What does it mean to view humans as machines?"; (2) to familiarize students with a set of engineering tools and methodologies for answering that question, namely systems theory, cybernetics and information theory; and (3) to address the major topics usually covered ina more traditional physiological psychology course (e.g. neuronal and synaptic transmission, regulatory systems, the nuerophysiology of learning and cognition, etc.), but from a new, technologically-sensitive perspective.

To address the issue of humans as machines three approaches to the mind-body problem were presented; the materialistic monism of psychobiology, the dualist-interactionism of John Eccles and a version of multiple aspect theory by Donald MacKay. Students were then introduced to the notion of viewing the brain as a natural system, subject to scientific analysis and open to the possibility of machine-like models of explanation.

The engineering tools and methodologies discussed included systems theory, cybernetics and information theory. Basic concepts in systems theory included the representation of system components and their interconnections and the role of variables and parameters in systems. The view of cybernetics as a theory of how to build systems that are both mechanistic in nature and yet produced adaptive behavior was discussed. Studetns were then presented with the components of an information network and a measure of information was developed. This measure was discussed with regard to its abiltiyto optimize the information carried over transmission channels. Information encoding schemes and the subject of noise and redundancy in information were discussed. Finally, a rationale was given for applying these information theory concepts to biological information processing systems.

The next major segment of the course introduced distinctions between physiological psychology, general psychology and neurophysiology. Thissegment ended with an overview of basic neuroanatomical terms and concepts.

The third, and by far the largest, segment of the course examined a variety of "systems". The section on neuronal systems began with a discussion of neural transmission and moved on to the topic of neural networks. Both natural and artificial neural networks were examined and studetns practiced building simple networks using computer spreadsheet software and designing logic networks as circuits in robots using Robot Odyssey, a computer learning game.

The next section, on sensory systems, included a discussion on coding theory and an analysis of the human visual coding system. Vision in machines was compared with human vision and students worked with simple perceptrons, modelled on the computer. This section ended with lectures on pain perception and the possibility of impossibility of pain perception in machines.

Under regulatory systems the concepts of homeostasis and homeorhesis were presetned and their relation to adpative and maladaptive behaviors was discussed. The example of body temperature was used to illustrate a regulatory system and biofeedback-controlled temperature regulation was demonstrated and discussed in terms of the regulation of adpative behavior.

Malfunctioning systems were addressed by first discussing mechanical versus psychological malfunctioning in humans. This was followed by an examination of mood and activity disorders as malfunctioning neurotransmitter systems. Basic concepts in the technologies of psychosurgery and drug therapy were discussed with an emphasis on the ways in which societal values and expectations have influenced the development of those technologies. In this context cost-benefit analysis was presented as a decision-making tool in treatment. This was followed by an analysis of the ways in which those technologies have influenced our view of disorders as peing psychological or mechanical.

The final section on adaptive systems presented students with the neuropsychological approach to learning, memory and thinking processes. Artificial and natural systems were then compared. The social factors influencing developments in artificial intelligence were examined along with the impact of those developments on the workplace and on our conception of human nature.

This final section of the physiological course led to the development of a second technology-realted course titled, "The Psychology of Persons and Robots." Taking as its starting point that there is in psychology no concept more fundamental, yet more misunderstood than that of person, this course examined the concept of personhood from two perspectives; human and artificial persons. Topics addressed included: the relationship between personhood and machinehood; a historical account of the concept of personhood in psychology; and the relationship between automata theory and personhood.

Students read (1) materials in the philosophy and psychology of personhood, such as <u>Preserving the Person</u> by

C. Stephen Evans, The Person in Psychology by Mary Stewart Van Leeuwen and selections from The Mind's I by Douglas Hofstadter and Daniel Dennett; (2) Igor Alexander and Pierce Burnett's Reinventing Man: The Robot Becomes Reality as an introduction to automata theory and robotics; and (3) a collection of science fiction short stories on robots as persons from Machines That Think edited by Isaac Asimov et. al.

Funding from "Technology in the Liberal Arts Project" gave me time to read and then develop the physiological psychology course. I chose to modify that course to reflect a technological emphasis because I had a pre-existing interest in issues related to viewing humans from a machine perspective. However, once I began exploring these questions other projects followed, in part, I believe because the initial questions I asked about technology were important to my discipline. In addition to the seminar course on persons and robots I have written the following three essays:

(1) "Person-Methodology Linkages and the Study of Persons": This essay describes an approach to the analysis of humans as machines by proposing a continuum of machinehood-personhood characteristics for both machines and artificial persons. Whether machinehood or personhood characteristics are stressed depends on the question one is asking and the methodologies appropriate for answering those questions.

(2) "Psychology as Technology": After rejecting a positivist philosophy of science as the basis for doing psychology, this essay proposes adopting a post-modern philosophy of science modelled on the work of philosopher of science, Larry Laudan. In conjunction with these ideas, psychology is characterized more as a technological activity than a "science" following Arnold PAcey's three-fold defintion of a technological activity as including technical, cultural and organizational aspects. It is argued that psychology incorporates the major methodological characteristics discussed by Allan Pfnister in his essay, "Technology and the Liberal Arts."

(3) "Technology and Personhood": This essay examines the manner in which advances in reproductive biomedical technologies, specifically in vitro fertilization, psychosurgery and artificial intelligence are influencing our concept of personhood. Short case studies are used to highlight these developments.

Since most mainstream colleges and universities cannot afoord to send faculty away to engineering schoold and technical institutes for a year in order to retrain, what can they do to encourage an active interest in technology studies among their faculty?

First, it is important to provide a minimal amount of release time from teaching in order to read background materials on technology and to develop meaningful technological questions in one's discipline. It is unrealistic to think faculty will spend their summers on such projects, though sabbaticals might be granted for such. At first the faculty member should read more general works in technology such as The Tower and the Bridge by David Billington, The Existential Pleasures of Engineering by Samuel Florman, To Engineer is Human by Henry Petroski, The Culture of Technology by Arnold Pacey, or Taming the Tiger by Witold Rybczynski.

Second, it is also important that the faculty member have a minimal budget to work with; perhaps $100 - $200 for books and periodicals, a telephone budget sufficient for calling others who can act as resource persons and finally (and perhaps idealistically) travel money sufficient for attendance at one or more technology related conferences per year. In all, costs to the institution be as low as $600 per faculty member per year or as high as $2500, depending on whether someone had to be hired to fill release time positions and the amount of travel monies alloted.

Third, it is advantageous to have more than one faculty member working on a technology studies project. Two or three team members even when working on different aspects of a project, will stimulate a greater number of ideas than someone working alone. In addition, team members are able to hold each other accountable for the task at hand.

In conclusion, those interested in infusing technology into the liberal arts curriculum should aim to meet the following requirements: (1) maintain a liberal arts focus in the course and (2) develop meaningful disciplinary questions about technology, defined in the broad sense to include technical, social and organizational aspects. The result will be longer term commitments and greater academic integrity to the technology studies courses we develop.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 55-60, 1987. Printed in the USA.
0270-4676/87

TECHNOLOGY STUDIES IN A LIBERAL ARTS CONTEXT

Gary R. Weaver

Anyone who has followed recent discussions of the state of American education will have noted the manifold cries of alarm regarding the scientific and technological incompetence of most Americans. Yet a close look at the curricular advice generated by such concern reveals a variety of motives and a diversity of views regarding just what it is we ought be doing to improve technological education. Prescriptions range from the introduction of "grand-tour" style technology appreciation courses to critical assessment of science and technology policy to immersion in remedial quantitative skills. My aim herein is to look at three important features of technology which have implications for how we deal with technology in the liberal arts curriculum.

Technology Is Not Merely Applied Science

It is useful to distinguish several components of what we might loosely call the "scientific and technological world":

science (i.e., "pure" research)

applied science (i.e., the use of the results of "pure" research to solve some humanly determined problem)

engineering

organizational/social/systems factors (i.e., how the artifacts we produce with applied science and engineering--cars, vaccines, buildings, etc.--in fact function in a world made up of other technological products or systems and human beings)

This delineation of the "scientific and technological world" helps us see that liberal arts colleges, insofar as they approach technology at all, traditionally do not cover all of it. We sometimes look at applied science, sometimes organizational and social aspects, and rarely the engineering side of the technological world. More commonly, though, we teach something closer to pure scientific theory. Yet any attempts to treat engineering specifically, and technology generally, as nothing but pure and/or applied science are undercut when one considers the histories of engineering and science, the goals of the two disciplines, and the practice of each discipline.

The historical fact is that many engineering activities or artifacts developed prior to the discovery or formulation of the scientific theories which could explain, in a deeper sense, why the technologies worked as they did. For example, the development and use of steam engines in the 18th century preceded by many decades the development of theories in thermodynamics, and indeed it was a desire to better understand the already existant steam engines which prompted research into what came to be called thermodynamics. True, once developed, thermodyamics could be used to further refine steam engine technology, but what this shows is that science and engineering are distinct, though mutually supportive disciplines.

Next consider the different emphases and influences in the goals and methods of science and engineering. The scientist tries to elucidate a natural order that already exists; the engineer aims at creating a new order, a "man-made" world. The engineer aims at solving fairly well-defined problems within a range of technical and social parameters. Scientific research, by comparison, is less closely tied to immediate socially determined goals, and in general the problems dealt with are broader, and less exactly defined, than those of the engineer.

Engineering is also a discipline which relies heavily on what has been learned in past practice; it often follows empirical rules of thumb, or a set of historical exemplars, in order to solve problems, rather than try to derive solutions from comprehensive theories. The point is not that general theory is totally irrelevant to good engineering practice, but that good engineering practice must encompass much more than deriving solutions to a problem from the latest versions of our scientific theories, for there is much wisdom latent in our practical experience which we may not yet have incorporated or understood in our general scientific theories.

Technology's distinctiveness vis-a-vis science will, I'll argue later, suggest that technology--especially its engineering aspects--has a rightful claim on the liberal arts curriculum, and that liberal arts colleges cannot claim they already deal adequately with technology. But not just any treatment of it will do, so let's look at two further topics bearing on how we understand technology.

The Situational Specificity of Technology's Impact

There is a temptation on the part of some students of technology to treat the social impact of technology monolithically. Thus optimists assume that technology is well nigh determined to be our servant, to be a beneficent force in the world, a force only evil in so far as humans make evil use of it. For the extreme in this kind of categorical optimism about technology, consider the claim of many doctors in late 19th-century Pittsburgh that smoke "was beneficial to healthy and diseased lungs alike and [was] the 'sure death of malaria and its attendant fevers'." (Stilgoe, p. 96) Similarly, consider the folowing claim--meant optimistically--in the visitor's guidebook to the 1933 Chicago World's Fair: "Science finds--Industry applies--Man conforms." (quoted in Pacey, p. 25) To a pessimistic observer of technology, the foregoing comments from Pittsburgh and Chicago are perfect examples of technology out of control, of technology as master. To the pessimist, it was technology, not human need, which prompted medical nonsense in Pittsburgh. And those who revere a technological hero have simply been seduced by the glamor of the machinery, or corrupted by the material, dominating values of the technological system, and have forsaken their own position as autonomous human beings in order to obtain the false comforts which come from molding oneself to the demands of a largely autonomous technology.

Both the pessimistic and optimistic views, when applied categorically, are problematic. Contrary to the pessimists, technological activity is not necessarily alien to human nature; people have always sought to manipulate their environment. Yet any optimistic claims that the people who have made technology understand it and thus can control it are likewise naive, for most of us do not fully understand our modern technological systems. More specifically, who among us--pessimist or optimist--grasps all the unintended consequences which result from our use of certain technologies? The history of technology is overflowing with case studies of such unintended consequences, some beneficial to a society, some not. Likewise, these examples often show that a technology which appears beneficial in one social setting has undesirable effects when transported to a different setting. Thus technology is not automatically good, and not automatically bad. But it does have morally significant consequences. And we need to realize that its social implications will vary from one situation to another, and in any situation will often involve consequences which are quite unintended and unforseen. Thus we must be wary of those who would claim to tell us our technological future, or to make categorical claims regarding the good or bad nature of technology. In the classroom, this means we must be wary of discussing and evaluating technology in the abstract, apart from some specific technology in its particular social setting.

Cultural Influences on Technology

As much as one cannot understand society without considering the intentional and unintentional effects of technology on society, one also cannot understand technology without considering the effects of social and cultural values and practices on it. Thus, any curricular program which looks only at the narrowly technical fails to fully understand technology. Consider that during the bleak years of the Great Depression, a popular view among industrial designers was that a complete redesign of society along "technological" guidelines would solve all our problems. The ideal was to obtain complete rational control over all of life. The major practical industrial result of this vision was the streamlined style of the 1930's, a style applied to everything from aircraft and trains to pencil sharpeners and glorified in Chicago and New York at the world's fairs of the decade. As much as this style stemmed from a philosophic ideal for the ordering of society, so did its rapid demise during the 1940's. As Jeffery Meikle has noted in his study of the period, "the monolithic coherence of industrial design's machine-age world--and its bent for processing people through curved flow lines--recalled European and Russian totalitarianism. As America entered the Cold War, social planning, a prime concern of society during the Depression, became ideologically suspect." (1979, p. 209) Thus one fails to fully understand the industrial practice of this period without considering the role of social and cultural factors. (Since one does need to distinguish industrial designers from everyday, practicingengineers, consider also on this point David Billington's (1983) discussion of the role of aesthetic values in structural engineering.)

Lessons for Liberal Artist

So what are the implications of what I've said for technology and education? I've made, essentially, three claims: (1) that studying science is not the same as studying technology, and more specifically, that engineering--as a significant part of technology--is a field of its own, with its own (man-made) world to discover, and its own characteristic methodological tenents; (2) that (as everyone admits) technology greatly affects society, though (as not everyone admits) its specific impact needs to be considered on a case-by-case basis; there is no technological determinism either toward the good or the bad; and (3) that society greatly affects technology--technological change is not solely caused by narrowly technical innovation, and social values inevitably affect the practice of the technologist. Let me apply each of these points to the liberal arts educational setting.

Without suggesting that liberal arts colleges become engineering schools, if I am correct in distinguishing technology broadly and engineering specifically from science, we must recognize that the absence of technology studies from our campuses may be more due to academic prejudice than anything else. Like Plato, who placed the artisan in a low social stratum, the academic aristocracy has through its own misconception of the topic relegated technology to second class status. Thus, I want in many ways to agree with those who are currently advocating more technological education in liberal arts institutions, though I do so on grounds of academic fairness rather than real or imagined needs to improve the economy or beat the Japanese. If my characterization of technology is correct, we should view it as an independent field of knowledge, not currently part of the liberal arts curriculum, but worthy of study by a liberal artist, i.e., a person whose goal is to understand the world. But technological literacy or competence, then, does not mean simply knowing how to use a technical artifact (e.g., a computer), or simply knowing the social issues prompted by the artifact's use. It involves those things, but it also requires that one understand the nature of the more technical side of the subject, and the interaction of those technical features with other technologies and human values in the overall organizational and social setting. And if technology is a field unto itself, there ought be some general concepts or principles one learns in the context of studying some specific technology which one can apply to other technologies as well, otherwise, for example, computer literacy will do little to make for a public which is technologically literate. Thus, in teaching about any specific technology, one ought also stress general technological concepts such as "feedback," "system," etc. That is, to continue the example, the product of a computer literacy program, or some other program aimed at increasing technological literacy, ought be able to look at devices as seemingly different as a simple electromechanical binary adder, a micro-computer, or a railway signalling installation, and--perhaps with a little explanation--be able to have a general understanding of how it is that these three things have common design and operating features.

If my second point is correct, we will never really understand culture if we do not spend some time studying the technologies which greatly affect it. Indeed, technology, or technology studies, seems a supremely interdisciplinary subject. Thus, liberal artists, by virtue of their interests in understanding culture and seeing the world as a whole, ought find technology a fruitful field for study. Yet if we merely throw some narrowly technical courses at our students, we would ignore the moral of my third point, namely, that one does not understand technology without understanding the complex organizational and social setting in which technologies are developed and applied. Mere technical training will not accomplish the goal of providing a comprehensive understanding of technology. Moreover, we ought perhaps draw a lesson from the current lament over scientific and mathematical illiteracy in the face of decades of science and/or mathematics requirements at colleges and universities. What has been wrong with such, that they have not forestalled such illiteracy? One suspects that courses designed for majors may appear largely irrelevant to the humanities or social science student, as such courses make little contact with his or her intellectual concerns.

Somewhat over a decade ago, recognition in the sciences that standard introductory courses were not effective among non-majors led to the introduction at many colleges of courses with somewhat condescending names such as "Physics for Poets." The analog in technology are the "technology and society" courses which largely concentrate on the societal side of things. Often failing to pay much attention to the "technical" side of technology, they risk becoming cursory "technology appreciation" grand tours or else courses in which technological determinism is assumed and little attention is then paid to the details of any specific technology. By raising questions of social impact and values, these courses often strike the humanities or social science student as relevant, but they sometimes paint with such broad strokes that it is hard to see that a comprehensive understanding of technology is gained. These courses risk treating technology monolithically, ignoring what I earlier called the situational specificity of technology's social impact. Thus, for the liberal artist to understand technology, it will be necessary to deal in some specifics, including technical specifics. Nevertheless, the product of any technological literacy program also ought be able to raise appropriate questions about the organizational and social aspects of technology in regard to any specific technology the student might encounter. The educational task, in short, is to produce teachers and students who are both technically literate and culturally and historically sensitive.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 61-70, 1987. Printed in the USA.
0270-4676/87

TEACHING TECHNOLOGICAL LITERACY IN THE THIRD WORLD

Eugene B. Shultz, Jr.

Introduction

Technological literacy is a field of global importance. It is not only necessary to include Third World cases in a well-designed science, technology and society (STS) program to give it breadth, it is essential to do so, to gain certain special benefits that will be the main subject of this brief paper.

First, let's consider the usual reasons why one might teach STS units, the objectives that have to do with integration of the sciences with the social sciences, utilizing technology as a theme. These ob-jectives are independent of geographic context, therefore, it has been possible to achieve my usual generalized technological literacy objectives in courses dealing only with case studies drawn from the Third World: examining social, political and economic implications; learning scientific principles behind important technologies; sharpening skills of analysis, synthesis and evaluation; helping students sort out values they hold with regard to technologies; and more.

Second, the special benefits of teaching technological literacy in the Third World context bring additional values to the study of STS, seven of which will be touched upon herein:

1. STS cases selected from recent Third World experience help students develop a much-needed global awareness.

2. Students who are beginning to develop their skills of technological analysis will often find that Third World impacts of technology are relatively easy to identify and analyze, because the impacts are often more severe and obvious than in the industrialized world.

3. Many technology/society issues of importance involve unique interrelationships between the industrialized world and the Third World, for example, the sale of illegal pesticides to the Third World and the pesticide "boomerang" effect.

4. Students should not be limited to a study of technology in its high-tech form, but should also develop an appreciation of small-scale, low-cost, labor-intensive technology ("appropriate technology" or AT). This is perhaps more easily accomplished in a study of its Third World applications. AT is often ignored in favor of high-technology, in courses centered on STS in the United States.

5. The Third World is especially vulnerable to disasters of various types due to misapplications of technology, and these disasters are not without subsequent adverse impacts on the United States.

6. Technologies often have especially severe impacts on poor people. Although this can be brought out in a United States context, it is perhaps easier to do so and more obvious in a Third World context. Most Third World people are poor, by far, and this is not true in the United States.

7. Third World STS studies, although they do not require knowledge of a foreign language or an intensive study of foreign cultures, may foster student interest in studying languages and cultures.

The above special benefits of Third World STS studies will be illustrated in a description of a teaching unit that begins with the disaster in Bhopal, India, at the pesticide plant of Union Carbide of India, Ltd. This case is rich with STS teaching opportunities. The essence of the chemistry can be described, the nature of the inherent hazard, and the similarity to the chemical technology utilized by the parent corporation, Union Carbide, in West Virginia. Questions can be explored concerning how best to transfer technology to the Third World, the value of human life, the problem of housing the urban poor in the Third World, the differing press coverage of the disaster in the United States and India, ethical issues, and much more. Social science as well as science teachers can cooperate in such a study. General intellectual skills can be exercised, and awareness of global technology-related issues can be advanced.

Correlated with the above could be a case study of food production technology starting with an analysis of the benefits and shortcomings of Green Revolution agricultural technology in India, and its dependence on chemical pesticides. This would be followed by consideration of alternative, simpler, lower-input and cheaper technologies for producing food. Included would be examples of integrated pest management (IPM), a technical approach that avoids or minimizes the adverse environmental impacts of synthetic chemical pesticides, which are often inherently hazardous chemicals to manufacture and use.

The Bhopal Disaster

The release of highly-toxic methyl isocyanate (MIC) from the pesticide plant in Bhopal, India, in December of 1984 has been termed the world's worst industrial disaster (Bowonder and co-workers 1985, Lepkowski 1985a, 1985b). Thousands were killed or injured, and deaths attributable to the disaster are still occurring. Most of the casualties were among poor people housed in a shantytown that was allowed by the city to grow up around the chemical plant. There is substantial evidence that the plant was operated under conditions that would not have been allowed in the West Virginia plant of the parent corporation at which MIC is also manufactured:

> Both Union Carbide and the [Indian] state government effectively ignored a 1982 warning that the inadequate safety procedures 'risked causing a serious accident.' Just prior to the accident, Union Carbide [of India, Ltd.] halved the number of maintenance staff, replaced skilled staff with unskilled staff and cut the working time of those remaining in an attempt to make economies (O'Keefe, Phillips and Munslow 1986).

The Bhopal incident brings out special aspects that study of a comparable domestic disaster cannot illustrate. Because Bhopal was in the Third World, we have the opportunity to raise and discuss questions such as these in an STS class:

Why are industrial working conditions often poorer in the Third World, in comparison with the industrialized world?

Why are environmental and workplace laws and regulations generally more strict in the United States than in the Third World?

When a company is faced with heavy competition, is it always good business practice to cut maintenance staff and replace skilled with unskilled workers? Would you answer differently if the life of the corporation were at stake? Why?

Are Third World governments inadequately informed about hazardous technologies? Purposefully lax? Inadequately concerned about public safety and welfare? About human life? Inevitably corrupt?

Was the parent corporation powerless to require its Indian subsidiary to correct obviously unsafe conditions?

Does prevailing business practice require a U.S. parent corporation to establish or tolerate poorer working conditions in its Third World subsidiary than it is required to maintain in the United States? Why?

Are Third World engineers less competent than U.S. engineers? Even when trained in the United States? Are Third World people less able than we are, in dealing with hazardous technology?

Did the dictates of short-term profit maximization, a strong ideology in business management, lead both the parent and its subsidiary into wishful thinking that no troubles would occur in the Bhopal plant, despite the poor operating conditions that were known?

Is business profitability in the U.S. dependent on cutting corners on safety in the Third World?

Why are the poor so vulnerable to disaster? What might be done in the future to mitigate this problem?

Was Bhopal an Act of God? An isolated example of human error or sabotage, unlikely to be repeated, and essentially impossible to prevent? Was it due to bad management, therefore, treatable by firing the managers and hiring good ones? Was it the result of basic flaws in the economic system? How should we think about Bhopal? How might similar disasters be prevented? Or, is it pointless to try?

If STS studies are restricted to the U.S. context they cannot delve into the above types of important questions, and many others that surround the vexing problem of technology transfer from industrialized to Third World nations. It is true that the elements of the relevant chemistry can be explained just as well in a non-Third World case, and this may be done in any event to take advantage of an opportunity to teach a basic science lesson. But Bhopal provides a much larger opportunity to explore major issues related to the proper role of technology in the world, and how technology should be managed in the interests of public safety and welfare of all concerned, in all nations.

The Green Revolution

Pesticides were in production in Bhopal because of a major technological change in food production in India which has been given the name "Green Revolution." In essence, new high-yielding varieties (HYVs) of wheat and rice were introduced in India in the 1960s, and this initiative has been successful in increasing food production. Because the HYVs were vulnerable to certain insect pests and plant diseases, a need was created for pest control, and this was provided by the chemical industry in the form of synthetic chemical pesticides.

An STS study of Bhopal can be amplified by an exploration of the benefits and disbenefits of the Green Revolution. Although yields of grain were greatly increased, there is a substantial body of research (see List of References) that describes the social cost of the Green Revolution. For example, increased social stratification has come about in rural areas where the new technology was introduced: a combination of HYVs, chemical fertilizers and pesti-cides, advanced agricultural machinery, and tube-wells for irrigation. The well-to-do farmer has generally benefitted more than the others. Because of the financial intensity of the technology, the more well-to-do are more likely to qualify, participate, and succeed. As some larger farmers have become richer, many small farmers have become poorer through foreclosure or sale. The result has been an increase in landlessness, pauperization and proletarianization (Sen 1985, 55).

So, although India has greatly increased its grain production, it has at the same time aggravated the problems of landlessness and drift of the unemployed to the cities. Baidya (1985) has written eloquently about this. Among the many cities to which the landless flocked was the city of Bhopal.

Also, it may come as no surprise that rural Indian women have been especially disadvantaged by the Green Revolution. Men are in control of the technology and carry out most of the tasks involving operation of the machinery. Women have been increasingly crowded into a narrow range of low-paying jobs at the low end of the labor hierarchy (Sen 1985, 46).

There are alternative food production technologies that are not financially intensive, that are sustainable and adaptable to many soils and climates, and that do not require the use of hazardous chemicals (Alverson 1984, Girardet 1986, Harwood 1979, Richards 1985, Senanayake 1983, Wiersum 1982). These are usually based on agroforestry methods that have been practiced in one form or another for many years as part of indigenous knowledge systems in the Third World. In many cases, modern science has been applied to such systems to improve rather than replace them (Beets 1982). At this point, the course might examine the biology of such systems, to demonstrate that the Green Revolution and its large appetite for synthetic chemicals is not the only route to high yields of food per acre.

Pesticides in the Third World

An STS teaching unit having Bhopal as the first issue under discussion might include a broader consideration of pesticides in the Third World, their widespread misuse and the deaths and illnesses that are the result. The genetic resistance effect that leads to increasing frequency and increasing futility of spraying, and the "boomerang" effect (pesticide residues returning to the U.S. on such crops as bananas and coffee) should also be explained. The List of References contains general materials on this topic.

It should be noted that deaths from pesticide poisoning in the Third World have been estimated at 14,000 annually, with another half million seriously affected (Mazingira 1985, 3). The actual numbers are likely to be much higher; most pesticide usage is in remote areas and many accidents certainly go unre-ported. A group of concerned nongovernmental organi-zations (NGOs) has called for the banning of 12 of the most dangerous: DDT; 2,4,5-T; aldrin; camphechlor; chlordimeform; chlordane; DBCP; ethylene dibromide; lindane; parathion; paraquat; and pentachlorophenol (Mazingira 1985, 3). This news affords an oppor-tunity for students to study the chemistry of the main classes of pesticides, and the hazards associated with each.

Beyond the chemistry and biology of pesticides, it is worthwhile to discuss the problems created when safety instructions are printed in languages that workers do not understand, the fact that protective clothing is often not provided or that the weather is often too hot for the special clothing to be worn, and the fact that repackagers often do not copy the warning labels. It needs to be pointed out that if insects can develop resistance to a pesticide by way of mutation, then the pesticide is for all practical purposes a failure. Attention then needs to be turned to alter-natives that are not going to be foiled by development of genetic resistance. The opportunity exists, at this point, to discuss some basics of strategic management of technology. Clearly, inventing still another pesticide that will simply cause the insects to mutate still another time may appear to be good business, because there appears to be a market, but is it good strategy?

Integrated Pest Management (IPM)

A variety of well-tested techniques that will cut down on the need for chemical pesticides should be considered: agronomic methods (crop rotation, fallowing, choice of planting date to avoid the annual flush of pests, etc.), biological controls (utilization of the pest's natural enemies), and development of resistant strains. Coordinated plans for using these techniques are often called "integrated control" or "integrated pest management" (IPM). Dover (1985a, 1985b) has published excellent descriptions of IPM at the basic level.

The inclusion of teaching materials on IPM affords many opportunities for explaining basics of biology and chemistry in the context of a major problem. As the many difficulties surrounding chemical pesticides become increasingly troublesome, the greater is the likelihood of continued growth in the development of sophisticated IPM schemes. It is interesting to note that M. S. Swaminathan (1986, 19), the Director-General of the International Rice Research Institute and one of the architects of the Green Revolution in India, has now called for the minimization or avoidance of chemical pesticides through use of IPM. A short selection of IPM references is given at the end of the paper.

Concluding Remarks

If disciplinary barriers can be discarded, a discussion oriented to the prevention of future disasters like Bhopal can lead naturally to the Green Revolution, one of the main reasons for transfer of pesticide technology to the Third World. From there, the flow of inquiry can move to the many problems of pesticides and the potential of integrated pest management for mitigating those problems, as well as the potential of high-yield agroforestry methods for food production without the need for chemical pesticides. At no time is there a need for the inquiry to stagnate at the boundaries of a discipline, although it may be helpful to collaborate with other teachers so that such boundaries present few problems. The discussion should keep moving from the problems, toward potential solutions, unhindered, always searching for new strategies that are worthy of further investigation. Discussions should not be allowed to stop at the level of problem description; students must have the opportunity to think about potential approaches to solutions.

In conclusion, all of the usual objectives that I have for designing STS units in a domestic context can be realized in a unit dealing with Third World STS. In addition, special benefits are obtained: enhanced attention to global issues, exploration of unique interrelationships that bind the United States to the Third World, awareness of the special vulnerabilities of the Third World to disaster, awareness of the special opportunities for appropriate technology in the Third World, and some understanding of the special needs of the Third World poor. In short, the pursuit of Third World literacy as well as technological literacy can be carried out simultaneously and effectively.

It is probably no more difficult to develop a Third World STS unit than a domestic STS unit. For me, the two tasks make similar intellectual demands, qualitatively and quantitatively. Further, students have not argued that Third World studies have little to do with their lives. On the contrary, they have often remarked, without prompting, that Third World problems show some remarkable similarities to those of the United States. Finally, although my experience with these units has been entirely with university students, both undergraduate and graduate students, it would seem likely that similar units could be prepared and used successfully with high school students.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 71-77, 1987. Printed in the USA.
0270-4676/87

MEDICAL TECHNOLOGY AND CRITICAL DECISIONS: AN INTERDISCIPLINARY COURSE IN TECHNOLOGICAL LITERACY

Theodore W. Ducas, James H. Grant and Alan Shuchat

Abstract

This paper describes a new course in Medical Technology and Critical Decisions, part of the Technology Studies Program at Wellesley College, established with the support of the Alfred P. Sloan Foundation's New Liberal Arts Program. The course uses the dramatic new options in medicine presented by technology to individuals and society as a vehicle for promoting general technological literacy in liberal arts students. The course motivates the study of the scientific principles on which the technology rests and the mathematical principles of a methodology for making rational choices. A case in point is the decision of a pregnant woman whether or not to undergo amniocentesis, a procedure used to determine the genetic make-up of a fetus from cells in the amniotic fluid. The course introduces students to the underlying notions of genetics; the physical principles behind the ultrasound imaging technique used to position the needle that draws the fluid; the probability and statistics needed to understand the risks to the woman and fetus both of having and of not having the procedure; and the methodology of decision analysis, increasingly used by genetic counselors to help prospective parents incorporate their personal values into the decision-making process.

Stella and Marlon Primagravida, in their late thirties, are expecting a child. Stella's brother has Down's syndrome, and her obstetrician has suggested amniocentesis to help determine whether the fetus she is carrying has such a genetic defect. Stella and Marlon have many questions and fears: What is amniocentesis, and how does it work? What can it and can't it do? What are the risks, and what are the chances of something going wrong? How common are genetic defects? Would Stella have an abortion if they knew the fetus had such a defect, and do they want to know?

Wellesley College and the Technology Studies Program

This is the kind of situation dealt with in Medical Technology and Critical Decisions, an interdisciplinary course being developed at Wellesley College with the support of the Alfred P. Sloan Foundation under its New Liberal Arts Program. The Foundation's hope in this initiative has been to encourage liberal arts colleges to rectify an imbalance in the undergraduate curriculum where students (largely in the humanities and social sciences) receive neither adequate exposure to technology nor sufficient experience in quantitative reasoning, which are critical for students to be prepared for life in an increasingly technological world.[2] Since 1983, it has provided grants to leading colleges and universities in the United States to support a variety of new programs, including the development of course curricula and related materials, faculty seminars and workshops, and research.[3]

Wellesley College offers a strong undergraduate education in the humanities and social sciences, physical and natural sciences, and mathematics. It also

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has a significant continuing education program for women who are resuming their education after an intervention of perhaps many years. Wellesley has no programs in engineering or technology, but has a cross-registration program with the Massachusetts Institute of Technology and exchange programs with many other colleges and universities.

Under its New Liberal Arts grant, Wellesley has established a program in Technology Studies, with curricular components that include the infusion of technology into existing courses and the development of new courses focusing on the technological aspects of various disciplines. Besides Medical Technology and Critical Decisions, the program includes some 17 courses, such as: Television Technology and Social Impact; Structure in Music: Experiments in Computer Modeling; Medical Ethics; Technology and Society in the Third World; Technological Applications of Light; The Politics of World Energy; Biotechnology: The Working Life; Introduction to Electronics and the Electronic Revolution. Also, the program supports courses, internships with the Smithsonian Institution and college-wide symposia on technology-laden issues such as the Strategic Defense Initiative ("Star Wars").

Medical Technology and Critical Decisions

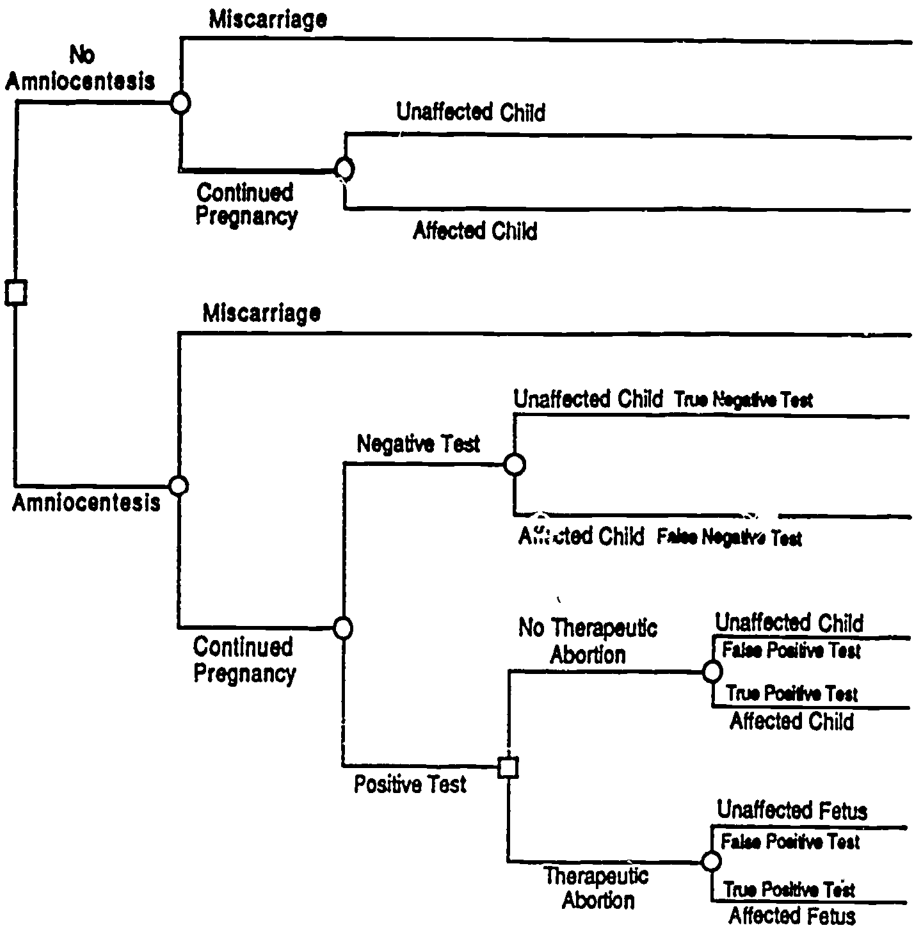
Medical Technology and Critical Decisions serves as an introduction to the Technology Studies Program, and has no prerequisite college courses. While designed for freshmen and sophomores whose primary interests are in the humanities and social sciences, it is open to all students. Its organizing principle and motivation lie in the dramatic new options being presented by technology. Technology expands human intervention into areas that were previously not in our control. These new possibilities for action create the need to choose among them. We can, of course choose not to follow one of the newly opened paths but this is now also a decision for which we are responsible.

It follows that an educational approach effective in meeting these issues in technological literacy should have three main components: (1) instruction in the technology of the new options, not just in the artifacts involved but also in the methods by which they are used to achieve intended results;[4] (2) instruction in the scientific principles on which the technology rests; and (3) experience in the technology of decision-making itself, modeling the choice problem by using analytical methods which include the statistical limits to available data, the probabilities of various outcomes, and the values of the decision-makers.

Case studies that incorporate these components in a natural way provide effective vehicles for communicating this ambitious range of topics. Medical decision-making problems make particularly good cases since they carry an inherent drama and form a class of experiences that all of us face in life. Such a case study provides the backbone of the course: the decision of a pregnant woman whether or not to undergo amniocentesis, a procedure for determining the genetic make-up of a fetus from fetal cells in the amniotic fluid, in order to test for genetic disorders such as Down's syndrome. We chose amniocentesis because of its particular relevance and appeal to our students, who are women. The small scale of the situation allows us to clarify the principles involved while developing the case in a rather complete way. We build up to more complex cases only after having established the necessary technological groundwork and analytical skills.

Amniocentesis has other attributes that make it especially suitable for our goals. There are aspects of genetics and medical imaging (ultrasound) at the frontiers of medical technology that are nevertheless accessible to students with little science and mathematics background. There is also an extensive literature on the decision-analytic approach to amniocentesis, which incorporates the values of the individuals and the role of the physician and genetic counselor (experts).

In this approach, the decision is represented by the tree shown in the accompanying figure. As we move through the tree from left to right, square nodes represent decisions to be made while circle nodes represent possible outcomes that can occur by chance. Each branch at a chance node has its own



Amniocentesis Decision Tree

[Based on Pauker and Pauker, *Yale J. Biology and Medicine* 50 (1977), 275-289]

probability of occurring, based on hospital and laboratory data.

The possible final outcomes appear on the right, and are given relative values (utilities) established by the couple, assisted by a genetic counselor. The procedure for finding an optimal choice involves "folding back" the values of the outcomes through the tree, weighing each according to its probability, until an "expected", or average, value is established for each branch of the decision node. The decision branch with the higher expected value is the better choice for the couple, given the values they have expressed and the probabilities used in the model. The analysis of the amniocentesis decision provides a natural template for the organization of the course, which is described below. As the various aspects of the decision unfold, they motivate the introduction of the different topics in the course.

Course Description

After a brief discussion of decision analysis and its relevance to the amniocentesis case, students are introduced to data representation and distributions. This allows them to summarize the empirical data about the incidence of Down's syndrome, and provides the foundation for all future discussions about extracting information from available data.

The concepts of probability, probability trees, and conditional probability are taught in the context of the reliability of clinical test results. The class then also has the skills to engage in the probabilistic reasoning necessary to understand the transmission of genetic disorders from one generation to the next. We also present an overview of the molecular and biological science useful for understanding chromosomal anomalies, such as Down's syndrome, and the techniques for testing for their presence.

The risk of complication in amniocentesis has been dramatically reduced by employing ultrasound imaging to observe the fetus in the womb and guide the needle safely. Discussions of the principles of wave motion and the design of imaging systems enable students to understand ultrasound and other minimally invasive imaging technologies, such as X-rays, CAT [computer-assisted tomography], and NMR [nuclear magnetic resonance], that are used to see inside the body. In particular, we explore the reasons why ultrasound is the technology of choice to assist amniocentesis. Classroom sessions are accompanied by laboratory work that gives students hands-on experience in using scientific instruments. They make measurements on the propagation of sound waves, use high frequency transducers and oscilloscopes to study ultrasound, and perform some rudimentary imaging experiments using an acoustic range-finder unit from a Polaroid™ camera. We also visit a local hospital to observe ultrasound in its clinical environment.

Hospital data on the genetic makeup of fetuses or on miscarriages is the result of sampling the outcomes of chance processes. We teach fundamentals of statistics, relating this to the earlier material on data representation, so that students can draw conclusions from the available medical information. This enables them to infer probabilities for the outcomes based on sample data and to know the uncertainties in these probabilities.

But knowing probabilities is not enough, and the individuals making the decision must also place a value on each outcome: how does one compare the birth of a Down's child, the birth of an unaffected child, an elective abortion, and a miscarriage that may have been induced by amniocentesis? Principles of utility analysis and cost-benefit analysis enable students to make such difficult comparisons and so to incorporate individual and societal values into such a decision. They can use the decision-analytic methodology to analyze the choice problem. Finally, to see the effect of inaccuracies and biases in the assumptions of the model on the decision it suggests, students must analyze the statistical properties and sensitivity of the decision to changes in these assumptions.

To consider the decision process in an integrated fashion as it is played out in actual cases, the class meets with a practicing genetic counselor, who brings the power of first hand experience with a wide range of couples. The impact of this session is dramatic as it drives home the relevance of our work to people's lives.

The capstone of the course is a final paper, which is a full-blown analysis of an actual clinical decision problem taken from the medical literature. The students are given a selection describing the patient's history, research results relevant to the case, and an outline of the possible choices the physician and/or patient can make. They then model the decision problem, acting as if they were a team of consultants to the attending physicians. To simplify the computations, they use interactive microcomputer software for decision analysis (e.g., ARBORIST™). Finally, each individual student analyzes the model, presents her analysis, and justifies her recommendations. This is a challenging assignment that serves to integrate their entire semester's experience in the course.

While the students are working on their final papers, we expand the scope of our class work to look at decision problems beyond the scale of the family and counselor. The economic issues involved in health policy and in the choices made possible by advances in medical technology lead to a consideration of the purposes and design of public policy toward health care.

We introduce principles of the economics of market externalities and of public goods, and of cost-benefit analysis as a method for the rational design of public policy. The relevance of such societal choices is made clear through examples such as kidney dialysis policies in different countries and the current debate in the United States over public funding of organ transplants.

COURSE OUTLINE

INTRODUCTION
- technology and decisions
- amniocentesis decision problem

DATA REPRESENTATION
- histograms and distributions
- mean and standard deviation

PROBABILITY
- probability trees
- conditional probability and clinical diagnosis
- laboratory: data and probability

GENETICS
- Mendelian genetics and probabilistic reasoning
- sex-linked traits
- genetics and statistics of Down's syndrome

ULTRASOUND
- nature of wave motion and sound
- extracting information: ultrasound and other imaging methods
- laboratories: frequency, wavelength and speed of sound; sound measurement

MIDTERM EXAM

CHANCE PROCESSES
- model for "random" generation of data
- probability histogram, expected value, standard error; normal curve approximation

SAMPLING AND STATISTICAL INFERENCE
- sample surveys, sample size, sampling errors
- confidence intervals

DECISION ANALYSIS
- decision trees and utility
- threshold probabilities and sensitivity analysis
- laboratory: decision trees (interactive microcomputer software)

AMNIOCENTESIS AND RECENT DEVELOPMENTS
- amniocentesis procedure and timing
- decision analysis case study
- other technologies for fetal diagnosis

PUBLIC CHOICE
- public choice vs. private choice
- opportunity costs and choice
- cost-benefit analysis: a case study in public policy

FINAL PAPER
- clinical decision analysis case study

Teaching Style

The teaching methods used in the course are as important as the material taught. We teach the course jointly, usually with a physical scientist and a social scientist. Team teaching strengthens the course in several ways, justifying the added expense. The course requires knowledge across several disciplines, and generally exceeds the expertise of any one instructor. The team approach allows faculty to teach approximately within the bounds of their expertise. Also, while one instructor is in charge of the class, the other participates actively along with the students. Team teaching simulates a "real-world" problem-solving environment, where experts contribute to the information used by decision makers. Our participation as skilled questioners learning unfamiliar material serves as an example for the students. This willingness to challenge, learn, and display our own ignorance and excitement sparks similar responses in the students. We have seen the classroom become more dynamic for it.

Of course, there is no ready-made text for such a course. Reading assignments include textbook chapters in statistics, genetics, physics, and economics, medical articles on probabilistic reasoning and analysis in clinical decisions, and selections on the impact of technology on society.

Adaptability

We designed this course to further the technological literacy of liberal arts students: in particular to give them experience in applying knowledge from various traditional disciplines to address the technology of a specific issue, the scientific principles underlying the technology, and the technology of modeling the decision problem involved in the issue.

Though the specific applied subject, medical technology, has served us well given our audience, one objective is to teach students that their newly acquired skills and experiences learned are broadly applicable. In fact, we have taught other versions of the course with different applications. We presented one class with the choice of alternative technologies for replacing an inadequate climate control system for the College's art museum (the options included a chilled water plant, chemical cooling plant, and use of water from a bordering lake). Another class organized itself as a local public school board; faced with certain declining enrollments it needed to decide whether and how to reduce the board's expenditures (the decision involved the possibility of school consolidations and other cutbacks). Each specific case has as its foundation a genuine decision problem of current interest.

The audience for this kind of course is not limited to liberal arts students. We have been fortunate to receive Sloan Foundation funding in support of our Technology Studies Program. However the skills this course addresses are increasingly important for students to learn at an earlier age. One product of any technological advance is the opportunity to choose among options that would not exist in its absence. Confidence in one's ability to learn new technologies and to make informed decisions will be ever more valuable. Though we have designed a liberal arts course the lessons are not unique to them, and can certainly be taught in other environments.

Conclusion

The central feature of this course that gives it a special place in the curriculum is its integration of a broad range of subjects and techniques - an integration rarely found in a liberal arts education and difficult to achieve within the traditional departmental structure. In designing a course whose organization is motivated by the analysis of a particular decision, we combined elements of quantitative reasoning and technology, and included aspects of individual and social values and critical thinking that often are dealt with explicitly only in courses entirely devoted to these subjects. Furthermore, we did not merely present students with pieces of data, but led them to develop the skills of extraction and synthesis necessary to use the data in a discriminating way. The dynamic inquiry in the classroom, guided by the teaching team, gave the students experience in getting information from a variety of sources and tying it together to help solve the particular problem at hand.

This motivated, unifying approach was something many of our students, even seniors, had never experienced in their educational careers. In pursuing the teaching of technology we had included aspects of science, social science and humanities in a single course in a way that exemplified not only real situations they would face, but the broad spectrum of knowledge that liberal arts colleges seek to convey.

We designed this course to provide a paradigmatic experience for students. In the same spirit, this course description is an example for teachers, professors and administrators, and a guide towards constructing their own course or program to include technology in the curriculum in a natural and effective way. The support necessary to get such a course off the ground is amply justified by the quality of student experience which liberal arts colleges are especially well-positioned to provide. The problem-driven approach, the style of team teaching and the range of student experiences are all essential elements. But the key to the success of this enterprise is the presence on campus of knowledgeable, energetic, and sympathetic faculty who see the value in this effort and work together to make it happen.

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[1]The authors are respectively Associate Professor of Physics, Assistant Professor of Economics, and Professor of Mathematics, at Wellesley College. We thankfully acknowledge support from the College's Technology Studies Program, funded by the New Liberal Arts program of the Alfred P. Sloan Foundation.

[2]Selected articles which give an overview of the New Liberal Arts in American college education include the following: James D. Koerner, Ed., The New Liberal Arts: an Exchange of Views, An Occasional Paper from the Alfred P. Sloan Foundation, 1982; Robert P. Lisensky, Allen O. Pfinister, Sharon D. Sweet, The New Liberal Learning: Technology and the Liberal Arts, The Council of Independent Colleges, 1985; and Russell Edgerton, "Feeling in Control," Elting E. Morrison, "The New Liberal Arts," John G. Truxal, "Learning to Think Like an Engineer: Why, What, and How," Samuel Goldberg, "The Sloan Foundation's New Liberal Arts Program," Robert Kanigel, "Technology as a Liberal Art: Scenes from the Classroom," and Nannerl O. Keohane, "Business as Usual or a Brave New World - A College President's Perspective," each in Change, March/April 1986.

[3]The Sloan Foundation currently sponsors New Liberal Arts courses in some 30 U.S. colleges and universities (NLA News, November, 1986). Programs similar to the New Liberal Arts are supported in other colleges and universities by the Council of Independent Colleges and other institutions.

[4]We take as a working definition of technology that offered by Maurice Richter, that technology encompasses "tools and practices deliberately employed as natural (rather than supernatural) means for attaining clearly identifiable ends." (Maurice N. Richter, Technology and Social Complexity, State University Press of Albany, 1982, p.8.)

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Bull. Sci. Tech. Soc., Vol. 7, pp. 78-87, 1987. Printed in the USA.
0270-4676/87

COMPUTER LITERACY FOR LIBERAL ARTS STUDENTS: AN APPLICATIONS APPROACH

Thomas T. Liao and David L. Ferguson

Introduction

Scene: It is a rainy April afternoon, and the liberal arts students in our computer literacy course are slowly seating themselves in the lecture hall. The lecture starts with a question about what the 180 students think the following items on the front table and screen have in common:

- a toy called "Big Track"
- a box of Kellogg's Corn Flakes
- a motorized vehicle that is controlled by infra-red sensors
- a library book
- an overhead tansparency with pictures of an industrial robot and a recent model of a microwave oven

After comments such as "things found in a high-tech professor's home" and "the belongings of a teenage hacker," we direct the students' attention to specific aspects of the above objects. For "Big Track," it's the programmable keyboard. The UPC label on the corn flakes box is discussed. The library book also uses a bar code for identification. We demonstrate how the motorized vehicle automatically follows the path of a black line. The microwave oven has both a programming pad and a temperature probe. The robotic arm can also be programmed to follow a sequence of steps.

This introductory presentation relates the theme of this day's lecture, "Computer-Based Automation," to everyday devices. The course, "Societal Impact of Computers," is designed to help students understand computer applications and their impacts. In order to make the course more meaningful for non-technical students, we start all lectures with concrete applications and examples. Students also apply what they learn in our microcomputer laboratory each week.

In this paper, we describe how the course was designed and implemented. We also provide three concrete examples of how the material from the lectures and readings are linked to laboratory activities. These examples show how the design criteria were achieved and how a microcomputer laboratory can be used for individualized instruction.

Design Criteria

In order to provide guidelines for course development and formative evaluation, four design criteria were formulated. The curriculum and instructional program should:

- be matched to the characteristics, capabilities, and limitations of the target audience;

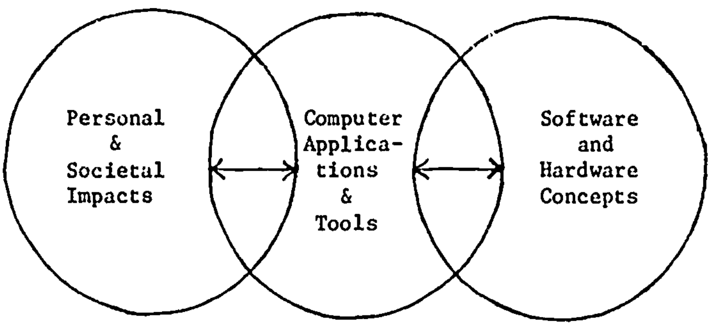
- use an applications-oriented approach;

- use an interdisciplinary approach to the study of computer applications;

- provide laboratory activities for students to apply their knowledge.

Since this type of course is intended for non-technical, liberal arts students, it must be designed to match their characteristics, capabilities, and limitations. These students, in general, feel more comfortable with verbal and pictorial representation of information. They are often intimidated by mathematics. Thus, word processing and graphics applications should be studied before discussion of mathematical modeling and computer simulations. Most of the students are novice computer users. Therefore, all discussion of software and hardware concepts must start with concrete examples.

To increase the likelihood that transfer of learning occurs, the study of computer concepts and impact must be linked to specific applications. This approach will also help to insure that learning occurs within a real-world context. The following Venn diagram depicts our integrated approach to the course content.



The third design criterion is an extension of the above Venn diagram, in that concepts from various disciplines should only be introduced when they are needed. When this criterion is used to design instructional activities, students find that learning becomes more relevant. Motivation for learning becomes intrinsic.

If students are to develop a working knowledge of computers, they must be provided with worthwhile laboratory experiences. The fourth criterion deals with the design and content of laboratory activities. We make sure that all work done in our microcomputer laboratories is integrated with the lectures and student readings. The laboratory activities must also be highly interactive and place the student as controller of the computer.

Course Organization and Syllabus

In the past six years, the demand for this course has been great. The size of the class (180 students) is limited by the size of the lecture hall and laboratory facilities. Since we have so many students, it is a real challenge to attempt to provide a more personalized and individualized instructional program.

As shown on the first two pages of the course outline (see Appendix A), students can arrange to meet with us and graduate teaching assistants for special help or enrichment. We also set up sixteen laboratory sections to make sure that students get individual assitance (by undergraduate laboratory assistants) when doing their work in our microcomputer laboratories.

In the course outline, students are shown how the readings (textbook and special readings) and the laboratory activities relate to the lecture topics. We also go over all quizzes and the mid-term examination to provide students with feedback on their performance.

Overview of Laboratory Activities

In our fourteen-week semester, students attend a one and one-half hour computer laboratory session eleven times. The laboratory activities are designed to provide "hands-on," concrete experiences in various application areas. They are of three types:

1) Usage of Application Software: Word Processing and Electronic Spreadsheet Activities

2) Usage of Computer Simulation Courseware: Activities that relate to Supermarket Automation, Water Pollution, Math, and VISILAN (Assembly Language Simulation)

3) Programming Microworld Activities: LOGO and Structured Basic

All of the laboratory activities are designed to enhance the study of specific applications. The following sections will provide an example for each of the three types of laboratory exercises.

To provide an example of how our students use applications software, the electronic spreadsheet activity is described. Currently, we use LOTUS 1-2-3 to introduce our students to modeling with spreadsheets and integrated software.

The concept of modeling and simulation is a recurring theme in our course. We have developed speical simulation courseware to use with our students. In one of our simulation activities, students learn about the operation of an automated supermarket. They compare the time it takes to check out items manually and automatically. They decipher a UPC label and learn how a computer program is used to improve the control of inventory.

Students learn the BASIC language and use it to gain insight into various application areas. To make it possible to involve beginning programmers with interesting applications, we provide students with partially written programs that they complete. In this paper, we describe the final programming exercise which shows how a probabilistic situation can be modeled using the "Monte Carlo" technique.

Laboratory Exercise #6: Electronic Spreadsheet Activity

An electronic spreadsheet is a large table that resembles an accountant's ledger. The size of the spreadsheet is determined by the number of rows and columns. The rows are numbered 1, 2, 3, ... N where N depends on the row-size of the particular spreadsheet package. The first 26 columns are labeled A through Z; the next 26 columns are labeled AA through AZ; the next 26 are labeled BA through BZ; the next 26 are labeled CA through CZ, etc. The intersection of a row and column is called a cell. A cell holds a number, a label (name), or a formula. For example, in the position A3 (column A, row 3), we may store a number, label, or formula.

The electronic spreadsheet is a powerful tool for studying problems that can be formulated in terms of a table with entries as numbers, or formulas. Such problems include problems in budgeting, financial forecasting, and a variety of statistical applications. Changes in a single cell of the table may cause changes in many (maybe all) of the other cells. The power of the spreadsheet is derived from the computer's ability to do these recalculations precisely and quickly.

Since the development of Visicalc in the mid-1970's by Daniel Bricklin and Robert Frankston, many spreadsheets have become commercially available. A leading package, LOTUS 1-2-3, integrates spreadsheet capabilities with graphics and a simple database system. This package is used in our course.

The aims of the spreadsheet lab are as follows:

1) help students learn the technical mechanics of how to use up a spreadsheet;

2) help students learn how to identify applications that lend themselves to spreadsheet analysis;

3) help students learn to use the spreadsheet to make predictions (i.e., answer "what if" questions).

Students use the spreadsheet to formulate a scheme for calculating their course grade, based on a weighted average of their peformance on laboratory assignments, quizzes, a midterm examination, and a final examination. The course grading scheme that must be used is as indicated in the course outline.

This activity requires that students know how to formulate the problem and insert numbers, labels and appropriate formulas. Students are motivated to ask "what if" questions.

<u>Laboratory Exercise #8: Supermarket Automation</u>

To provide students with a specific example of the automation of service industries, we study how the UPC (Universal Product Code) label is being used by supermarkets. First, we study the operation of this system (see Fig. 1). Then we discuss the positive (benefits) and negative (costs and problems) impacts of this type of computer-based automation (see Fig. 2).

We have developed a microcomputer courseware package that simulates three aspects of an automated supermarket. As discussed in the laboratory assignment sheets

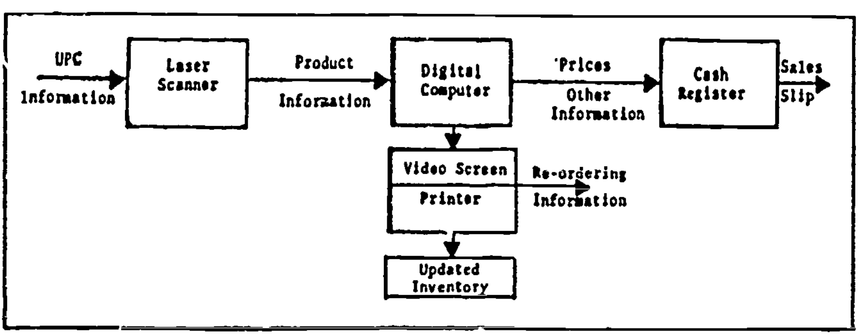


Figure 1. Operation of an Automated Supermarket System

Advantages are:

1) Faster check-out.
2) Better inventory control.
3) Potential monetary savings due to
   a) less inventory
   b) less labor costs
   c) less theft
4) Easier determination of consumer reaction to sales and advertising.

Disadvantages are:

1) Loss of jobs.
2) Difficulty to comparison shop because the packages do not have prices on them. (Due to consumer pressure, most automated supermarkets have been required to stamp prices on UPC packages.)
3) Dishonest manipulation of prices by supermarket managers.
4) Sales slips with errors which are normally attributed to price changes that have not yet been placed in the computer program.

Figure 2. Advantages and Disadvantages of Automated Supermarkets

(see Appendix B), students first collect data about the time it takes to check out ten items manually and automatically (via a simulated scanning system). The second section asks students to use the UPC system of coding to decipher a UPC label that is generated by the computer.

Finally, students can interact with a simulated supermarket as a shopper and store manager. These activities help students to see how an inventory database changes as people shop and managers make decisions (such as putting an item on sale).

Laboratory Exercise #11: Monte Carlo Simulation

In describing his minicourse on computer simulations, Zaven Karlan (1) comments that computer simulations are useful in situations where:

a) complete mathematical formulation of a problem is not possible or available;

b) available analytic methods require simplifying assumptions which distort the true nature of the problem;

c) available methods are so complex that they become impractical;

d) it is too complex or too expensive to conduct real-world experiments;

e) it is necessary to change the time scale to study the dynamics of a system.

We expect students to understand the role of simulations in each of these situations. In addition, we use simulations as a gentle and concrete introduction to concepts underlying mathematical formalism.

Much phenomena in engineering, physical sciences, social sciences and other fields involve probabilistic models. That is, given a set of values for the input parameters, due to randomness, we can get different values of the output parameters. A simulation that uses a probabilistic model that incorporates outcomes that depend on random numbers is referred to as a Monte Carlo Simulation. One of our laboratory activities focuses on this type of simulation.

The "Sampling and Opinion Survey" laboratory assignment (see Appendix C) gives students hands-on experience with a Monte Carlo Simulation. The aim of the lab is three-fold:

1) help students understand what is meant by a Monte Carlo Simulation;

2) show students how random numbers (actually psuedo-random numbers), generated by the computer, are used in a probabilistic model;

3) help students to develop an understanding of some of the concepts of inferential statistics (especially hypothesis testing and significance level).

The statement of the problem (see Appendix C) is provided to students. The major body of the program is also provided. Students must complete three subroutines:

Subroutine 1000: The computer generates a random number between 0 and 1, and the student must write relationships that determine the class level (freshman is 1, sophomore is 2, junior is 3, senior is 4). The class level will be determined by the specific interval in which the random number falls.

Subroutine 2000: The student writes the expression that causes the computer to generate a number between 0 and 1. Given a class level, the student's response (say, 0 for no, and 1 for yes) is simulated by writing an expression that determines the value of R (response) depending on the interval in which the random number falls.

Subroutine 3000: Proportion of students in each class level in favor and proportion of students opposed is formed, rounded off, and printed out.

Students are asked to run the simulation for various values of K (sample size) and compare the proportions that they get to the newspaper's results. Since the model is based on the newspaper's results, students note that, as the sample size increases, their proportions converge on the proportions reported by the newspaper. Consequently, they get a rough idea of the sample size needed to refute or reject the newspaper's results. Readers interested in this type of approach to teaching statistical concepts may refer to Stoodley's book. (2)

References

1. Z. Karian, Computer Simulation of Discrete Sytems Minicourse, Annual Meeting of the Mathematics Association of America, San Antonio, Texas, January 21-14, 1987.

2. K. Stoodley, Applied and Computational Statistics (a first course), John Wiley, New York, 1984.

APPENDIX A

DEPARTMENT OF TECHNOLOGY AND SOCIETY

EST/CSE 100 - The Societal Impact of Computers

SPRING 1987

Professors:	Dr. David L. Ferguson	Dr. Thomas T. Liao
Office:	Room 210B, Old Engineering	Room 210A, Old Engineering
Office Hours:	Monday, Wednesday: 3-4 PM	Tuesday, Thursday: 3-4 PM
Office Phone:	632-8763	632-8767
Graduate Teaching Assistants:	Jacqualine Fazziola Room 216 (Hrs. by appointment)	Jacqueline Delaney Room 216 (Hrs. by appointment)
Course Schedule:	Monday, Wednesday, Friday: 1:55 - 2:50 PM (Sec. 01) Room E-143, Old Engineering, Lecture	
Microcomputer Laboratory:	Rm. 211 - Old Engineering Building - TTBA Rm. 246 - Light Engineering Building - SINC LAB	
Required Readings:	(1) The Mind Tool: Computers and Their Impact on Society N. Graham, West Publishing Co., NY, 4th Ed., 1986 (2) Special Class Notes. D. Ferguson. T. Liao Department of Technology and Society	

COURSE DESCRIPTION

This course will help you develop a basic understanding of the operation and applications of digital computers. In addition to our study of some of the technical aspects of computers, we will examine the social implications of the widespread use of computers.

A major objective of the course is that you be able to demonstrate understanding of the devices that comprise a computer system, as well as examine the capabilities and limitations of the system. The computer languages BASIC and LOGO will be used, and you will have the opportunity to create and run computer programs. The experience with programming languages and applications software will help to deepen your understanding of how computer systems operate.

A wide range of topics will be surveyed - including simulations and modeling, artificial intelligence and robotics, computer-assisted instruction, and applications of computers in medicine, business and government. As a result of this course, you should be able to analyze more critically the societal impact of various applications of the computer.

EST/CSE 100 - Readings & Lab Assignments Spring 1987

DATE	TOPIC	READINGS	LAB ASSIGNMENTS
1/26	Course Organization & Overview (Requirements and Content)	TMT-Preface, Ch. 1	Orientation to Microcomputer Labs: SINC LAB Y-246 PET LAB E-211
1/28	Computer Hardware and Software (Historical Perspective)	TMT-Chs. 2,3,5	
1/30	Computer Software and Applications (Historical Perspective)		
2/2	Writing, Word Processing and other Application Software	TMT-Ch. 8 SCN-I, II	Lab #! (Hand in this assignment after lab sec.)
2/4	Electronic Publishing		

2/9	LOGO Graphics (Introduction to Structured Programming)	SCN-IV, V	Lab #2 (Due 2/16)
2/11	Interactive Computer Graphics and Art Applications	TMT-Ch. 14 SCN-III	
2/16	Introduction to BASIC via PET Graphics	TMT-A1 - A45 SCN-VI	Lab #3 (Due 2/23)
2/18	Algorithms and Programming Comparison of Programming Languages	TMT-Ch. 6,7	
2/23	How a Computer Works (Assembly Language-VISILAN)	TMT-Ch. 4 SCN-VIII	Lab #4 (Due 3/2)
2/25	Review and Quiz I		
3/2	Computers in Education - CAI/CMI (Microworlds & Other Applications Software)	TMT-Ch. 13	Lab #5 (Hand in this assignment after lab sec.)
3/4	Computers in Education-Capabilities, Limitations, and Issues		
3/9-3/13	WINTER RECESS		
3/16	Introduction to Spreadsheets	TMT-Ch. 9 SCN-XII	Lab #6 (Due 3/23)
3/18	Spreadsheets and Decision-Making		

APPENDIX B

Laboratory Assignment Sheet

Activity 8: Simulation of Supermarket Automation

In this assignment you will have the opportunity to play various roles in a supermarket automation simulation--clerk, shopper, and manager:

1. Clerk

In Parts 1 and 2, you will play the role of a clerk who will use either an automated (laser scanner) or a manual check-out system. Complete the following instructions: (1) check out the ten items that are in the computer program both manually and automatically; (2) go to Section 3 to record and analyze the results of your work.

	Manual	Automatic
No. of Items		
% Correct		
% Wrong		
No. Wrong		
Time Used (sec)		
Avg. Time Per Item		

What to you think is the main reason for the faster check-out time of the automated system?

____

____

Human Scanning

A greatly magnified UPC code of a grocery product will appear when you select Choice 4 on the simulation menu. In order to decipher the code, you should enter a binary digit (1 for dark and 0 for light). Indicate the name of the manufacturer and product in the space provided on the following page:

Manufacturer: ______________________________

Product: ______________________________

2. Shopper and Manager

Selection of Choice 5 in the main menu will take you to the inventory menu. First, you will role play a shopper so that you can see how your shopping will affect the inventory. Next, you will be asked to change prices so that you can see how the price structure in the inventory is affected.

a. How does the automated system make it easier for the manager to control the inventory?

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b. Why would it be easy for a manager to put an item on sale?

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c. Suggest one way of making the simulation more realistic.

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APPENDIX C

DEPARTMENT OF TECHNOLOGY AND SOCIETY

EST/CSE 100 - The Societal Impact of Computers

SPRING 1987

Laboratory Assignment #11 - Sampling and Opinion Survey

Various polls have been taken to determine people's opinions regarding the opening of the Shoreham nuclear power plant. Assume that a local newspaper has claimed that of the 10,000 undergraduate students at Stony Brook, the proportion of students, by class level, for the opening and the proportion against Shoreham is given by Figure 1 below:

	Proportion for Shoreham	Proportion Against Shoreham
Freshman	.30	.70
Sophomore	.40	.60
Junior	.50	.50
Senior	.35	.65

Figure 1

Assume that it is known that the proportion of the entire undergraduate student body represented by each class level is given by Figure 2 below:

	Proportion of Undergraduate Student Body
Freshman	.35
Sophomore	.30
Junior	.20
Senior	.15

Figure 2

A student group on campus wishes to challenge the student data on Shoreham that was presented in the local paper. (See Figure 1) The group is trying to decide how large the sample of the undergraduate student body must be to invalidate the newspaper's conclusion. The group has decided to use a computer simulation of the sampling to see what sample size is needed to make the sample proportions converge on the newspaper's proportions--assuming that the proportions reported really do represent student opinion.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 88-92, 1987. Printed in the USA.
0270-4676/87

COMMUNITY COLLEGE CHALLENGES IN SCIENCE, TECHNOLOGY AND SOCIETY. FACULTY PERSPECTIVES: RE-EDUCATION AND MOTIVATION

Corrinne Caldwell

Community colleges have an important role in the provision of education for an increasingly complex and technologically sophisticated workforce. Most community college curricula include offerings which prepare students directly for work as technologists. All of these technologies, whether they be health related or industrial, have experienced rapid change as a result of an explosion in computer and digital technology. Effective education in these technologies requires a faculty and facilities on the cutting edge of development. The fiscal constraints under which most community colleges operate mitigate them against being able to maintain this level of currency. This presentation will address the difficulties in maintaining a technologically current faculty and curriculum at Community College of Philadelphia. First, problems inherent in upgrading faculty skills and knowledge will be considered, and secondly some actual and potential solutions to the problem.

There are two principle categories of problems inherent in the maintenance of a technologically current faculty at community colleges. There are: the demographic characteristics of the faculty, including their background and age; and the financial and other structural constraints within the college.

First, the demographics of the faculty will be discussed. Community colleges have experienced phenomenal growth. In 1962 there were fewer than 900,000 students in 704 colleges while today there are nearly 5,000,000 students in over 1,400 colleges. (Carnegie Commission of Higher Education, 1980)

Where, in such a short time, have community colleges been able to acquire this faculty? Obviously, the faculty did not plan and prepare for careers in a system that did not exist at the time they were considering their professional futures. There are three principle origins of community college faculty. They are the secondary school system, graduate schools, and industry. Community college faculty were largely recruited from the first two sources. (Medsker and Tillery, 1971) Studies vary in the percentage of faculty coming to the community college from the secondary system. In the 1960's, some studies indicated that there were as many as 67 percent. However, more recent studies, such as Cohen and Brawer's (1977), show that the secondary school system is no longer the primary source for teachers. New recruits are more likely to come directly as students from other post-secondary institutions or from industry.

In the technical curricula, they are even less likely to be specifically prepared as post-secondary educators than their collegues in more traditional transfer curricula. Most technical faculty were high school vocational teachers or professionals formerly employed in industry. Both groups experience difficulties in remaining current. The former high school teacher is most likely to have had very limited technical training. There are two sources for high school vocational educators: journeymen who entered vocational education after careers as hands-on technicians, and college graduates in vocational education, whose curriculum emphasized pedagogy at the expense of science and technology. These vocational educators, although interested in science and technology, had already forgone more traditional career paths for people with these interests.

The professionals who came to the community college from industry typically had much more rigorous technical educations, usually with a master's degree in their field. However, they had, for a variety of reasons, oped out of the competitive industrial setting. Frequently they realized that their interests were not primarily in developing and marketing products but in people. Teaching was for them, a far more satisfying career. (Caldwell, 1985)

Independent of the origin of the faculty, the situation is becoming exacerbated by their aging. A recent study of community college careers in Pennsylvania and New Jersey (Caldwell, 1985) showed that the mean length of time at the college was 12 years with a mean age of 49 years. Twelve years is a very long time to be away from systematic exposure to new technology in a time of rapid change. Faculty members are also less responsive to change and involvement in developmental activities as they age. (VanWest, 1982) Spontaneous involvement in research or development of new curricula is unusual in faculty, whose main satisfaction is gained from teaching. Many faculty have made the decision to maximize the logistical benefits of their careers, and are unwilling to take on additional work which will impinge on time they have allocated elsewhere. This tendency to devote less time to their faculty roles increases with age. Less than 20% of faculty members are actively engaged in curriculum change and development. (Caldwell, 1985)

There are also structural considerations within the colleges themselves which mitigate against a large investment in faculty development, even if there were a high level of faculty motivation. Colleges have difficulty investing heavily in any activity which does not rather readily yield results in increased enrollment. Budgets, already constrained by stable or declining enrollments, often cannot be stretched to support activities not directly related to the generation of credits to support FTEs. Faculty upgrading and currency have a long term effect on the vitality of an institution. Short term losses and gains are more likely to be attributed elsewhere.

Additionally, the vehicle for the coherent regular upgrading of technical curricula is not present in many colleges. Although most technical curricula have advisory committees and at least some faculty members who are current in their technologies, the process by which curriculum is conceived, changed and approved is cumbersome and time-consuming. The need for regular curricular revision is not reflected in the structures which support and approve curricular change. So, the end result is a slow but insidiously increasing distancing between the college curriculum and industry requirements.

Given the constraints described above, how can a college design and implement an effective faculty development program? A program planner has to consider all the demographic and personal characteristics of the faculty set within a very constrained environment. In the face of these limitations it becomes clear that an effective program must have at least some of the following characteristics:

1. Be of minimal cost to the college. The program would have to be either very inexpensive or dependent on outside funding.

2. Be individualized to meet a particular faculty member or members' upgrading requirements. The knowledge and skills required by individual faculty are widely divergent, so most educational efforts will have to be unique to meet a particular faculty member or members' needs.

3. Be logistically palatable to the faculty member. Faculty members are extremely resistant to any activity above their prescribed workload, especially if they have limited control of the arrangements.

4. Be directly related to the curriculum in which the faculty is teaching. Most community college faculty are not expert in curriculum development and cannot easily make the leap from being exposed to new knowledge to implementing it in their teaching. A vehicle and instructional development support must be provided to make this translation of knowledge and skills happen.

5. Be at least partially in the control of the faculty member who is going to participate. Faculty members quite justifiably see themselves as professionals with considerable useful input about their own educational needs.

6. Be at least income neutral or remunerative to the faculty member participants. Faculty members in community colleges are very aware of the extent of their obligations and are generally unwilling to take on work which will adversely affect them financially.

7. Be strongly supported by top level administration. Faculty need to see development as an institutional priority. One of the institution's goals for all faculty must be currency in their discipline.

Traditional college in-service programs, with their emphasis on global issues affecting faculty members, such as andragogical issues or group presentations on the state of community college education, although interesting, are unlikely to help meet the goal of producing a technologically current faculty. This is not to suggest that these programs are not worthwhile, just that they have different objectives. Further, most of these group in-service programs originate with the college administration and do not arise from the faculty. As a result, faculty members are frequently hesitant to be involved, and if involved, to appreciate their value.

New Approaches to Technical Faculty Development

A new approach is required. This is an approach which recognizes that the provision of in-serve education must take place within the multi-dimensional matrix decribed above. Dimensions of the marix must include: the personal characteristics of the faculty member, the technological upgrading required, and the college support available. It is only when all these dimensions are considered that an effective individualized upgrading program can be developed.

The Mathematics, Physical Sciences, and Engineering Technologies Division of the Community College of Philadelphia has implemented a program in faculty upgrading that addresses most of the dimensions in the matrix. Five years ago the Department Heads and Division Dean became very concerned about the technological currency of the faculty. They felt that the faculty were not fully aware of all the developments in their fields, and those that were, had not incorporated these developments into their curricula. Examples of this lack of currency included: CAD was not included in either the Architectural Drafting or Engineering Graphics classes, the microcomputer courses in the Electronics curriculum were not state-of-the-art, the Chemistry faculty were not all conversant with the new computerized instrumentation, and the list goes on. Although the college had an impressive range of educational opportunities for faculty including tuition loans, limited union administered conferences funds, regular group in-service, tuition free courses at Community college of Philadelphia, the desired results were still not being achieved. The tuition loan plan paid only for credit courses at accredited colleges and universities. Many of the courses required for upgrading were short term non-credit and offered by a wide range of non-accredited providers, largely industry and proprietary sources. The administration-provided, union-administered travel funds were very limited and competitive. These funds supported only a small portion of only a few faculty members' travel to academic meetings. These meetings were usually in the traditional academic subjects and limited to scholarship as opposed to hands-on upgrading. Courses at

Community College of Philadelphia were seldom at an appropriate level for their own faculty.

It was decided to seek outside funding. A number of proposals were submitted and one to the Ben Franklin Partnership was successful. These were Commonwealth of Pennsylvania funds channeled through the Department of Economic Development of three local funding bodies. In Southeastern Pennsylvania the local funding group was the Advanced Technology Center, a program of the University City Science Center, a consortium of local industry and research universities. Ben Franklin Partnership funds were allocated to projects that were directly related to the economic vitality and growth of Pennsylvania industry. The college argued successfully that maintaining technological currency of the fauclty, of a major educator of this region's future technologists, would contribute significantly to the future viality of Pennsylvania industry.

The award of Ben Franklin Funds required a match of either private or federal funds. The college raised matching funds from a federal grant for industry/education liaison and from numerous private sources, including a major grant for technological curriculum development from IBM. The result of all this fund raising was a combination of cash and equipment totaling over $300,000 for the past three years. The Ben Franklin Funds, which could be used directly for innovative staff development activities, amounted to $35,000 for 84/85 and 85/86, and $50,000 for 86/87.

The parameters of the project were developed in accordance with the characteritics of successful projects described in the earlier part of the paper. The project funds were expended through a system of internal RFPs. The actual projects were developed in the following way:

1. Each technical department identified the areas in which the faculty and the curriculum required technological development.

2. Faculty were strongly encouraged to develop proposals or educational projects which fit within the department's identified needs. Priority was given to projects which were directly related to the curriculum and which would result in curricular review and upgrading as necessary. Projects could include individual attendance at conferences or courses, group upgrading siminars at the college, subsidized internships in industry, and curriculum revision and development projects. All participating faculty were expected to both formally and informally disseminate their new knowledge among their colleagues.

3. Upon completion of the project, each participant submitted a final report, including the newly revised and developed curricula.

This approach to faculty development has been very successful in a number of ways and less successful in some others. It has definitely provided opportunities for fauclty who were self-motivated and interested in upgrading their skills and knowledge. It has reuslted in substantial curriculum revision and new curricular development. Virtually all technical courses in the MPSET Division and many in the Allied Health Division have been reviewed and revised as a result of faculty participation in the project. One new curriculum was developed in Automated Manufacturing Technology. New equipment has been purchased and integrated into the curricula as a result of the matching funds. Very few of the fauclty would have been able to participate in any of the educational projects without the additional grant funding.

The project has, however, had some limitations and weaknesses. It has not been possible to involve some of the weakest and most educationally needy faculty in projects. These faculty members were unwilling to invest the time and energy necessary, both to develop a project, and follow through on it. Although considerable peer pressure has developed in the departments for all faculty members to become upgraded, some people have remained resistant. Some projects did not provide as much impetus for curriculum development as had been originally envisaged. The department head had to ensure that the linkages took place. Faculty members were very reluctant to participate in internship projects. They felt that these longer term proejcts impinged too much on the logistics of their lives. And finally, the project required an increasing amount of administrative time and effort. This year it has become necessary to expend some of the funds on salary for a part-time administrator.

After three years of funding the project has made considerable impact on faculty member's preparation at Community College of Philadlephia. The challenge now is to continue to raise enough money to support the project on an ongoing basis and to develop a continuing reliable source of funding. This is a very difficult challenge because of the constraints of the institution's budget. However, if we are to fully realize our mission, and genuinely prepare students for technological employment, this is a worthwhile and necessary challenge.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 93-102, 1987. Printed in the USA.

THX-1138 AND THE STAR THROWER

Rev. Dr. James B. Miller

I have always been suspicious when a writer begins with a series of qualifications. Nevertheless, I find myself in need of doing that very thing. The first is that I hope that, by the end of this essay, the title of this paper will make sense, because it is going to take a bit of a rhetorical journey to get there. Secondly, although it is my task to address the relationship between STS and campus ministry, I must begin by acknowledging that I can not represent all campus ministries or campus ministers. In the course of these remarks, I hope to make clear just which portion of the campus ministry community I feel confident to represent and in so doing to at least offer my views on the likelihood of STS connections with other forms of campus ministry. In one sense this is simply to acknowledge that while the STS movement is manifest in a variety of academic forms and intentions, there is an even greater diversity among the various manifestations of campus ministry.

One final caveat has to do more specificly with the limits of ecumenism. All of the papers in this session, given significant differences in theological tradition and ministerial perspective of their authors, nevertheless share in a common rootage in the Christian tradition. I would hesitate to claim that what follows is representative in anyway of what those from Jewish or Islamic traditions might contribute to the present discussion, to say nothing of representatives from either non-Western or Native American religious traditions.

With these qualifications in mind, let me begin by indicating something of the ground I hope to cover. First, I will attempt to indicate what kind of campus ministry would likely be interested in some form of interaction with STS. This will entail offering a working typology of campus ministries. Second, I will suggest some of the agenda items which such campus ministries will bring to their interaction with STS. Third, I will indicate some of the resources which such campus ministries may bring to that interaction. Fourth, I will try to make clear some of the obstacles which can impede an effective campus ministry/STS interaction. And finally, I will suggest that fruitful campus ministry and STS interaction is dependent upon some shared vision of the future of the human community.

Types of Campus Ministry and Their Potential for STS Interaction

All typologies are problematic and this because they are an effort to cram an unthematized world into neat thematic boxes, boxes which the human intellect can manage. The inherent flaw in typologies is that they call for a distortion of experience, for a making of distinctions where there are no differences; and this so especially at the boundaries of the types. So, I am sure that many of you out there will find legitimate fault with the following typological distinctions. I can only ask for your patient and indulgent consideration of the conclusions in relation to which this typology functions.

Campus Ministry Types

	ecclesiological relationships	type of leadership	theological orientation	ecumenical propensity	mission foci
Campus Student Organization	non-denominational; sometimes a national or regional network; possible local congregational relation (usually sectarian)	student led; sometimes with local faculty and/ or regional staff advisor	traditional/ conservative to fundamentalistic	organizationally insular; non-associational	strongly evangelical; nurture of personal piety (morals and right religious practice)
Local Church Student Fellowship	denominational; part of program of local church; physically and institutionally based in local church	parish minister or staff member in large local congregation	progressive to *traditional/ conservative*	possibly open to ecumenical co-operation; dependent on local pastor	low-key evangelism; pastoral care; catechesis & liturgy; charitable service
Denominational Campus Ministry	denominational; physically based in local church or separate center; based institutionally in more inclusive judicatory than the local congregation	professional campus minister; with local parish experience	*progressive* to traditional/ conservative	often open to ecumenical campus ministry associations; dependent on campus minister	Same as above except: passive evangelism; ethical reflection and moral action
Ecumenical Campus Ministry	ecumenical; usually Protestant; based institutionally at local, regional and national levels; usually physically based in separate center but local church possible	professional campus minister; often ministry in higher education seen as vocation	revolutionary to *progressive* to traditional/ conservative	usually seeks broader ecumenical associations than given ones (other religious traditions and secular)	same as above except: non-evangelical; focal concern for academic enterprise in all its intellectual and social dimen.

I would suggest that all campus ministry can be divided into four basic types which can be distinguished by their (1) ecclesiological relationships, (2) type of leadership, (3) theological orientation, (4) ecumenical propensity, and (5) mission orientation or focus. Rather unimaginatively I would label these four types as: Campus Student Organizations, Local Church Student Fellowships, Denominational Campus Ministries, and Ecumenical Campus Ministries.

Campus Student Organizations are typically non-denominational. In the Christian context groups like Intervarsity, Campus Crusade, and the Navigators are examples of such groups. Although such local groups may have a more or less strong connection with a national or regional organization, they are ordinarily student led. Occasionally, local leadership is provided by recent college graduates though not by persons with professional religious training or ordination. The theological orientation of such groups ranges from traditional/conservative to fundamentalistic and these groups are seldom interested in the intellectual dimensions of religion. A group such as this tends to be organizationally insular even finding it difficult to develop working associations with groups having similar theological orientations. It may, however, identify particular local congregations as proper church homes for its members. The programmatic foci of such groups tends to be active campus evangelism and the nurturing of a strong personal piety in terms of individual morality and particular religious practices (e.g., prayer and bible study groups).

Local Church Student Fellowships may share a number of the characteristics of the Campus Student Organizations depending on the particular congregation involved. However, these groups are explicitly denominational in that they are a part of the program of specific local churches. Leadership is usually provided by students in close association with the minister of the church or one of the other professional staff in the case of large congregations. The theological orientation of such ministries can range from progressive to traditional/conservative depending upon the particular congregation and its staff. In general, their theology is often toward the traditional end of the spectrum. Campus ministries of this sort are sometimes involved in broader ecumenical associations, cooperating with other ministries serving the same campus. The program of Local Church Student Fellowships usually includes low-key evangelism, pastoral care, traditional nurture through catechesis and liturgy, and charitable service.

Denominational Campus Ministries are usually a program of a unit of a denomination more inclusive than the local congregation. For some traditions (e.g., Roman Catholic) such ministries may actually take the form of a campus parish comprised of students, faculty and staff. Such ministries may be physically based in a church adjacent to the campus, but are institutionally based beyond the local congregation. Due to a rash of capital campaigns in the denominations during the 1950's and '60's, such ministries may be housed in facilities specificly built by the denominations to serve as campus ministry program centers. Primary leadership is usually in the hands of a professional campus minister; that is, an ordained clergyperson with previous parish experience. The theological orientation will range from progressive to traditional/conservative although the tendency is for it to be more toward the progressive end. Such ministries often are actively cooperative in ecumenical associations, working with other ministries serving the same campus. Denominational Campus Ministries usually offer programs which are more passively evangelical in character but manifest similar emphases as Local Church Student Fellowships. In addition, however, Denominational Campus Ministries also usually have significant programs which encourage ethical reflection and moral action in relation to the major public issues of the day.

Ecumenical Campus Ministries are predominately a Protestant phenomenon and fairly recent in origin. The largest example of such is the national consortium of 7 denominations [American Baptists, Christian Church-Disciples, Church of the Brethren, Episcopal Church, Moravian Church in America, Presbyterian Church-USA, United

Church of Christ] which constitutes United Ministries in Education. This form of campus ministry is not strictly structured in a hierarchical fashion; therefore, local and regional manifestations of this national ecumenical body (usually called local United Ministries in Higher Education Boards or state or regional UMHE Commissions) may also include ecumenical partners not participating at the national level (e.g., Lutherans and United Methodists). Such ministries are ordinarily led by professional campus ministers, the bulk of whose ministerial careers have been spent in campus ministry of one sort or another. The theological orientation of such ministries is usually on a spectrum from revoutionary to traditional/conservative and on the average well into the progressive domain. Such ministries not only participate in but usually promote cooperative ecumenical associations beyond their formal denominational constitutencies (e.g., with Roman Catholic and Jewish campus ministries). Such ministries are ordinarily non-evangelistic in a traditional sense though they may advocate innovative ways of reconceiving the received tradition.

The program of such ministries is similar to that found in Local Church and Denominational ministries but often involves significant differences. This is because on the average Ecumenical Campus Ministries take with much more seriousness than the other two ministry forms both the phenomena of higher education in general and the particular form and processes of higher education which constitute the specific campus being served; that is, the progrm will include: pastoral care with special sensitivity to the human needs and personal crises attendant to teaching, learning and administering within a contemporary college and university; liturgy deliberately celebrating the promises of life within the academic community.; catechesis in relation to the rich diversity and breadth of the historic Christian community and with an appreciative awareness of the other great human religious traditions; theological reflection open to conceptual innovation at the heart of the faith; ethical reflection which encourages personal and corporate responsibility in the acquisition, propagation and application of knowledge in a morally ambiguous world; service which moves beyond incidental charity to a sense of lifelong career-related vocation.

I suppose at this stage the sort potential each of these forms of campus ministry bears in terms of a fruitful relationship to STS should be obvious. Nevertheless, let me quickly summarize what seem to me to be the likely possibilities. Campus Student Organizations are unlikely to be interested in STS. Their insularity retards their ability to form associations, in general, and their relatively dogmatic theological character tends to disincline their participation in activities requiring intellectual openness.

On the whole Local Church Student Fellowships because of their congregational institutional base have a more diffuse sense of the academic enterprise. Further, their non-academic locus and more traditional religious concerns often lower their sensitivity to issues of scientific and technological development growing out of academic life. Nevertheless, particular clergy in specific congregations may be by experience or concern exceptionally good potential colleagues for STS/campus ministry interaction.

The potential for fruitful STS/campus ministry interaction in the case of Denominational Campus Ministries is also highly dependent on the particular campus minister involved. However, constituitively this potential is generally enhanced by the concern for social ethics ordinarily integral to such ministries and the greater likelihood that the attention of the ministry will be toward the campus.

In general, Ecumenical Campus Ministries offer the highest potential for significant interaction with STS on campus. Again, the individual campus minister is the single most important factor. However, the campus and academic community orientation of such ministries and their concern for the moralities of knowledge almost inherently incline them toward engagement with STS issues and groups.

One final observation about campus ministry types and their potential for interaction with STS. The programmatic focus of campus ministry on ethical reflection and moral action, a focus which is especially prevalent in the latter two types, can be an impediment to effective interaction with STS as well and an incentive for it. All too often the ministry of prophetic witness begins with an absolute, an ideological-like conviction as to the justice or rightness of a particular policy position. In this instance "reflection" can only serve to provide justification for that position or to rationalize away objections to it. Such a stance undermines the capacity of a campus ministry to engage in the sort of open inquiry which is required; that is, inquiry in which the most revered moral positions may be compromised by new insights and new knowledge. Effective interaction of campus ministries with STS requires that the former have a profound sense of the relative or conditional character of moral and ethical judgments. While no judgments can be made without conviction, absolute conviction closes out the future, that future in which we learn as much from our errors as from our sucesses.

Campus Ministry Agendas

Having made this observation about conviction, let me hasten to repeat that there is no convictionless position. Every campus ministry which entertains a relationship with whatever passes for STS on the campus will bring with it certain convictions. These in part form its ministry agenda and it is to a consideration of relevant elements of such an agenda that I now turn. Again, let me emphasize that I am speaking very specificly out of my own experience as campus minister serving as staff for two different ecumenical campus ministries.

As I noted in the discussion of types, the latter two are especially charcaterized by concerns for encouraging ethical reflection which leads to moral action. This is a very significant element in the agenda which ministry brings to the campus. In relation to scientific and technological development it is a concern for the quality of consequences. There is a concern for justice which might be expressed in cost/benefit terms. Who benefits at whose cost? The concern for consequences may be personal, institutional or environmental. It may focus on the consequences of development for the immediate academic community, the surrounding municipality or urban region, the intra- or interstate region, the nation or even the earth as a whole. Because campus ministry seeks to encourage both reflection and action it will encourage broad assessment of the policy alternatives related to development but it will also seek some form of closure toward advocacy of the one or more of those policies which seem most fitting. All that I have said earlier about absolute moral judgments is relevant here. Nevertheless, it is pragmatically necessary to stand somewhere even if one is ultimately open to changing that stance. Thus, campus ministry can be expected to be an active participant in the process of policy development.

A second but no less significant agenda item is a concern for the "general education" of all learners as contrasted with "disciplinary training" of particular learners in particular fields. It is not that there is something inappropriate about the latter educational focus, but only that campus ministry works out of a conviction that education, even when not intended, is of the whole person. In higher education especially, persons acquire not only facts and skills but also at least tacitly the attitudes and value commitmnents of their professional field. With respect to STS specificly, campus ministry will be concerned that what passes for STS in the educational program of the campus will reach out beyond particular disciplines and have an impact on the education of all students in the school. This seems to be crucial in two respects. First, it is important that those preparing for scientific and technical careers appreciate the social technologies (e.g., economic and political institutions and processes) by which their own professional practice is made possible and within which the products of their work are made available to the larger society. But second, it is equally important that those preparing for non-scientific or non-technical careers have an appreciation of the basic structure of the world both natural and social in which they live and a sense for the real opportunities for acting in and shaping that world.

Thus, campus ministry will likely be an advocate for STS programs which are interdisciplinary in character rather than "quasidisciplinary." What does this mean? In some instances STS programs have taken academic forms which parallel those of the more traditional disciplines. By having a "quasidisciplinary" status STS acquires a degree of academic credibility with its own faculty, research and publications. But such status also tends toward the same sort of disciplinary isolation manifest in the other fields. Perhaps this is not a necessary consequence of the process of academic development but it is a frequent one. Without devaluing the academic potential of this form of STS program, campus ministry will want to ask how students not enrolled in such a program can still develop the degree of STS sophistication which will allow them to be more responsible practitioners of their own professions.

A final agenda item has to do not so much with what campus ministry seeks to bring to the STS relationship but what it hopes to get from it. The churches are institutions which mediate particular interpretations of the meaning of human existence. As science and technology are avenues to new understandings of what the world and humanity are like, they ought to have an impact on the thought and practice of religious communities, on theology and liturgy. It is not the primary responsibility of scientists or engineers to pursue this impact. In point of fact, our culture for the past 200 or 300 years has studiously avoided pursuing such questions. However, it is attendant upon campus ministry to engage in or to facilitate the engagement of others in the task of the theological appropriation of developments in science and technology. This task campus ministry has on behalf of the larger church community. Further, scientific and technological developments alter the context within which moral judgments are made. For example, life sustaining technologies affect moral judgments as to what constitutes death and so the taking of life. Or, recombinant DNA technologies make exquisitly poignant the historical rather than essential character of the category "human" and so raise the unprecidented moral issue of the deliberate participation of humanity in its own bio-evolutiuonary change. In this regard campus ministry needs to draw upon STS resources to help the larger religious community exercise appropriate moral leadership in the society.

The Resources of Campus Ministry

Campus ministry not only comes to the STS relationship with an agenda but also with resources. I believe that the resources I will mention here indicate that campus ministry can be a valuable ally of STS on campus. Others, of course, may judge differently.

The first "resource" I would mention may not seem like a resource at all. It is the marginality of campus ministry. Except in a few private colleges and universities campus ministry has no formal instutitional standing in academia. Although connections between campus ministries and the school are frequently sustained through the Office of the Dean of Students or some comparable office, such connections are organizationally tenuous. There is sense in saying that unlike any other participant in the campus community, campus ministry is there without having any place. As a consequence campus ministry has the opportunity to remain unidentifiable in terms of academic politics. This is not to say that campus ministry is a non-participant. But it is the case that it is neither easily identifiable as faculty, administrator or student. Such marginality allows campus ministry to develop networks across the various disciplinary barriers and the several segments of institutional order. Further, either on campus or adjacent to campus, such ministry can provide "politically neutral turf," space within which efforts to establish and develop interdisciplinary or intra-institional relationships can occur.

A second resource campus ministry can provide is an alternative perspective to the one most frequently found in the academy; namely, one which is generalist, public and personal in character. In an age of disciplinary expertise, campus ministry (in no small part because of its theological concerns) tends to manifest a generalist perspective. To be a generalist is not to be an expert in everything; nor is it to be an expert in nothing. In fact expertise has little to do with it. A generalist is one who appreciates the relevance of the work of others for his own enterprise and seeks to understand, as a literate lay person, the work of others. It is also the case that generalists are often infected with an omni-curiousity; they find developments in all fields of endeavor to be inherently interesting.

Such a generalist perspective has great utility for a public or societal perspective. As theological concerns nurture a generalist perspective so the moral and ethical agenda of campus ministry nurtures a perspective which looks for the public or societal consequences of events. It is to be expected that campus ministry will ask of any particular scientific or technical development, "What will be the consequences for the community, for the common life, for the society-at-large?"

The pastoral concerns of campus ministry will also incline it to look below the broad impacts to where the rubber meets the road in individual lives; it will have a personal perspective. Public policy deliberations can reduce themselves to a calculation of the greatest good for the greatest number. This is a well practiced ethical principle. However, campus ministry will resist easy acquiescence to such a position. It will seriously consider the possibility that individual, anecdotal impacts of scientific and technological development are instances of more broad actual impacts not easily seen in the politically and economically conditioned calculus of the common good. Or, it will consider such impacts as possible harbingers of more socially widespread consequences yet to occur. Campus ministry will not want persons to get lost in society nor the individual good to become simply subsumed in a common good.

The last area of resource I want to mention is that of a particular value sensitivity which campus ministry brings with it to its potential interaction with STS. In particular it is a concern for the powerless, for the institutional non-participant who nevertheless shares in the consequences of scientific and technological development. This concern is relevant in a day in which it is profoundly the case that "knowledge is power" and power controls the acquisition and dissemination of knowledge.

For example, policy research in a particular area can emerge out of the sheer curiosity of the researcher (who may be fortunate enough to acquire the resources necessary to pursue her research). The policy assessment or policy alternatives arrived at through such research are likely to be disseminated through scholarly media but it is unlikely, unless they are unusually controversial, that they will be communicated to that segment of the society perhaps most directly affected by the possible policy decisions. When the research is stimulated at the outset by some non-academic agency, and so has a proprietary character from the beginning, the chances that the results of the research will get a wide and public dissemination are significantly decreased. Campus ministry can help form links between academia and various social constituencies which seldom have sufficient power to either buy or demand access to knowledge. To the extent that the final "S" in STS is inclusive of the relatively powerless in society, then campus ministry can be one instrument by which the powerless are actively factored into STS investigations.

Obstacles

It would be pollyanna to suggest that what has been described thus far as a relationship between campus ministry and STS actually exists anywhere, although elements can be found in a number of locations. This is because there are significant obstacles to the formation of this relationship. Let me mention only two.

The first comes from the side of campus ministry. Even assuming that you have the type of campus ministry most receptive to interaction with STS, the possible fulfillment of that relationship depends significantly upon the interest and intention of the particular campus minister. I have already indicated one possible difficulty; namely, moral absoluteness. But perhaps a more pervasive obstacle is what might be called **techno-phobia**. I don't mean here a fear of machines, but rather a "fear of technical knowledge." Relatively few religious professionals have had more than a minimal academic introduction to math and natural science. Their science of choice tends to be biology rather than physics or chemistry. There are a larger number of campus ministers who actually majored or minored in one of the social sciences. However, virtually none have studied engineering, computer science or cognitive psychology. Many campus ministers experience a sense of intimidation when confronted by the scientific or technical professions. This intimidation is often not even explicit; yet it generates and sustains an isolation of the campus minister from crucial segments of academic and intellectual life.

The way around this obstacle does not entail that the campus minister become a scientist or engineer. It does entail a disciplined cultivation of acquaintanceships with individuals within the scientific and technical community, the development of an appreciation for scientific and technical development as such, and an effort toward a ongoing attention to the social policy issues which emerge with such development. Although not the only means, the annual meeting of the American Association for the Advancement of Science can provide an opportunity to engage in all three of these activities.

The second obstacle is at least as serious if not as personal. For the past four centuries Western culture has developed and refined an intellectual schizophrenia which has fundamentaly separated material (scientific/technical) concerns from spiritual (religious) concerns. This dualism underlies in part the "techno-phobia" I just mentioned. It also generates a level of non-expectancy on the part of scientists and engineers, even those actively related to a religious community. That is, there is virtually no expectation that religion has anything to do with scientific and technological development. There is little or no expectation that a campus minister has anything relevant to say to a scientist qua scientist or engineer qua engineer. There may be some recognition that the campus minister (or any minister for that matter) may have an obligation to speak out on issues of social ethics or public morals but there is no expectation that such an individual has anything useful to say regarding the structure of scientific and technical education or research. I may be overstating this obstacle, but not by a lot. And frankly I must admit that the way around it lies more with the initiative of the campus minister than with that of the scientist and engineer. In a sense it is an issue of credibility; and credibility is earned not acquired through demand. But credibility must be bestowed if it is to function at all. It is necessary for the scientist and engineer to be open to acquaintanceships with the campus minister, to be willing to explain what is happening in their fields both in terms of research and in terms of policy issues.

STS in a number of its forms can provide the arena in which both of these obstacles can be overcome. STS can provide a place where the campus minister can cultivate an understanding of what science and engineering are in our immediate culture and in the world-at-large. STS can also provide opportunities in which scientist, engineer and campus minister can engage in common deliberation around issues of mutual concern: issues of education and academic life, issues of scientific and technical research and development in the society, issues of public policy. In the STS arena the professional resources of all can contribute to an enhancement of community.

"Without a Vision the People Perish"

This statement is found in the King James Version of the Book of Proverbs (29.18a) and I would like to use it as a portal back to the title of this talk. As I suggested earlier, I would define a religion as a social institution which mediates through symbol and rite a particular interpretation of the meaning of human living. Religious professionals are in the myth, symbol and ritual business. We are dealers in visions: visions of what it means to be human.

In the late 1960's, prior to the critical and commercial success of American Graffiti" and the "Star Wars Trilogy," George Lucas produced a 20 minute short subject entitled "THX-1138-4eb" while a student of at the University of Southern California. He later went on the co-write and direct a much expanded version of this film as his first major theatrical production. It was not a box office smash. Nevertheless, for the moment I would like fto consider his vision of science, technology, religion and society which was displayed in both versions of "THX".

The plot of the films centers on the efforts by an individual (namely, THX-1138-4eb) to escape an authoritarian, highly technological society. It is a society in which human beings are interchangeable parts in the societal machine; it is a society in which individual human variances are drug-controlled in order to assure production accuracy and conformity; it is a society in which the police are robots; it is a society in which religious dogma and spiritual counsel serve political and economic goals; it is a society in which all activity is determined by the accountant's "bottom line."

This is not a pretty vision. But as you may recognize, this was the vision of the technological society for many sensitive people in the late '60's and early '70's and it remains the sense of a significant contemporary subculture. It is a vision of authoritarian religion as either handmaiden to or tool of an arthoritarian scientific technocracy. It is interesting to note Lucas' vision of salvation. In the last scene of both the short and the full length feature THX is successful, he climbs out of the underground society and into the bright glare of the sun shining on a technologically empty (one might even say desolate) landscape. It is a return to nature in the raw.

It is interesting to compare the THX films with the "Star Wars" series. There is plenty of technology in the latter series, yet it is the personal and non-technological elements of the story which are central. Even the two robotic characters are interesting because of their human-like flaws and virtues. The villians in the piece might well be seen as a space-faring version of THX's society with its hierarchical authority and oppressive technology. At the end of "Star Wars" proper it is Luke Skywalker's reliance upon his mystical union with all of existence, his reliance upon "the force," which allows him to succeed rather than any dependence on the instruments of his X-winged fighter. In the last film in the series, it is the technologically primative Ewoks who defeat the high technology of the Empire. Thus, even in the "Star Wars" series Lucas has propogate a vision of the nature of humanity which down plays science and technology at best or views them as the instruments of oppression at worst.

This vision appeals to many of my campus ministry colleagues. It helps explain why many of them are inclined toward that form moral absolutism, that prophetic romanticism, which undermines their ability to appreciate the subtleties of the world and hampers their capacity to establish open relationships with many in the scientific and technical community.

In significant contrast with this vision is that found in the works of the late Loren Eiseley (1907-1977). For those of you who may not be familiar with his works, Loren Eiseley was a clinical anthropologist ("a bone man" as he would refer to himself) who taught from 1947 until his retirement at the University of Pennsylvania. In addition to his technical publications he produced ten books of essays reflecting on both natural history and the history of human understanding of nature. It is one essay in particular, "The Star Thrower" [The Unexpected Universe (New York: Harcourt Brace Jovanovich, Inc., 1964)] that I wish to consider.

A recurring question in Eiseley's writings has been, "What is the place of humanity in the universe?" This is clearly for me a religious question. In "The Star Thrower" Eiseley wrestles with this question in the light of the Darwinian model of the struggle for life on the tangled bank red in tooth and claw and of his experience of shell hunters on the beaches of Costabel.

In Eiseley's eye the shell hunters seem more rapateous than the fiercest lion over a fresh kill. At least in the case of the lion, the killing serves to sustain life. In the case of the shell hunters, life (the small creatures within the shells) is being destroyed for the sake of decoration or adornment. It seems to Eiseley to be the most chilling possible outcome of the evolutionary process; a creature, the human, so self-consumed as to forfeit all the rest of life to its own pleasure.

But as he continues on down the beach he encounters at the base of a rainbow a solitary figure who is stooping into the fringes of the storm-tossed surf to retrieve living star fish, hapless creatures which have been washed ashore, and then flinging them back into the sea. In the act of this individual Eiseley catches an alternative vision of the possible meaning of human life. The vision which he expresses is at once personal, explicitly religious and poignant in that it is the vision of a scientist. It is a vision which, it seems to me, can orient the natural and social scientist, the engineer, the campus minister and all who are concerned for what is at stake in contemporary life. Let me close by simply sharing with you a portion of this vision in Eiseley's own words:

> I cast again with an increasingly remembered sowing motion and went my lone way up the beaches. Somewhere, I felt, in a great atavistic surge of feeling, somewhere the Thrower knew. Perhaps he smiled and cast once more into the boundless pit of darkness. Perhaps he, too, was lonely, and the end toward which he labored remained hidden -- even as with ourselves.
>
> I picked up a star whose tube feet ventured timidly among my fingers while, like a true star, it cried soundlessly for life. I saw it with an unaccustomed clarity and cast far out. With it, I flung myself as forfeit, for the first time, into some unknown dimension of existence. From Darwin's tangled bank of unceasing struggle, selfishness, and death, had arisen, incomprehensibly, the thrower who loved not man, but life.... (Eiseley, 1964: 91.)

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Bull. Sci. Tech. Soc., Vol. 7, pp. 103-105, 1987. Printed in the USA.
0270-4676/87

STS ISSUES FOR TEACHERS OF RELIGION

James F. Salmon, S.J.

The thoughts I share with you this morning derive from the experience of my coming to a college in 1981 whose religious studies department offers courses to fulfill an ethics requirement. Each senior at the school takes, as part of the core, one introductory course in ethics, offered by either the philosophy or religious studies department. Although not an ethician, but with an interest in STS issues, I seized the opportunity to offer a course which surprised me, both with student interest generated and positive evaluations. Class size ranged between 35 and 40. However, the course raised questions for me which I believe could also arise with church groups in discussion of STS issues.

The course was divided into halves. The first part was concerned with principles and the second with specific STS areas where ethical issues occur. It might be said to be divided into General Ethics in the first half and Special Ethics in the second half. A purpose of the course was to evaluate specific STS issues in terms of principles learned in the first half. In this way it was hoped that principles would be grasped and some understanding of STS problems would be gained.

As expected, the second half of the course generated interest. The class split into groups of 6 to prepare presentations of particular issues and possible solutions within such areas as environment, food and population, life sciences (genetic engineering, positive eugenics), responsibility and freedom in scientific and technological reporting, technology transfer questions, women in technology, energy options, communications, appropriate technology, just war theory in a nuclear age, and scientific approaches to ethics as proposed in journals like Zygon (The Journal of Science and Religion). Case studies were popular. Grades for the presentations of the groups were made by the remainder of the class using clear guidelines, agreed upon by all.

It is a privilege to openly discuss religious and ethical values and since the course was under the aegis of a religious studies department, I looked for a text, particularly for the first part of the course, which would come to ethics from a Judaeo-Christian perspective. I seriously considered literature from the World Council of Churches meeting at MIT in 1979 which I had been privileged to attend. I found these documents, concerned with a just, participatory and sustainable society, excellent but not quite suited for an introductory course in which one important goal was to develop skills for understanding ehtical decisions. As Paul Albrecht, the editor, wrote in the introduction to Volume 2 of the report, "The 1979 conference could highlight the problems -- it could not resolve them. It could help the churches understand the immense promise and threat of modern science and technology, the challenge these present to Christian thinking, and the desire of many scientists to work with the churches in determining their social responsibilities." I was able to use these books with some of the student groups, however, in the second half of the course when we got down to issues discussed by the reports of the MIT conference. Another text I examined carefully was The Christian Moral Vision by Earl H. Brill which is part of the Church's Teaching Series of the Episcopal Church. Other faculty used this book but after a careful reading I felt it was not an appropriate preparation for students to handle STS issues despite being a good general text.

I carefully examined a fine introduction to Christian morality from a Roman Catholic viewpoint, Principles for a Catholic Morality by Timothy O'Connell. I found the principles in this book, for my students, would take at least a semester to digest. There would not be time for treating the STS issues.

So I resorted to something I had rejected years before in my student days, a manual. I chose Andrew Varga's little book On Being Human (Principles of Ethics). It is a clear and concise presentation of a self realization theory based primarily on Aristotle's Nichomachean Ethics. Although there is discussion of criteria of morality used by the major ethical systems, the book takes a definite stand on the existence of objective morality and for a natural law appraoch in builidng a solid ethical system. The small readable book of 150 pages was easily digesested over a period of some 20 classes, leaving about the same time in the second half to deal with STS issues. Since Varga's text did not discuss justice explicitly it was covered in class so that basic concepts of social ethics could be applied later.

I have some reflections after trying this course a few times.

1. In the evaluations, students reported the introduction to ethics was quite beneficial for their own moral life. Varga's self realization approach, following Aristotle, helps the student understand how moral choices can affect personal growth. Moreover, since one of the criteria for evaluating presentations was how well students applied what they had learned, probably a beginning skill for handling norms of morality, rights, and moral judgments was gained by most.

2. As a beginner, I suspect there is a problem in dealing with STS issues using only the skills which can be generated through courses based primarily on philosophical ethics. For example, the introduction to natural law ethics covers such topics as moral good, human acts, free will, norms for morality, rights and conscience. This begins with an emphasis on the individual and on human actions. It does not approach the sophisticated and complicated networks which society deals with when many technological issues are raised. Therefore, although students can gain an introduction to wisdom and skill for making ethical decisions in their own individual lives it was difficult for them to handle many of the STS issues which I mentioned earlier. Ian Barbour in his book Technology, Environment and Human Values, which I used for one semester as a text, introduces some of the complex questions necessary for handling the ethics of STS issues. But there was not time enough to make much of such suggestions as cost-benefit and risk-benefit analyses and technology assessment considerations. In other words, when we went from an ethical system focusing on individual human actions, which seems to be what most philosophy courses deal with, to societal questions (and when you add to that introducing something about the technology involved), it is difficult in one semester's time to offer a foundational ethics and have it work on contemporary STS issues.

3. Despite apparent success, I felt disappointed at the conclusion of each semester. True, students had an introduction to moral philosophy and to one solid tradition. They had fun working on some of the moral dilemmas society faces today. However, it raises questions for me. When one bases solutions on self realization ethical theories, one can easily overstress human nature as a criterion and overlook elements of a deeply rooted Judaeo-Christian morality. My disappointment was that students in a Christian institution learned that models of moral life could be seen as extrinsic to a Christian commitment. What I see needed is a transition to more of a biblical based model for ethical decisions which in the limited time would prepare students to better handle STS issues. For example, a vivid background theme for incorporation of humankind into cosmic creation can be found in many of the Psalms and in chapter 8 of Letter to the Romans. Another theme easily overlooked in a philosophical approach to morality is the Pauline theme of the body of Christ. Paul seems to see an organic unity as pervading creation. For Christians the realities behind such themes offer potential for a deeper appreciation of the seriousness

of many STS issues. I have not seen a book which fulfills these criteria and I would be grateful for suggestions. At the time I was not familiar with writings of Alasdair MacIntyre and Stanley Hauerwas.

In summary, I have reviewed the results regarding an experimental introductory course in ethics, one-half of which was directly concerned with STS issues. Three observations I have noted are:

1. The course was popular and seemed to have fulfilled its obligations for the core curriculum.

2. I suspect that treating STS issues with the tools of a self realization moral philosophy will at most whet one's appetite.

3. There can be a difference between a so-called ethical pedagogy and a so-called Judaeo-Christian pedagogy in approaching STS issues.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 106-108, 1987. Printed in the USA.
0270-4676/87

WHY SHOULD THE CHURCH SUPPORT SCIENTIFIC AND TECHNICAL EDUCATION?

Brent Waters

I begin with a story. There was once a village in which a group of bright and enterprising individuals trained some bears to perform a few menial tasks. They were quite successful, and after awhile they taught the bears to take on more jobs. Over time, the bears assumed greater responsibilities and even moved into such areas as entertainment and village defense. There was talk among visionaries of someday breeding highly intelligent bears that could perform highly sophisticated functions.

There were also a variety of consequences. As the bears took over more jobs some workers were displaced. New careers in the growing bear service area were created, but they could not absorb all the unemployed. The problem was compounded by increased birth rates and greater longevity. Using the bears created new wealth that had a ripple effect throughour the village. The standard of living was high, but the wealth was not evenly distributed. The bears, as might be expected, created some pollution of their own, but the problem was due primarily to increased consumption made possible by the new wealth. Occasionally a bear would destroy life or property without warning. There is now a fierce debate whether the bears are a problem or a promise for the future of the village.

The village clergy are aware of these developments, but their response is not uniform. Some denounce the bears as the source of all evil. The villagers should trust in God, not furry creatures. A few others accept the bears using them to support their particular interests. The bears are gifts from God. The majority, however, don't know what to make of this situation, and go about thier businness of preaching and caring for souls as if nothing has happened. There are, afterall, few bear stories in the scriptures.

This admittedly simplistic story provides a crude analogy of the church's attitude toward the role of science and technology in the contemporary global village. There are some voices in the church which proclaim an unqualified condemnation of technology. They argue that technology has become a system with its own set of dehumanizing and demonic values which must be resisted. Some others uncritically embrace selected technologies. As long as they are used by the right people for a good purpose they are divine blessings. The reign of God will no doubt prosper from communication satellites.

Overall, however, the church is ambivalent about science and technology. Historically it has not decided if its relationship with scientific communities should be one of warfare, detente, or mutual inquiry. Its traditional religious symbols have not equipped the church for sustained moral reflection on technology in order to offer informed and critical judgements. Consequently, the church does not oppose or support scientific and technical education -- it tends to ignore it.

This ambivalence creates a dilemma for someone like myself. Why do I argue that the church should support an activity it cares little about? There are two reasons.

First, scientific and technical literacy is simply necessary for living in the contemporary world. Science is the dominant mode of thinking, and the church must be conversant with scientific communities in order to engage in pertinent theological reflection and perform its ministry in a responsible manner. The technological application of scientific knowledge has in turn become a pervasive reality in our culture in which people must make moral judgements regarding potential risks and benefits. The issue cannot be ignored. As Roger Shinn has observed, technology has helped create a number of forced options in which "... to compromise indefinitely are themselves decisions -- as surely as is the deliberate choice of one of the alternatives."[1]

In an age where moral decisiveness or indecisiveness about such technologically related issues as energy, hunger, genetics, and nuclear war can produce equally devastating results, the church cannot help people make informed and critical judgements in a scientifically and technically illiterate society. The choice to ignore scientific and technical education is itself a moral issue. In short, the church cannot love God and neighbor without taking into account the scientific and technological context in which that love is expressed.

The second reason is really prior to the first. The church must allow science and technology to inform its theological imagination and ministry in order to enable people to make informed and critical judgements.[2] Religious language and symbols have not kept pace with a rapidly changing intellectual and moral context.

For example, for much of the history of Christianity it has been nature, not its human manipulation, that presented the fundamental challenge requiring a religious response. It was capricious acts of nature that were most life threatening. Consequently, many religious symbols were used to explain natural cruelty in moral terms -- for instance, the plague was God's punishment for evil behavior.

Now, however, the most life threatening circumstances are no longer natural but humanly produced through the introduction of various technologies. Granted that from time to time natural disasters, such as a snow storm in Washington, remind us that our mastery of nature is far from complete, but by and large death or debilitation usually confronts us in the forms of war, automobile and airplane accidents, or lifestyle related diseases.

The religious quest for meaning no longer takes place within a context of human victimization by natural processes but one in which the principal threats are the result of human design and calculation. Yet, there is still ambiguity -- few of us choose to be confronted by weapons of war or car accidents. How do we live in a world of greater control, yet still no control? If the church is to provide some guidance in a search for meaning and value, its theological imagination and itsministry must be informed by, and responsive to, the scientific and technological context it now finds itself in. If it is to assist people in making informed and critical judgements in an age of control, yet no control, there must be some understanding of the potential benefits and limits of science and technology.

If these reasons for supporting scientific and technical education are at all valid, there is one last concern that must be addressed. The church cannot effectively support scientific and technical education in general. Where should it begin? I offer three suggestions.

1) Science and technology should play a larger role within theological education. As Donald Shriver argues: "The religious challenge is to find ways of thinking scientifically and theologically at the same time."[3] How science informs theological thinking, and how it is in turn appplied to moral reflection and the performance of ministry needs more overt attention. This omission from the theological curriculum has serious intellectual and practical consequences. For example, when a minister is approached by infertile people, how are they helped to think theologically about such options as remaining

childless, adoption, in-vitro fertilization, artificial insemination by donar, or using a surrogate mother. Theological models, and how they are constructed, can go a long way in helping to make informed and critical judgements about the moral implications of various technologies. the wall usually separating the science and divinity schools needs a few doors installed.

2) Scientific and technical educaiton should receive more overt attention from campus ministry. It could become one of the doors between the science and divinity schools through which members of the scientific, technological, and religious communities pass to engage in discussion and dialogue. The opportunity, however, is often overlooked or ignored. For example, attention is routinely directed toward providing pastoral care for victims of large dehumanizing research institutions, or prophetically denouncing the university's complicity with the Department of Defense. This does not suggest these are unimportant concerns, but that it is not the same thing as understanding science and technology as a particular context of ministry. Could helpful models for society and the church be developed at selected universities where scientific and technical literacy provided a focus for ministry?

3) The church needs to engage in a process of redefining its role and identity in a scientific and technological age. This is a large issue which cannot be adequately addressed within the limited scope of this presentation, but let me give a hint of what I have in mind. Given the instant communication, interdependent economies, and destructive nuclear weaponry of our world, what does a sense of community now mean or imply? Within a global community what does the practice of piety now mean or imply -- what moral responsibilities do we owe to others, the natural environment, and future generations? Answering these (and related) questions requires a scientifically and technically literate public if the church is to serve the world in a faithful and fitting manner.

I conclude with a postscript. To argue that the church should support scientific and technical education does not imply that it must bow to the latest form of scientific thinking or technological application. I am not pleading for a baptism of the Enlightenment and its legacy. Rather, I am suggesting that postmodern science and technology has made new ways of thinking and acting which were not possible a few decades ago. The church needs to be a part of this new discussion both for its own sake and for the sake of the world. To return to my opening story, the issue is not if the village needs more or less bears, but how the bears will best be used in the future. That is a judgement call, but also an important task requiring a thoughtful appraisal of scientific and technical knowledge within a framework of values and moral commitments. It is a crucial endeavor worthy of the church's sustained and faithful support.

Notes

[1]Roger Lincoln Shinn, Forced Options (San Francisco: Harper & Row, 1982), p. 3.

[2]This material is adapted from my forthcoming article, "Technology as a Problem for Christian Ministry," which will appear in the Autumn, 1987 issue of Word and World.

[3]Donald W. Shriver, "Theological Education for the Twenty-First Century," Pacific Theological Review (20:1), p. 15.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 109-111, 1987. Printed in the USA
0270-4676/87

LITERACY: A COMMON NEED

Robert A. Brungs, S.J.

In this report I shall make ten brief observations about a common need for literacy between technology and religion.

1. Garden-City (not in New Jersey)

To begin, I would like to point out something quite obvious, really. The Jewish Scriptures open in a Garden. The Christian Scriptures close in a City. This is not meant to be probative of anything but to be suggestive of many things. It leads immediately to observation 2.

2. Urban Was a Good Name for a Pope

Christianity is an urban religion. Its founder was born at least near a city, grew up in a village and died just outside a city. On Pentecost the Holy Spirit propelled the apostles into the streets of Jerusalem. Its early adherents were city folk.

As a Catholic I acknowledge an incarnational, sacremental, covenantal faith. I acknowledge the basic belief that material things (water, oil, bread and wine, the spoken word) are privileged vehicles of the Holy Spirit. The church notes in the Mass the role of technology in worship: We pray "Blessed are you, Lord, God of all creation. Through your goodness we have this bread to offer, which earth has given and human hands have made. It will become for us the bread of life." God's goodness includes the wheat and our ability to transform it into bread. The transformation of bread and wine into the Body and Blood of Christ presages our bodies being transformed into copies of Christ's glorious body--as St. Paul prophetically proclaimed. Human technological activity certainly has some role in this transformation.

3. God's Will

The family of Christians MUST be interested in the products and affairs of the city. In our day, science and technology are among the foremost forces--if not the dominant one--active in the city. Christianity cannot fulfill its mission "in the city" unless it becomes fully familiar with and deeply involved in scientific and technological affairs. It must inform that work. We are not called to a spectator's role. Vatican II officially stated something I think we all knew already: "To believers, this point is settled: considered in itself, such human activity (science and technology) accords with God's will."

4. Necessary, Not Sufficient

To inform science/technology, the church must know what is happening in the laboratories and commercial board rooms of the world. Christians must understand not just isolated processes and products in themselves. Rather they must comprehend the sweep of technological and scientific advance.

While it is necessary to understand the details of contemporary scientific and technological advance, it is not sufficient. The church must also ponder the human significance and spiritual meaning of that advance both for people in general and for Christians in particular. This, I think, is an essential part of the Christian prophetic task.

5. Love S/T or Leave the City

Again, it is not sufficient for the church to attain only an intellectual understanding of the advances in science and technology as well as the meaning of these advances. It must feel the wonder of the universe, the exultation and exaltation of the discovery and of the rearrangement of the "stuff" of creation. The church itself must ponder and then proclaim to the world the appropriateness for worship of such human activity.

6. Grass Roots

To accomplish the informing of science and technology the church needs the literateness of its members who live and work in the scientific/technological community. Twenty years experience in this arena with the Institute for Theological Encounter with Science and Technology leads me to believe that we cannot expect church leaders (bishops, theologians, pastors, opinion makers, church office people, bureaucratic staffs, and so on) to experience that wonder and exultation that occasionally occurs in S/T life. We should hold their feet to the fire for attaining some awareness of what is happening. But for the church to incorporate technological literacy into her life, we need the commitment of the literate faithful more than the knowledge of the leadership.

In brief, it is time for the scientifically and technologically literate Christians to assert themselves both in their churches and in the sci-tech community. In the Catholic Church we have a simply stated problem: scientists do not identify themselves as scientists to their pastors nor as Catholics to their colleagues. We have to find them and bring them together with like-minded co-religionists.

But, these literate Christians are the ones to proclaim to the church and to their colleagues the potential for worship and for holiness that can be found in scientific and technological endeavor.

7. How Many Idiots

Scientists/technologists do not fulfill their human potential or civic duty simply through scientific and technological literateness. They need social, politicial and, yes, religious literateness. They must raise questions that go beyond scientific/technological "what" and "how." Their obligations--ours as well--extend to "why." Why do we, for instance, want to begin altering human genetic characteristics? Scientists and technologists should be literate about ends and purposes. They should not be "idiots" in the Greek sense of the word--private entities who have withdrawn from the affairs of the City.

8. Might May Not Make Right, But What Are the Virtues and Liabilities of a Pluralistic Society?

Can pluralism without some form of public consensus--Walter Lippmann's "public philosophy"--be an adequate approach to our living together? All parts of our society should face the possibility that a lack of public agreement will lead to an increasingly intrusive legal system. Where do we decide science-technology issues? In agencies and courts? Potential tyranny can flow from untrammelled pluralism. Might, after all, may not make right, but it can make law. What might scientists and technologists bring to forming or re-forming a public philosophy?

9. Faithful and Literate

We must expect Christian scientists and technologists to be religiously literate--the "what" and "why" of Christian teaching. How can their belief help the church cope with contemporary issues in science and technology? If the church is to be scientifically and technologically literate, it will be in and through its members who are technologically and religiously literate. We need those who are literate and faithful!

10. Interesting Times

Things are a mess! That's the glory of it! I've heard that there's a Chinese curse: "may you live in interesting times." That may (or may not) be a Chinese curse, but I see it as a Christian blessing. The times may be trying but that should call forth our creative energies--on both sides of the literacy issue. It's posible we may avoid nuclear incineration only to destroy ourselves by injudicious genetic manipulation. To use all these new capabilities--along with the old ones, of course--for the welfare of all people and for the glory of God--we must understand them and respect them and make sure our response to them is appropriate.

The church needs people who are dedicated to their science or technology and committed to their faith. The country and the world needs people so dedicated and committed to understanding the whys of their work and of their existence.

To survive and to thrive we must all extend our horizons toward the final fulfillment of humanity and of all creation.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 112-116, 1987. Printed in the USA.
0270-4676/87

TECHNOLOGY, COMMUNICATION, AND THE FUTURE GRADUATE

Barbara M. Olds

The Problem

Nearly ten years ago, the Colorado School of Mines undertook a study to determine the roles that Mines graduates would be expected to play in society and their profession in the future and how the school might best go about preparing students for these roles. After a painstaking process of surveying employers, alumni, and faculty, a document was produced by the steering committee headed by Professors Frank Hadsell and Rex Bull. This document, known as the "Profile of the Future Graduate" (PFG) has become CSM's policy statement on the training of its engineering graduates.

What qualities did the committee decide were essential to the successful engineering graduate?

- technical competence
- communication skills (written, oral, graphic)
- ability to self-educate
- ability to solve open-ended problems
- breadth to integrate ethical and aesthetic values into technical choices
- sensitivity to cultural and social differences
- integrity and self-discipline

How did CSM graduates measure up to this ideal? The good news was that our graduates possessed unquestioned technical ability. As the PFG states, "At the present time, the School appears to be succeeding in an exemplary way in producing graduates who are technically competent . . . and who have a splendid attitude towards their work and their employers."

The bad news was that we were less successful in the other areas. To quote again from the PFG: "However, the response of employers in questionnaires and at the [faculty] conference, and a tremendous amount of literature on the subject, written by both educators and employers, stress the need for other, broader, attributes which Mines, along with other engineering schools, is to a greater or lesser extent falling short in fostering. Most graduates lack good communication skills, even in writing. They are unfamiliar with working in interdisciplinary groups. Further, we apparently fail to develop in our graduates the ability to investigate an unfamiliar problem starting from fundamentals, and impart only limited knowledge of, <u>and interest in</u>, their responsibilities to their social, political, and natural surroundings."

The EPICS Program

To their credit, the faculty and administration at CSM did not simply give lip service to the "motherhood" statements of the PFG. Instead, they began to look for ways in which to implement the Profile. Among a number of curricular changes at CSM, an innovative, far-reaching program was developed by Richard Culver, JoAnn Hackos and others. This program, which was funded by an Exxon education grant, was named EPICS (Engineering Practices Introductory Course Sequence).

The EPICS sequence, now required of all freshmen and sophomores at CSM, combines previous courses in technical writing, graphics, computing, and mapping. However, instead of merely fusing these courses under a new title, EPICS has added new emphasis on communication in all its aspects (written, oral, graphic) and in many modes (interpersonal, manager/employee, client/consultant, large group, small group, individual/group); in addition, EPICS focuses on open-ended problem solving.

An overview of the course sequence may be helpful. (1) During their freshman semesters, students take three "tracks" of EPICS simultaneously: computing, graphics/mapping, and projects/communications. The emphasis in all is on versatility and problem solving.

- In the computing track, students learn two languages, Basic and Fortran, on both a personal computer and a mainframe. This gives them the adaptability to learn new languages on new machines in the workplace.

- In the graphics/mapping class, they learn not only the traditional graphics, but visualization techniques through an innovative program that focuses first on "right brain" sketching and only later on drafting techniques.

- The projects/communications track focuses on solving open-ended problems of increasing difficulty. With a great deal of coaching from an interdisciplinary faculty team, students learn how to solve problems, how to work in teams, how to self-educate, and how to communicate their solutions effectively.

(2) During the third semester, the students take an integrated computer-graphics course. They learn to use sophisticated software packages (CAD, spread sheets) on a third machine.

(3) The fourth semester is the capstone of the program. As second-semester sophomores, the students work for a client in industry, government or academia to solve a bona fide engineering problem of some complexity. As they do so, they must call upon all of the skills they have developed in EPICS: computing, graphics, communications, and problem-solving. In the process the students gain confidence and experience and the client gains helpful and often creative solutions to problems. The exchange has been mutually beneficial.

The Connection

How does the EPICS program answer the concerns of the PFG? What does it do that the old courses which it absorbed did not? In order to illustrate the connection, I will examine the project/communications track, the portion of the course in which I teach, in the light of the PFG concerns.

Technical Competence

According to the PFG, "The graduate must have undisputed technical competence in some field related to minerals and/or energy." The EPICS program has not impacted this area. Our students are still as technically competent as ever.

Communication Skills

The PFG states that the graduate "must have the ability to communicate his thoughts and actions orally, in writing, and graphically, both to his fellow professionals and to the layman. He should be competent in the art of working in diverse teams of specialists on multi-disciplinary projects, and his ability in this respect will depend greatly upon his communicative skills."

EPICS has had perhaps the greatest impact in this area. Taking "communication" to mean many things in this age of technological literacy, EPICS trains its students towards computer literacy and graphics literacy in addition to the more traditional areas of written and oral communication. The integration of the communication track with problem-solving has been very successful, as I hope the discussion below will illustrate.

Writing Skills

Replacing a required course in technical writing, the project/communication track allows us to spread instruction in writing over four semesters, a definite benefit to the students. In addition, the problems the students solve present them with authentic examples of technical writing and genuine writing assignments. For example, in the traditional technical writing class, it's often difficult to make the writing situations we give our students seem "real" to them. How do you conjure a "progress report" out of thin air? In EPICS, the progress report is introduced at a time in project work where it makes sense and serves a purpose--for the course instructor/managers need to be informed about the progress their students are making in solving the outside client's problem.

Also, spreading writing instruction over four semesters allows the students to practice their skills. Instead of writing one long report in a typical technical writing class, they are asked to write at least five over their four semesters in EPICS. Such iteration is of obvious pedagogical benefit.

Over the course of their EPICS careers, the students are introduced to nearly all of the standard technical writing formats in a real-life setting: letters, memos, reports, progress reports, meeting minutes, etc.

In addition to receiving their instructor's assurance that writing skills are important, the students also have the reinforcement from their clients of the value of communication. When a senior corporate engineer tells them that writing is important, they listen.

A particularly valuable skills that our students learn is collaborative writing. Most of them have had no experience in joint authorship (in fact, it is often strongly discouraged by high school and university teachers). However, we know that engineers must often work in teams to produce important documents--reports, proposals, etc.--and that such collaboration does not come easily or naturally. By assigning our students collaborative final reports in three of their four semesters and by carefully coaching them through the process, we teach them ways to handle collaborative situations in the workplace with relative ease.

Oral Skills

We are convinced that successful graduates need to have oral as well as written communication skills, and that the skills they generally work on in "public speaking" classes often don't meet the need. Therefore, Professor John Hogan developed the EPICS oral communication assignments to maximize practice in job-like situations and to minimize theory. Over their four semesters in EPICS, our students make nearly a dozen oral presentations. Because of our belief that most of their professional presentations will be made in a small group, staff format, we schedule most of their presentations to groups of ten or fewer people. In these presentations we stress Professor Hogan's "Three P's"--promptness, professionalism, and preparation. Through the two years of EPICS the students have the opportunity to make a variety of presentations to fellow students, to faculty members, and to outside clients. They are videotaped several times and study the tapes with their instructors, and they learn to use a variety of presentation aids from notecards and flipcharts to slides. Their final presentation as sophomores is usually made at the client's place of business to an audience of professionals in the client's field. Both students and clients have been very pleased with the results. In fact, several clients have remarked that such presentations would have been far beyond their capabilities as college sophomores.

This year, with the help of an NSF grant, we are experimenting with another dimension of our communication curriculum. Students are working on projects for three out-of-town clients (two with the Department of Energy in Washington, DC, one with Phillips Petroleum in Bartlesville, OK) using a hardware and software system designed to transmit voice and data in real time.

In addition to their formal presentations, the students gain a great deal of experience in EPICS in informal, small-group communication. They are assigned to teams to work on their problems, and they need to develop teamwork abilities in order to get the job done efficiently and effectively. Through practice and coaching, they become quite skilled at working in groups.

Collaborative Skills

As mentioned above, our students spend much of their time in EPICS working in teams to solve problems and to write reports. We know that they will be asked to do this as professionals and that teams often solve problems better than individuals. In addition, we think that the EPICS program itself serves as a model of collaborative effort. The project has, from the beginning, stretched beyond disciplinary or departmental lines. Its teaching faculty are drawn from every department of the school. Each project/communications class is taught by a team of faculty from different disciplines. These interdisciplinary teams serve as valuable models of collaboration for the students early in their careers.

Self-Education

According to the PFG, the graduate "should have been inspired, and should have the background and desire, to be able to continue to learn independently after graduation."

In the past, educators have often spent too much time teaching content and not enough time teaching students how to learn. EPICS emphasizes learning-how-to-learn in all of its tracks, but especially in the communication/projects portion where students must learn that solving a real engineering problem involves the use of many resources: library, consultants, even fellow students. Learning how to make the most of these resources, to ask the right questions, to teach themselves the jargon of a new and unfamiliar discipline are all ways in which EPICS students prepare themselves for their professional careers.

Open-Ended Problem Solving

The PFG states that a student's college experiences "should have stimulated his natural curiosity so that enquiry, analysis and syntheses based upon fundamentals should be a natural response to any unfamiliar situation." Today an emphasis on "critical thinking" can be found at just about any school as a buzzword concept, if not an actual practice. However, the notion has particular applicability to engineering education and to the kinds of courses student engineers often encounter. Many basic preparatory courses for engineers are rather cut-and-dried affairs. Concepts are taught, "problems" are presented to test understanding of those concepts, answers are found at the back of the book. As a result, students sometimes begin to believe that any problem can be solved if they just plug in the right numbers and perform the right calculations. EPICS quickly disabuses them of this notion.

One of the primary criteria for any EPICS project is that it must be open-ended. By that we mean that it should have no one, obvious, "right" answer. Since most engineering problems are genuinely open-ended, this is not usually a difficulty. However, the students, particularly first-semester freshmen, understandably have some difficulty with this concept since many of them have been taught only the answer-at-the-back-of-the-book approach to problem-solving. For this reason, we introduce them to open-ended problem solving by presenting them with a method, a case study and then an increasingly complex set of problems to solve.

As a model we use Charles Wales' Guide Design process, carefully explaining that each expert problem solver evolves his/her own methods and this is not necessarily the "right" one for each of them. Wales' process takes the students through a number of steps designed to help them solve complex problems.

By the time the students have reached their fourth semester in EPICS, they are prepared to take on a bona fide project and devote the semester to solving it with minimal supervision. Instructors become "managers."

<u>Other Considerations</u>

The PFG states that a graduate "should realize clearly the potential impacts of his professional actions upon the political, social, economic and natural environments in which he practices, locally and internationally, and the constraints that these might impose upon his actions. He should have a broad understanding of why and how governmental laws and regulations affect the practice of his profession and how he may influence governmental processes. While at the School, he should have continued to develop his own intellectual and cultural values."

One of the advantages to EPICS is that the open-ended problems our students solve inevitably contain non-engineering constraints that cannot be ignored--ethical, legal, political, economic, environmental, and aesthetic. The students learn early that these factors are an integral part of problem-solving, not merely last-minute considerations. The students are also forced to examine their own values and ethics as they propose solutions.

<u>Integrity and Self-Discipline</u>

Finally, the PFG says, an engineering graduate "should have, as any professional, high standards of <u>integrity</u> and <u>self-discipline</u>, and a positive attitude to the professional responsibilities of his job." EPICS students learn integrity and self-discipline through their course experiences. They generally come through EPICS convinced that they have worked hard but learned much.

Conclusions

Our students have come to realize as the writers of the "Profile of the Future Graduate" did, that engineers of the 21st century must be more than technically competent. Unless they are able to solve problems creatively, collaboratively, and with limited guidance, they will quickly become professionally obsolete. In addition, they realize that most problems are multi-faceted, full of ethical, legal, environmental and other issues in addition to "pure" engineering. Finally, they realize that the ability to communicate is essential if the problems of the future are to be defined and solved.

A program like EPICS, therefore, addresses in an integrated and innovative way the concerns of all of us for technological literacy. Such an approach, it seems to us, could be adapted to many settings and situations.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 117-120, 1987. Printed in the USA.
0270-4676/87

TECHNOLOGICAL LITERACY: THE ROLE OF INDUSTRY AND PLAIN ENGLISH

William S. Pfeiffer

Today we face two types of illiteracy: that of language and that of technology. As a college writing teacher my usual province is the former, which keeps me busy enough. Over the last seven years, however, I've also worked as a part-time writing consultant and, for one year, as a full-time manager of human resources for a geoscience firm. Close association with scientists and engineers has helped me see the importance of spreading that other literacy--knowledge of science and technology. Flowing from my industry experience, this paper shows how technical firms can communicate fundamentals of their field to employees, to clients, and to members of the community.

I will focus on four strategies for making this corporate contribution to technological literacy:

(1) Offering seminars that teach experts how to present technical subjects to a non-technical audience.

(2) Publishing in-house newsletters that describe recent technical projects in language that can be understood by non-technical employees.

(3) Sponsoring internal "technical awareness" sessions so that all employees, not just specialists, can hear first-hand about the firm's technical developments.

(4) Rewriting job descriptions so that technical experts are regularly required to discuss technical subjects with interested community groups.

Communication Courses for Technical Experts

In the course of their work, many technical specialists must communicate with clients and other groups that either lack basic technical learning or have long forgotten what they did learn. Often made up of laymen or non-technical managers, this audience may be, for example, a committee of vacation homeowners who hire geologists to evaluate the safety of their lake dam, a group of managers at a plastics plant who want to purchase robotics manufacturing equipment, or a college English faculty that solicits a report about the newest audio-visual equipment on the market. Each of these groups has the same problem: it needs--it deserves--technical information communicated in language that it can understand.

My experience suggests that writing and speaking seminars can help technical experts learn to address the needs of a non-technical audience. Such seminars can be taught (1) during regional or national meetings of technical societies, (2) through programs at nearby colleges, or (3) at the companies themselves. Meetings of technical societies are an excellent forum because they allow professionals from different companies to share problems and solutions. College programs can be effective also, particularly when handled by continuing education departments that cater to the needs of business and industry. In-house seminars, however, offer perhaps the best opportunity to change old writing and speaking habits. Such courses go beyond superficial training courses and can include multiple sessions, actual cases from company files, and substantive assignments.

Whatever the context, communication seminars for technical experts must share some basic features. Members of writing seminars should practice these sorts of techniques for simplifying prose: using more active verbs, writing shorter sentences, starting paragraphs with strong lead-off sentences, defining all terms, using clear headings, and beginning and ending documents with overviews. Such strategies decrease the likelihood that readers with little or no understanding of technology will be left behind.

Like writing seminars, courses on technical oral presentations must include lots of practice. Participants should give presentations for a simulated non-technical audience, receive written and oral evaluations from the instructor and peers, use videotapes for practice beforehand, and use videotapes of the actual speech for evaluation afterwards.

Before leaving the subject of communication seminars, I should point out that such courses sometimes can go beyond helping experts deal with laymen and non-technical managers. This kind of training also shows experts how to communicate with other experts from different fields. Several years ago a company's head geologist asked me to teach a writing seminar to a group of micropaleontologists employed at a branch office. These "bug-counters," as they were affectionately called, examined samples of rock from deep within the earth, determined the rock's age by the kinds of fossilized creatures found in it, and then sent a report on their findings to geologists at the main office. The geologists would incorporate these micropaleontological findings into their own final reports, which concerned the chances of finding oil in a certain location where borings were taken.

As you have probably guessed, the geologists often could not understand the micropaleontological reports and thus could not use the information in their own documents. My job was to conduct a writing seminar that would help the more specialized scientists write to those who were less specialized. That experience brought home three lessons for me: (1) there are many levels of technological ignorance, (2) we usually err in the direction of assuming our audience has more knowledge than it does, and (3) the audience--whether colleagues, clients, or the public--turns us off unless we use language it can understand.

In-House Newsletters

To be sure, the head geologist's problem noted above is one of technological level not literacy. Yet the technical firms for which I've done work generally have many non-technical staff and professional employees who don't really understand what their firm does. My second suggestion, therefore, is that companies develop internal newsletters to inform employees about the technical underpinnings of their business.

When I helped start an internal newsletter at a geoscience firm, the goal was to move beyond chatty banter about birthdays, service anniversaries, and re-assignments. Instead, we asked engineers and scientists to write substantive articles on current projects, both in the field and in the lab. Entitled Insite, the newsletter was geared mainly for employees who were out of the technical mainstream, had little or no technical education, and probably knew just as little about the firm's day-to-day business. Ironically, we discovered that the newsletter was just as frequently read by the engineers and scientists as it was by the support staff.

So what can such a newsletter accomplish besides providing some lunchtime reading? I believe it can have these results:

(1) Both morale and productivity can increase as employees view their work in the context of the company's total product or service.

(2) Exposure to clearly written technical material increases the chance that employees will develop an interest in science and technology. This interest may not directly affect the firm's balance sheet, but it does further the cause of technological literacy among the workforce--and that's a worthy goal even if not an immediately profitable one.

(3) The exercise of writing to a non-technical audience helps engineers and scientists clarify their thinking, as well as their editing skills.

In summary, the newsletter exercise can prove useful to both writers and readers alike.

Technical Awareness Sessions

Newsletters help spread technical and scientific knowledge within a company, but they leave out an important ingredient in any educational process: dialogue. To encourage discussions of technical issues, we started biweekly "technical awareness" sessions at the geoscience firm where I worked.

Held during lunch hours in mid week, each session brought one of the company's scientists or engineers to speak before an audience of any employees wanting to attend. Speakers generally focused on three types of topics:

- Equipment resulting from research and development efforts, such as new down-hole devices for logging data from boring holes,
- New technical services offered by the firm, such as waste management services whereby chemical engineers analyze the toxic materials at a site and recommend clean-up measures, and
- Technically interesting or unique projects that were recently completed, such as the use of new mooring equipment to secure an oil rig in water thousands of feet deep.

For many employees, particularly those without college experience or a high school background in science, these discussions provided a first exposure to science and technology in a classroom format. Speakers were instructed to (1) reduce the level of technical language as much as possible, while still giving the essential information, (2) provide brief background information that would help the audience understand the topic, and (3) use a flexible format such that questions were encouraged either after or during the presentation.

Through the technical awareness program, the company made a genuine effort to create an internal educational forum. As an interesting by-product of the program, the engineers and scientists who spoke at the sessions received useful practice that would later help them make presentations to clients and to participants at technical conferences.

Technical Education in the Community

My final suggestion is that job descriptions of a firm's technical experts should specify involvement in some community educational programs each year. Although many firms encourage community service, the service component I'm advocating for engineers and scientists would focus on what they know best--science and technology. The premise is that companies have a civic responsibility to educate community groups, not just their own workers and clients.

Recent interest in "productivity" has caused many firms to take seriously what for many years have been either ignored or considered a standing joke: performance appraisal systems. Today more employees are being evaluated on objective criteria set forth in job descriptions. To encourage engineers and scientists to act as sources of technical education within the community, their job descriptions should require them to speak before groups such as:

- Public school science classes, at all levels,
- College engineering and science classes, at all levels, and
- Civic planning boards and other groups of elected and appointed officials.

Some of these exchanges already take place, though usually for different reasons than improving technological literacy. For example, a senior engineer may visit an upper-level college class to discuss a technical project and, of course, to recruit students for the firm. However, visits also need to be made to public school and lower-level college classes, where many students who will not become engineers and scientists receive their only formal training in technology.

A company's effort to send experts into the community brings current ideas in science and technology into the classroom, into the public meetinghouses, and into the minds of those who may have little exposure to the technical world. As it happens, the good will generated by this effort can also serve as an excellent long-range marketing tool.

Conclusion

In summary, I suggest that technical companies can do their part in the fight for technological literacy by (1) teaching technical experts to write for the lay audience, (2) starting internal newsletters that contain substantive articles on field projects and research, (3) holding technical awareness discussions for all employees, and (4) requiring experts to present technical and scientific information to community groups and schools.

These recommendations won't do much to solve the main technological literacy crisis--that of curriculum development and teacher preparation at the pre-college levels. But they do address the concerns of those millions of citizens, already out of school and in the workforce pipeline, who don't want to be left behind.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 121-122, 1987. Printed in the USA.
0270-4676/87

STS IN K-12 EDUCATION: INTRODUCTION

Jon L. Harkness

Today, hardly an educator involved with secondary school science can be found who cannot at least decode the acronym, STS. Many can demonstrate some knowledge of STS as a new development in precollege education. Less, but some, familiarity with STS probably can be detected among precollege educators involved with other-than-science subjects or with elementary school grades. Clearly, awareness of STS as a new development in American education is established, and, among precollege science educators, STS has replaced the likes of PSSC, BSCS, CHEMS, etc. as the "buzz acronym."

It was five years ago, in 1982, when the National Science Teachers Association gave impetus to STS for K-12 science through two actions. First, NSTA issued a position statement (NSTA, 1982) which called for STS as a new emphasis for precollege science during the 1980s. Second and nearly simultaneously, NSTA identified, through its first (and since annual) Search for Excellence in Science Education (SESE), existing school science programs which met research-based criteria for excellence in STS. Evidence that STS was then a new phenomenon for K-12 educators is supported by the condition that not even the representatives of exemplary STS programs identified in 1982 via SESE had familiarity with the label until it was applied to them by NSTA; that is, the teachers who were "doing" STS didn't know what it was called. As a matter of historic interest, it is quite clear that STS was formalized as a new phenomenon in K-12 education in 1982 and that the formalization occurred in a science education context.

In the intervening years, STS has grown to become a significant, yet limited movement in K-12 education. Evidence of its significance as a growing trend is indicated by:

1. NSF-Supported STS Projects

Federally funded projects, some of which have been operating for as much as three years, stimulate STS in precollege years through clearinghouse and materials development activities.

2. STS Teacher Networks

Operating networks of educators active and interested in STS have been established through a variety of mechanisms, including NSF Projects, universities, and grass roots teacher groups.

3. An STS Literature Base

Extensive treatment of STS in professional literature, including detailed documentation of exemplary STS programs, has captured the attention of many, especially those inclined toward reform of precollege education.

4. STS within Standards

STS is beginning to appear within standards which drive K-12 education, including state curriculum mandates and a variety of evaluation instruments (e.g., standardized achievement tests, state/national assessment instruments).

5. International Cooperation in STS

Interest in STS is high not only in the U.S., but also in other nations, including Canada, England, The Netherlands, Japan, and Australia. International STS conferences and seminars among precollege educators which already have occurred indicate STS is more than a "flash-in-the-pan" American bandwagon effect.

6. Professional Identity for STS Educators

Identification of STS educators as a discrete professional group already has begun within the educational community as witnessed by recent formation of the Science Technology Society Research Network by an international group of educational researchers. High interest among field practitioners in forming an "STS Society" recently was found by the S-STS Project staff at The Pennsylvania State University. Judging by the level of participation in the STS conference (TLC) reported in this issue of BSTS, a need and constituency for such a society exists.

Even though STS has a strong foothold in K-12 education in the U.S., its occurrence is limited in both quantity and quality. As of now, precollege treatment of STS is mostly limited to science classrooms. And even within science, many teachers are not involved with STS, due perhaps to various factors which contribute to resistance to change. Truly interdisciplinary treatments of STS across the gamut of school subjects are not known to exist. However, encouraging signs of STS activity are appearing within social studies, English, and technology education. It is quite clear that the extent and nature of treatments of STS in the nation's K-12 institutions is highly varied.

Whether STS has or will become a "megatrend" (Roy, 1985) in precollege education, is argumentative. But one thing is clear: the ultimate status of K-12 STS will be determined by teachers behind their classroom doors. What eventually will happen with STS in those millions of classrooms may yet be influenced as a "definition of STS as a way of providing science for all" continues to unfold (see Yager, 1987). The collective wisdom of all interested actors is needed to continue shaping the sculpture of precollege STS.

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Bull. Sci. Tech Soc., Vol. 7, pp. 123-124, 1987. Printed in the USA.
0270-4676/87 STS Press.

LOOKING BACK AND FORWARD: INTRODUCTION TO STS IN K-8 EDUCATION

Carolyn Steele Graham

As I read the papers in the K-12 Education section following, the excitement and energy I had felt in the air at TLC II returned once again. As at the conference, I was struck by the variety of the approaches to STS and the quantity and quality of thought on the part of the contributors.

The excitement and energy remind me of a seemingly long-ago time, when I was involved in those first few heady years of ISCS. At the time, to me and to many of the teachers I met and worked with in NSF training institutes, ISCS was the answer to all our problems in middle school science education. Yet, as we all know, ISCS virtually is dead. It has even been dropped by many of the teachers who initially were most committed to it. The reasons are probably many, but as I reflect on my own experience, one reason seems paramount: ISCS did not change. As a result, two things happened: ISCS seemed to become less and less relevant over the years to students studying it, and teachers themselves stopped learning as they taught the same program over and over.

Why do I mention ISCS, which to some is the antithesis of STS? Simply because the very diversity of the approaches to STS, which became clear at TLC II, may be the deciding factor which guarantees the long-term implementation of STS in the classroom. With a "smorgasbord" of approaches, which include several different subject areas to select from, STS programs will be different in different locations and will be able to change over time to meet changing local needs. And, as teachers and students become bored with and stop learning from the STS course being taught, the course can be changed almost at will by selection from the "smorgasbord."

But will programmatic diversity by itself move STS education into the classrooms of this country? Where do we stand in our attempts to foster STS? To be sure, much has been done in a very short time. We have achieved the goal of a STS community, no mean task. The centers of the *S-STS Reporter* now bulge with reviews of STS-related curriculum and programs. As described in a following paper, the State University College at Potsdam, New York, with funding from the National Science Foundation, is developing an interdisciplinary program in STS for its preservice middle school science teachers. In 1991, a relatively short time from now, these prospective teacher will be in the classroom. Dr. Glen Aikenhead describes in his paper two exciting teaching units, usable at the middle school level, which help students to understand "authentic" science and the importance of consensus in scientific decision making.

Yet so much remains to be done. As I talk with teachers and administrators across New York State, I hear little about the implementation of STS in the classroom. This leads me to speculate that, even in a state where STS education is in a sense mandated in middle school science, little in the way of STS instruction has reached the middle school classroom.

Regarding elementary STS initiatives, we have barely broken the ground of debate. Initial discussions seem to indicate that, yes, there is a place for STS education in the elementary schools of the country, but what that place will be has not yet been defined clearly. I suspect, though, that we'll begin to see elementary STS taking its place as another effective instructional practice: child-centered, integrative, and fostering both critical thinking and school work that is productive work for teachers and students alike. Taking into consideration developmental appropriateness, elementary STS will probably evolve more as a study of science and technology as they relate to the real world of children, their everyday personal, family, and school experiences, rather than as a focus on societal issues.

What action must be taken to ensure the movement of STS into the classroom? To begin, we have to stop stating the **need** for STS over and over (we all know the need by now) and begin to talk about **what** and **how**, especially at the K-8 level. We need many more models of exemplary STS units and curricula. We need more preservice programs, perhaps modelled after the Potsdam approach, with an interdisciplinary STS emphasis. Most importantly, we need a formalized, structured, and massive program of in-depth, long-term staff development for teachers already in service. And we need to conduct research side by side with all these efforts to prepare the needed research base described in the paper by Peter Rubba. Without solid research into the effectiveness of STS education, we are dooming it ultimately to failure.

None of this, of course, will be simple or cheap. But if each of us is convinced of and has made our decision about the efficacy of STS education (and I think we have), we need to stop talking and to take action. Let's get on with it!

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Bull. Sci. Tech. Soc., Vol. 7, pp. 125-136, 1987. Printed in the USA.
0270-4676/87

PHYSICS IN ITS PERSONAL, SOCIAL AND SCIENTIFIC CONTEXT

Harrie M.C. Eijkelhof and Koos Kortland

Introduction

Numerous publications of the last decade illustrate an increase in popularity for changes in science education at secondary level to be characterized by more attention to the interactions between science, technology and society (so-called STS). Other authors refer to many of these publications so we will not repeat those long lists. In the Netherlands (our home country) we follow with great interest STS developments in other countries such as the UK, Canada, Australia and (for the last few years) also in the USA. After a period of relative silence in science education we are now impressed by STS developments in the USA as we find them described in the S-STS Reporter and in the Newsletter of the Teachers Clearinghouse for Science and Society Education.

But in the small independent country in Northwestern Europe where we live with over 14 million people at only 40.000 km^2, we do more than just watch what others do in the field of STS education. In the second half of the seventies we developed a course on *Physics in Society* for pre-university students as a (optional) part of the physics examination program. That course was small (15 periods) and dealt only with STS aspects which were not found in the rest of the program.

Of a more ambitious nature was the PLON-project. It stands for *Physics Curriculum Development Project.* Its start was in 1972 and in the first years most attention was paid to making physics more attractive in junior secondary schools. Materials emphasized physics in daily life, student activities, working in groups, reporting about findings to peers and differentiation according to personal interest. Since 1978 materials were produced for senior secondary education. Here a more risky area was entered as physics is an optional subject in senior high schools often chosen by those preparing for university and college entrance. So external pressure to keep up standards were high and a physics curriculum dealing with only the implications of physics to society would not be acceptable to teachers, inspectors and civil servants from the Ministry of Education. Within this boundary condition, curricula were developed in which a very specific integration of physics, technology and society was strived for. We would call it real STS based on both the values of an academic physics course and STS courses about the impact of science and technology on society.

In this paper we will describe what aims we had in mind and how the senior high school materials were constructed. You will also be informed about our experiences with constructing some 20 teaching units and about the experiences of teachers using the units in their classrooms. Finally we will summarize some research findings and indicate what kind of specific problems of STS teaching need further research.

Curriculum Materials

Context and Basic Questions

The PLON-curriculum for senior general secondary education (students aged 15-18) is characterized by a thematic structure. The themes have been chosen keeping in mind the aims we had: which knowledge from the realm of physics would be useful for everyday life, for presenting an authentic view of physics, for triggering the various interests among students and for preparing students for further education?

In each unit a practical situation--taken from the society students live in--gives rise to one (or more) *basic question(s)* as an organizer for a number of physics lessons.

These practical situations may deal with:

- the (future) social role of the student as a *consumer* (with the ability to cope with and make decisions about products of science and technology in everyday life on aspects like quality, safety, costs, health and environmental hazards, sensible use, etc.);

- the (future) social role of the student as a *citizen* [with the ability to interpret public debates and to make (more) thoughful judgments on controversial socio-scientific issues];

- aspects of *further studies* or *(future) employment* (of a scientific, technological, etc., nature), relevant for the specific group of students.

Therefore two important features of the thematic teaching units developed by PLON are:

- a focus on decision-making situations of a personal or societal nature with scientific/technological aspects--an *issues-based* approach;

- a presentation of physics contents and skills relevant for a better understanding of the decision to be made--*physics in* (a personal, social and scientific) *context*.

Decision-making situations can be rather close to the student, focusing on his/her (future) social role as a consumer.

A first aspect of this life-role is making the best buy. For example, in the unit *Light Sources* the question of choosing a lamp is dealt with. Which would be the best buy: a filament bulb, a strip light or an (energy-saving) SL-lamp? Strip lights and SL-lamps cost more, but use less energy delivering the same amount of light. Which type of lamp is most economical in the long run? The relation between energy, power and time (physics concepts and laws) and the ability to draw and interpret diagrams (physics skills) are useful to arrive at an answer. Knowledge about the physical properties of light and way sto measure and calculate them are useful to compare the amount of light these different types of lamps produce. Knowledge about the mechanisms of converting electrical energy into light-energy in these different types of lamps provide a background for an understanding of the differences in the color of the light, and point at possible environmental problems (mercury pollution). (Of course the energy efficiency of the lamps is related to environmental problems too.) It appears that making fair comparisons, even in rather simple decision-making situations like the one described above, isn't easy at all.

More examples of practical situations are to be found in other units, like interpreting weather forecasts (in the unit *Weather Changes*), like possibilities of influencing room acoustics in order to improve the quality of (reproduced) sound (in the unit *Music*), the ways to check electric motors in order to be (more) able to carry out small repairs on household appliances (in the unit *Electrical Machines*). These examples are more or less connected to a second aspect of the consumer life-role: a sensible use of products of science and technology. More clearly this aspect is dealt with in the unit *Traffic:* wearing a seat belt or not when driving a car (although wearing a seat belt when driving is compulsory by law, some 50% of Dutch car drivers don't worry about that), selecting the speed of driving based on considerations of traffic safety and fuel economy (also related to environmental pollution). Mechanics concepts and laws are useful for getting an idea of the magnitude of the force acting on a car driver during a collision (one of the factors being the speed of the car), of the way in which traffic safety devices like seat belts and crash helmets help to prevent injuries by diminishing the forces acting on the human body, of the relationship between speed and fuel consumption of a vehicle, etc. We hope that in this way physics can help to promote an understanding of the legal measures enforcing speed limits, the use of seat belts and crash helmets, etc., and that students will be able to make a better-informed choice regarding these measures. So the aim is: (more) thoughtful action on the part of the students in everyday life traffic situations concerning traffic safety and fuel economy. This decision making on a personal level also has a bearing on deciding on an attitude towards issues at a societal level. Mechanics in the context of fuel economy is useful for a better understanding of the debate on increasing maximum speed on motorways, a current debate in the Netherlands in which environmental considerations are not getting too much attention.

Of course, besides speed limits there are more issues on a societal level. There is the ongoing debate on different scenarios for our energy future (reflected upon in the units *Energy and Quality* and *Ionising Radiation),* on nuclear armament (also in the unit *Ionising Radiation*) and microelectronics (dealt with in the unit *Electronics*). Those debates are getting a lot of attention in the mass media, but information often is rather fragmentary.

A debate which doesn't get too much attention is the way of spending money in scientific research: applied or fundamental research? This question is addressed in the unit *Matter*. To be able to assess the value of fundamental research into the nature of matter, an idea of what these high-energy physicists are up to is necessary.

The contexts chosen for the units cover a wide range of applications. This is done deliberately to meet the different interests and plans for the future of the students. The emphasis in a specific unit might be on consumer decisions or socio-scientific issues (of general importance for all students), but also on the nature of science and scientific research (for example the fundamental research into the nature of matter), on technology (for example the characteristics of electrical machines, related to the task they have to perform), on applications of science and technology in different sectors of society (like the medical use of ionizing radiation). In this way the curriculum as a whole not only gives students a (more) firm grip on decision-making situations of a personal or societal nature where scientific/technological aspects are involved, but also provides them with an orientation on the choice of a type of further education or future employment.

General Format of a Teaching Unit

The first part of each teaching unit consists of an *orientation* on the basic question(s) and the student activities. The basic question sets the scene for the unit by summarizing the main features of the practical decision-making situations on a personal and/or societal level and the physics contents involved.

The orientation is followed by presenting some *basic knowledge and skills,* preferably by means of student activities stimulating independent work. The basic question acts as a selection criterion for the physics contents and skills dealt with.

After this compulsory part of the teaching unit students start working in parallel groups on different *options*. These optional parts of a unit require an exchange of learning experiences between the different groups of students in a *reporting session*.

The learning experiences of the parallel working groups are complementary to each other and are required in the next part of the unit. In this section knowledge and skills acquired so far (including the optional part of the unit) is extended to a somewhat higher level of abstraction and/or is being made use of in a number of practical situations within the chosen context (deepening and/or broadening of subject matter), thus increasing the degree of versatility the students have in applying these concepts a little bit.

Optional parts at the end of a unit (if present) are meant to acquire a certain skill such as using external sources of information, writing reports, etc. Options like these offer the possibility to meet the different interests of students with respect to their preference for a more scientific, technological or social approach or with respect to the student's plans for further education or employment.

Reporting on learning experiences in this case might be more informal. The last part contains a *retrospection* on the unit, related to the basic question(s) stated in the orientation.

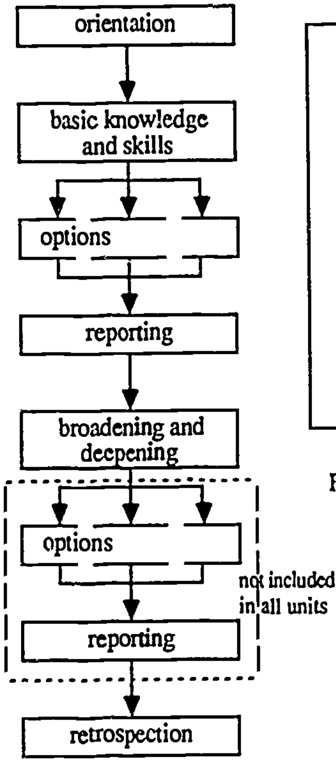

Figure 1. General format of a teaching unit.

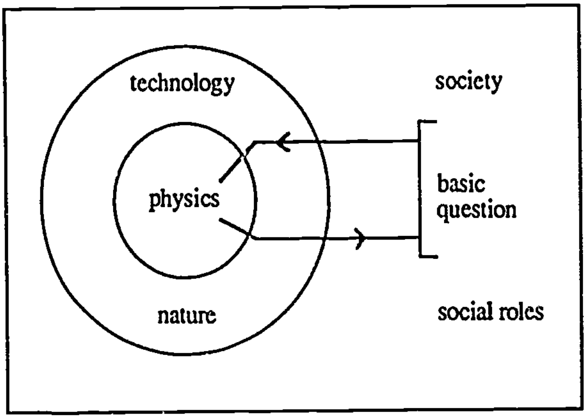

Figure 2. The relevance of physics teaching.

The general format of a unit as described above reflects the relevance of this way of physics teaching. The basic questions--taken from the society students live in--determine the (relevant) physics to be taught. And after that the basic question turns up again: does the physics help in finding (an) answer(s) to this question, help in being able to cope with a technological device, a consumer decision, a socio-scientific issue? This turning back to the basic question--to society--is essential because it reflects the relevance of our physics teaching:

- preparing students for *furthur education* or *employment* (with an emphasis on an adequate mastering of scientific skills, concepts, etc., and on an orientation on the use of scientific knowledge in different societal sectors and types of further education);

- preparing students for *coping with life* in a technologically developing, democratic society (with an emphasis on *physics as one of the tools* students can use in dealing with *decision making* on a personal and societal level--decisions on which buy would be best, a point of view, a course of action).

An Example of a Teaching Unit: Ionising Radiation

It is not possible to present a detailed description of the contents of each unit in this paper. However, to illustrate the format of the teaching units we will describe one of them: the unit *Ionising Radiation* (for students aged 16-18).

The central theme in the unit *Ionising Radiation* is the acceptability of the risk of applications of ionising radiation. This theme has been chosen because many controversies in this area seem to be based on differences of opinion on benefits and risks of various applications of ionising radiation, and because information given on this topic in mass media seems to be rather haphazard and muddled.

The unit contains a lot of relevant knowledge and procedures of risk analysis and evaluation.

During their work on this unit, students get familiar with various aspects of ionising radiation: properties, acute and late effects on the human body, activity, dose, half-life, radiation protection, natural radiation and applications such as medical use of ionising radiation, nuclear energy and nuclear weapons.

We hope that the procedures of risk analyses and evaluation in this unit will help students to make (more) thoughtful decisions when confronted with a situation in which ionising radiation might be applied, be it on a personal or societal level. Besides that, we hope that getting acquainted with these procedures will also be of use to the students in dealing with other kinds of risk in society.

In the orientation period (the first chapter of the unit) the students reflect on a list of situations in which people come into contact with ionizing radiation in the personal or social sphere. A short introduction deals with the risk concept. A distinction is made between low and high probabilities and between small- and large-size effects; also some risk evaluation aspects are described.

The next three chapters contain basic information about the nature, effects and sources of x-rays and radioactivity. Several concepts are introduced which are important in risk assessments, such as half-life, activity, dose, somatic and genetic effects. Students also become familiar with the dose limits recommended by the International Commission on Radiological Protection. Finally in this section sources of ionizing radiation in nature and in technological and medical applications are studied.

The next part of the unit contains three options: nuclear energy, nuclear arms and the use of radiation for medical purposes. Groups of students work on one of these options. The textbook provides background information on risk and safety aspects of each of these areas of application. So attention is paid to risks in the nuclear fuel cycle, the safety of nuclear power stations, the immediate and delayed effects of nuclear arms explosions, protection by nuclear shelters and the use of x-rays and radioactive sources for diagnostic and treatment purposes. Students study this information, but also visit places where ionizing radiation is used such as radiotherapy departments of hospitals, dentists' and vets' surgeries and also nuclear shelters for public or government use. In several subsequent lessons, students report their findings to other groups in class.

In the final chapter procedures are dealt with to analyze and evaluate risks. A distinction is made between personal and societal risks. Students are asked to evaluate personal risk in situations they might get into, such as: being prescribed a brain scan, living in the neighborhood of a nuclear power station, buying food which has been irradiated for preservation purposes, etc. This evaluation is structured by questions like: what advantage do you have concerning this application of ionizing radiation? what advantage do others have? how large is the risk to you and to others estimated to be on short- and long-term with or without the application of ionizing radiation? how could the risk be reduced or avoided? On the societal level, students are asked to comment on statements like 'local authorities should provide nuclear fallout shelters for all inhabitants,' 'dumping of radioactive wastes in the sea should be forbidden,' etc. The questions mentioned above can be used to structure the discussion, but now social, economical and political aspects can be touched upon too.

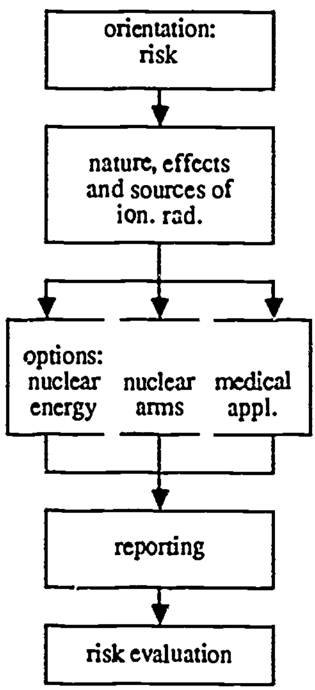

Figure 3. Formation of the teaching unit *Ionising Radiation.*

New Contents and Methods

Broadening the aims of physics education as described in the previous sections has some consequences for the contents taught in physics lessons and for the teaching methods as well.

Teaching physics in its personal, social and scientific context does not change the necessity of an adequate mastering of scientific concepts--on the contrary: (more) thoughtful decision making cannot be based on badly understood concepts. What makes the difference is that these concepts have to be looked upon (at least partially) as tools to reach other goals: (more) thoughtful decision making in everyday life situations (including socio-scientific issues).

As a consequence contents and skills learned in physics lessons are partly different from what is customary in a traditional approach. The basic question chosen for a teaching unit determines the (relevant) physics content. In the case of fuel economy dealt with in the unit *Traffic* this means that attention has to be paid to frictional forces in a quantitative way--a topic that is almost completely lacking in the usual approach to mechanics teaching.

But there is more to it than different physics knowledge: we also have to include *contextual knowledge* in physics lessons, like the social aspects of applications of science in society, arguments pro and con on different points of view on these applications. A very important aspect of this contextual knowledge is providing *frameworks* for thinking about an issue. Thinking, for example, about a sensible use of energy in the home and in society (dealt with in the unit *Energy and Quality*) could be guided by keeping in mind the following four aspects: task aspect (how much water is necessary for making tea?), efficiency aspect (filament bulb, strip light or SL-lamp?), quality aspect (electric, gas or solar heating?), and systems aspect (combined production of heat and power, use of 'waste energy?'). Another example of this contextual knowledge is the series of questions meant to structure thinking about risk evaluation as mentioned in the example teaching unit section.

With regard to skills, there might also be a change of emphasis. As it is not possible to cover in physics lessons all specific situations in daily life where physics knowledge and skills might be useful, students have to be prepared to tackle (new) situations and issues independently. This means they have to learn to retrieve and structure (relevant) information, to compare information from different sources critically, etc.

So new contents and skills are introduced (besides part of the old ones), but there is one other aspect regarding contents. Using physics as a tool requires knowledge of the *limitations* of this tool. Science doesn't give all the answers (although this seems to be the case in a more traditional approach: to every question in the physics textbook there is one and only one correct solution). Not only because there are more factors besides physics influencing decisions (like economical, cultural, political factors), but also because of the nature of scientific knowledge. Science isn't just facts: see the controversy on the effects of low dose radiation, the uncertainties in, for example, the predicted rising of the sea level due to the greenhouse effect. The models describing complex systems, like the human body and the global carbon cycle, are in no way adequate (yet). Uncertainties give way to different interpretations, also by experts. Presenting an authentic image of pysics--physics as a product of human activity in which objectivity and subjectivity are less separated domains--is a prerequisite for using physics as a tool for decision making.

Thematic and Systematic Units

Concept development in thematic units is necessary (as stated in the previous section) and not impossible to do, but generally the degree of *versatility* students reach in applying these concepts in different contexts is low: concepts developed within one specific context are not automatically used by students when solving problems in another--known or unknown--context. For senior general secondary education this limited transfer can be accepted, to a large extent, because key concepts from the fields of, for example, energy and mechanics appear in a number of units in different contexts. But this isn't enough for students in pre-university streams. These students are expected to be able to use a number of basic concepts from the fields of mechanis, energy, oscillations and waves, electric currents, electric and magnetic field, corpuscular models of matter in a great variety of contexts (be it personal, social, scientific, technological, historical or otherwise).

The physics curriculum for pre-university education therefore only partly consists of thematic, context-centered units (which means that the broadening of aims strived for in the curriculum for senior general secondary education is also valid for pre-university education; in some cases the same units are used in both types of secondary education). To reach a higher degree of versatility, however, another kind of unit had to be developed: a *systematic* unit.

The main objectives of these systematic units are:

- to give students insight into the systematic structure of physics, particularly in relation to motions, energy and work, (gravitational, electric and magnetic) fields;
- to broaden and deepen selected basic concepts and widen their applicability by means of mathematical methods;
- to develop problem-solving abilities in situations taken from everyday life or from science, and to stimulate the use of heuristic strategies in problem-solving.

The innovative curriculum for pre-university education, therefore, now consists of both thematic and systematic units.

The general format of both types of units are compared in Figure 4.

Systematic

orientation:
- introduction to the basic (systematic) question(s)

broadening and deepening:
- using familiar concepts in new contexts
- linking concepts from different units
- defining concepts more sharply
- giving a mathematical form to concepts and relationships between concepts
- exploring the limited applicability of concepts

problem solving:
- applying the (deepened) concepts in new 'life world' situations

retrospection

Thematic

orientation:
- introduction to the basic (thematic) question(s)

basic knowledge and skills:
- introduction of new concepts
- broadening of skills

options:
- application of subject matter to different domains within the theme

broadening and deepening:
- extending concepts to a higher level of abstraction/versatility within the chosen context

retrospection:
- evaluation of the basic question(s)

Figure 4. General format of a systematic unit, as compared to the format of a thematic unit.

Experiences: Pitfalls and Classroom Issues

Pitfalls

Experiences with the first versions of the units have taught us a great deal about the specific problems a curriculum writer has to overcome when constructing thematic units for senior secondary education. The educational aims as set out previously could not readily be reached using traditional methods of writing curriculum materials. Some of the lessons we have learned about pitfalls which one should try to avoid are given below. They have to do with contents, teaching methods and dissemination.

Abundance

Most themes encompass very complicated problems or large areas of knowledge. Boundaries with other disciplines are sometimes vague. The abundance of aspects of each theme poses serious problems for curriculum writers: what should one choose? If one is not careful, non-physical and non-scientific aspects will dominate a unit, students will get confused by the abundance of aspects and teachers will have problems with the time available.

We try to avoid abundance by not aiming at completeness, by keeping in mind what the specific contribution from physics could be to development of an insight in the theme, and by using basic questions when trying to set out the contents of a unit. These basic questions should reflect the relations between physics and technology and/or society (be it in everyday life situations or in controversial issues) and/or the structure of science. Besides, these basic questions should have relevance for the students, should be broad enough to meet the differences in interest which the student have and should offer the possibility of being translated into suitable student activities.

Fashionable Themes

Linking physics with everyday life and developments in society does mean that one has to keep a close eye upon actual news. If one does not, contents of units might be obsolete. If one chooses too many topics of the day, the contents will initially be timely but may soon cease to be so interesting.

We chose our themes, taking note of long-range developments. The units are based on surveys of literature and discussions with experts. We have constructed the units in such a way that teacher and students are invited to fit in actual news when working on a theme.

Neglect of Concept Development

We have recognized that the educational aims are difficult to balance. Trying to move away from current practice in physics teaching could lead to throwing out the baby with the bath-water. The balance of educational aims deserves a great deal of attention. We try to keep in mind a proper development of skills and concepts, both within each unit and across the curriculum.

Poor Differentiation

Taking account of the differences between students is not easy. Differentiated parts of a unit tend either to be limited to non-essential subtopics or to be so varied that a fruitful exchange of learning experiences is not feasible. In some of our first versions the optional parts of the units were too difficult to be studied independently, let alone to be explained by students to each other.

Our current practice is to avoid the introduction of difficult concepts in the differentiated chapter of a unit; instead such concepts are dealt with first in the introductory section. We also try to construct the differentiated chapters in such a way that learning experiences supplement each other and are usable in subsequent parts of the unit.

Weak Coherence of a Unit

A unit should form an organic whole. When the various chapters are weakly connected to the basic questions and to each other, teachers easily neglect the innovative chapters and pay most attention to the traditional ones. Students become insecure as a result of their uncertainty about the aims of all the parts.

In setting up the outline of a unit, while writing and when commenting on colleagues' drafts, we pay particular attention to the need to link up the various parts of a unit.

Poor Layout

We have found that a good lay-out for the unit is very important to students and to outsiders to take an interest in the project. A poor lay-out is confusing and demotivating to students. Both students and outsiders form an initial judgment on the quality of the project materials on the basis of their lay-out and presentation. This is why it is important to pay careful attention to lay-out, even where trial versions are concerned.

Unsuitable Student Activities

In our first version units we paid one-sided attention to the contents of the units. From students' and teachers' reactions we have learned that we should not just think about *what* students should learn, but also about *how* they should learn. Just reading long texts doesn't work with many students at this level. So in the second versions we have included a great number of activities for students to do, both inside and outside the classroom.

Lack of Choice for Teachers

We accept that each teacher is an individual personality with a characteristic teaching style. No book could suit exactly the ways in which a great variety of teachers work. So we do not try to make the materials teacher-proof. We leave lesson plans and many specific teaching instructions outside the student materials, but include them in the teachers' guides.

Classroom Issues

Avoiding pitfalls when constructing thematic units is a necessary but not sufficient condition for successful thematic teaching. Excellent thematic units cannot eliminate problems in classes. Some of these issues are described below.

Uniformity Versus Variety

Teacher want to respond to differences in student interests, abilities and plans for the future, and, at the same time, prepare as many students as possible for success in the examinations. Continuous tension exists between striving for uniformity and for variety.

Ideally teachers try to use individual learning experiences of students in activities which promote interaction between students, such as reporting sessions, market periods and exhibitions. But that is easier said than done.

New Contents and Methods

In the teaching units one will find many topics and student activities which are new to most teachers (for example risk evaluation in the unit *Ionising Radiation*). Naturally this increases teachers' feelings of insecurity. Some experienced teachers reported that they felt like beginners when they taught the PLON curriculum for the first time. It appears to take several years before teachers are familiar with thematic units and have adapted their methods for teaching. We try to help them by organizing meetings in which teachers are instructed about the contents and activities in the units and in which teachers discuss their ious experiences.

Concept of Learning

Most skills are learned very gradually. For instance, 'making fair comparisons' and 'orally reporting on activities' cannot be learned instantly. So sometimes student ask themselves or the teacher: 'Now, what did we learn?' They use a *digital* concept of learning in which knowing and comprehending can be described in definite steps. It is a very difficult task for the teachers to widen the students' concept of learning and make them recognize *gradual* learning as real learning. And this also requires a changing of assessment techniques to include an evaluation of this gradual learning.

These classroom issues cannot be resolved easily. They should ultimately be solved by each teacher him- or herself. It requires support in the form of in-service training and sufficient time to adapt.

Some Lessons from Research about PLON

Students' Opinions About the PLON Units

Using a questionnaire we asked 356 students at senior general secondary level about their opinion of the various units. About 60% of them had used 10 PLON units in forms 4 and 5; the others had studied 6 units in form 4. After analyzing the answers we were able to draw the following conclusions.

Students show preference for some units while others are far less popular. Popular units are those which relate to daily life or to specific interest areas of students, e.g., the units *Traffic, Music, Weather Changes, Electronics* (some of the boys) and *Ionising Radiation* (most of the girls). Students are less fond of units which are either theoretical or technological, e.g., *Matter, Electrical Machines* (girls), *Energy and Quality* and *Electronics*.

On the other hand, nearly all units are mentioned by a lot of students answering the question: 'From which two units did you learn most?' Sometimes the answers are in disaccordance with the students' preferences, e.g., the units *Electronics* with girls and *Ionising Radiation* with boys.

No significant effect of the teacher was found on students' preferences and judgments. In general students had a positive attitude towards the physics lessons, especially regarding student activities and the applied physics in the curriculum. Less positive was their opinion about the personal contribution of students to the lessons, which is still too small according to them.

Students' Ideas on Radiation

Students from eight different classes filled in questionnaires before and after the unit *Ionising Radiation* was taught. These questions were asked with several aims in mind. Firstly we wanted to know the interests of students in specific topics to do with ionising radiation. Secondly, we were interested in the attitude of students towards the concepts of radioactivity and x-rays. Finally, we wanted to find out whether and in what ways students use scientific knowledge in formulating their opinions in risk issues associated with applications of ionizing radiation.

Students' interest seemed to be largest about topics such as the effects of radiation and radiation protection. Girls are mainly interested in health applications while boys prefer the topics nuclear energy and nuclear arms.

Using a 16-item attitude test, called 'semantic differential,' the attitudes of students towards radioactivity and x-rays before and after the unit were assessed. Students appeared to have a significantly more positive attitude towards x-rays than towards radioactivity. Postmeasurement showed hardly any change in the former but a definite shift in the later. The girls' attitude especially became more positive after the unit. This in spite of extensive and realistic descriptions of both acute and long-term effects of ionizing radiation on the human body.

Finally, it was found that students show signs of misconceptions about radiation before the unit. Some of these misconceptions (e.g., 'food becomes radioactive after irradiation with a radioactive source') seem to be caused by confusion between radiation and radioactive source. They particularly emerge when students are forced to use their school knowledge in unknown real-life situations.

Suggestions for Further Research

From the above-mentioned results we might conclude that it is possible to create an STS curriculum in which most students are served regarding interest and learning needs. Two points, however, deserve special interest in STS circles.

One is: what contents should be chosen for an STS curriculum? Traditional curricula do not help us in this as they miss an STS criterion for selection of contents. Teachers are not familiar with all areas of STS, in any case far less than with traditional science. Experts could be consulted but they are experts in only one field and often are not familiar with the difficulty of teaching certain concepts at different age levels. We suggest that for various areas of STS research will be done about which practical situations and which contents are suitable for STS in the eyes of experts, teachers and scientists. This should result in criteria for choosing contents and a weighing of the importance of various applications.

The second point regards misconceptions. It is likely that STS teaching which tries to integrate science, technology and society promotes the occurrence of collisions between 'natural thinking' and 'scientific thinking,' between 'personal' and 'scientific domains.' In academic science courses one could draw a clear line between thinking in the science lessons and in the real world. That is not possible in STS courses. So we suggest not to restrict the so-called misconception research to academic teaching but to direct this kind of research especially to STS courses. It might be a source of student thinking and a possible way to bridge the gap between lay and expert thinking.

In our group we made a start with this kind of research in the field of ionizing radiation. In due course we hope to be able to publish some of our results. We do need these kinds of research results if we want to write better STS materials than we were able to do so far.

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Bull. Sci. Tech. Soc., Vol. /, pp. 137-145, 1987. Printed in the USA.
0270-4676/87

A MODULE FOR TEACHING SCIENTIFIC DECISION MAKING

Glen S. Aikenhead

Introduction

In today's society, everyone makes decisions on social issues related to science and technology: (1) a consumer buying food or receiving medical attention; (2) a newspaper reader or TV viewer wondering what to believe; (3) an informed citizen deciding what position to hold on questions of nuclear power development, abortion or local water purification; or (4) a member of a political party, government agency, industrial board or local regulatory committee establishing policy for a nation, a company or a community. Socioscientific decisions such as these have been investigated by analyzing the prerequisite knowledge required to make these decisions, by clarifying the decision-making process itself, and by noting pitfalls to avoid when including socioscientific decision making in science lessons (Aikenhead, 1980, 1985a; Copeland et al., 1985; Hickman, 1985; McConnell, 1982; Murray, 1986; Rushefsky, 1984; Science, Technology & Human Values, 1984; Ziman, 1984).

This paper reports on a curriculum project which translates these investigations into field-tested classroom materials. A module, Scientific Decision Making (Aikenhead, 1985b) introduces 14 to 17 year olds to the decision-making process as it is practised in the scientific community. The materials provide students with knowledge about science which is prerequisite to making informed decisions about socioscientific issues. The capability of making informed decisions is an essential part of technological literacy. The rationale for the module is predicated on the assumption that if students are aware of the epistemological and sociological nature of scientific information, their decisions about socioscientific issues will be more astute. One method of teaching the epistemology and sociology of science is to engage students in decision-making simulations which generate scientific findings; for instance, scientific inquiry activities.

The purposes of this paper are (1) to describe Scientific Decision Making in terms of its background and development, its objectives, and its content; and (2) to portray some salient classroom events which operationally define the module's objectives. The module's impact on student learning is evaluated elsewhere (Aikenhead, 1984).

The Module

Background and Development

A number of years ago, Fleming and the author developed a full-year tenth grade course, Science: A Way of Knowing, SAWK (Aikenhead & Fleming, 1975), with the major objective of demystifying science (Aikenhead, 1979a). Originally we intended to develop a course dealing with the interactions of science and society. We discovered however that our students, of average academic ability, were so imbued with myths about science and were so woefully ignorant about their society that they could not successfully deal with the interactions between science and society. Consequently, we developed a course that (1) taught inquiry skills such as critical and analytical thinking, (2) taught students about authentic science, and (3) taught them how to look at their society (albeit in an oversimplified manner). These learning outcomes prepared students for the last unit of SAWK, the interaction of science, technology and society. The course received two years of formative evaluation and two years of summative evaluation (Aikenhead, 1979b).

Recently we began to update the course by developing each unit into an independent module, and by placing more emphasis on the STS domain. Many science teachers had felt that the original SAWK unit on decision making lacked the science content expected in a natural science course. The revisions addressed this concern by adding two scientific inquiries, one dealing with the pendulum ("Fast Swing") and the other dealing with the solubility of gases in a water solution ("Why the Fizz"). The first revision of SAWK's unit on decision making was field-tested by the author with a class of academically talented eighth graders. The unit was then revised and field-tested again with a class of academically unmotivated tenth graders. The student materials were revised a second time incorporating ideas and expressions the students devised. A detailed teacher guide was written. Next, three high schools were invited to use the unit. Volunteers taught grade 9 science (where the pendulum content matches the curriculum syllabus) and grade 10 science classes. Except for one "below average" tenth grade class, the students were typically average for their schools. The field-trial teachers and their students were most helpful in suggesting ways to polish the student manual, the lab directions and the teacher guide. The revised unit, Scientific Decision Making, is a one to two week, independent module.

Objectives

The "Fast Swing" and "Why the Fizz" inquiries are simulations of the scientific decision-making process called consensus making (Kuhn, 1970; Wessel, 1980; Ziman, 1984). Consensus making poignantly portrays science as a human endeavour. Scientific knowledge is seen as the consequence of humans making a decision (reaching a consensus) rather than the discovery of some mythical truth. The subjective role of craft in scientific investigations (Ravetz, 1971) is revealed in the simulations. In addition, students discover how scientific data tend to be theory-laden (Goldstein & Goldstein, 1978) and that the acceptance of these data can depend upon psychological and social factors (Barnes, 1985). Students themselves experience the need for imaginative curiosity as well as critical logic. Thus, students become aware of two different components of authentic science, private science and public science (Holton, 1978). With this perspective in place, students discuss the role that objectivity and subjectivity play in real science. All of these issues are made explicit by leading students into difficulties similar to those encountered by scientists when they are making decisions. Students are then required to explicitly reflect upon the natural consequences of such difficulties and their resolutions. The goal of this module is for students to gain insight into the realities of authentic science. The specific objectives are summarized in Table 1.

Table 1

Summary of Student Outcomes for "Scientific Decision Making"

Concepts

1. reliability and accuracy of data
2. experiments:
   - variables and control of variables
   - the role of imagination
   - subjective factors affecting what observations are made and how they are interpreted:
     - craft
     - beliefs (theory-ladenness)
     - biases
     - confidence
3. consensus as scientific decision making
4. scientific laws and scientific theories
5. private science and public science
6. pragmatism in science (usefulness versus truth)
7. Canadian scientific accomplishments
8. (optional) values and scientific values

Inquiry Processes

1. creating hypotheses
2. deciding upon pertinent variables
3. setting up an experiment (either according to precise directions or according to self-composed directions)
4. measuring variables
5. collecting, organizing, graphing and interpreting data
6. cooperating as a research team
7. participating in scientific consensus making

These objectives define a significant aspect of technological literacy, and they represent prerequisite knowledge for science-technology-society (STS) studies. When students study a STS issue, they may draw upon several sources of scientific knowledge. They may read, for example, the testimonies given by scientific or technical experts concerning the effects of low level radiation. Disagreements among experts must be assessed before a thoughtful decision can be reached. The thoughtfulness of such a decision will be enhanced by the student's ability to understand the sociology and epistemology of science; that is, the human aspects of science, the ways in which scientific knowledge is generated, the resulting status of that knowledge, and how that knowledge can be a resource to technology. If a student is imbued with scientism or an anti-science view, informed study of STS seems improbable and a literacy in technology unlikely.

The Content

Teachers adapt print materials to suit their needs. Accordingly, Scientific Decision Making allows a teacher to do one, two or all three of the module's simulations. Each simulation can also be modified to match the characteristics of the students.

The first simulation, "Dangerous Parallel," is a commercial kit used by social science teachers to develop knowledge of the decision-making process. In this context, the concepts of reliability and accuracy of data are developed. During a post-simulation discussion, students are introduced to the skill of reflecting upon what they have done. A total of five hours is required for this simulation and its discussion.

The second simulation, "Fast Swing," is an inquiry into the period of the pendulum. Although students are rigidly guided in their data collection procedures, they are given full responsibility for reaching a consensus on what to believe about the period of a pendulum. Research teams from six fictitious countries investigate one of the following variables: the mass of the bob, the shape of the bob, the displacement, the drop, the length of the string, and the distance between the top of the string and the middle of the bob. Students collect data, interpret these data and make a tentative decision. Then at an "international conference" (full-class discussion), each team presents its group's decision and tries to persuade the class to accept this decision. "Fast Swing" requires two to three hours, depending upon the need for instruction on specific inquiry skills (for example, how to make a graph), and depending on the amount of debate taking place during the international conference.

The third simulation, "Why the Fizz," is a model of scientific inquiry. The experimental part can be accomplished by most students at home in about two separate half-hour sessions as they investigate the discrepancy that carbonated drinks fizz when in contact with ice cubes (contrary to solubility laws). Students must imaginatively create their own hypothesis, design their own experiments, solve technical problems, collect data, logically analyze the data, and form a tentative conclusion. During approximately two half-hour sessions of class discussion, research teams present their findings and attempt to reach a consensus. The success that most students achieve at "Fast Swing" ensures enough confidence and experience for success at "Why the Fizz."

Both simulations can be reformulated into technological inquiries by shifting the objective away from satisfying own's curiosity, to responding to a human or social need (for example, redesigning a grandfather clock, and developing a fizzless ice cube). By doing so, the class would address the differences and relationships between science and technology (Fleming, 1987; Ziman, 1984). Technological literacy is enhanced when students view science as one component in the infrastructure of technology (DeVore, 1986).

After completing one or two of the science-technology inquiry simulations, students answer a series of discussion questions. These questions focus on the unit's objectives and require students to reflect upon what they did in the simulations. By discussing these questions as a class, students clarify the ideas associated with the objectives (Hickman, 1985; Holman, 1986). About two to three hours of class time are spent preparing tentative answers and then discussing them.

Classroom Events

Classroom observation notes, cassette recordings and debriefing interviews with teachers, documented a number of "teachable moments" that highlighted subjective qualities of authentic science. Teachers noted several incidents which they had discussed with their students in order to provide concrete illustrations of the epistemology and sociology of science. Some of these teachable moments are described here. Due to limits of space, only the events in "Fast Swing" are reported.

Many students had strong preconceptions that the variables mass, displacement, drop and shape, would affect the period. (None of them do.) Although the grade 10 students had completed a pendulum lab a year earlier, it made little difference to these misconceptions. In "Fast Swing," these preconceptions served as the "researcher bias" commonly observed in authentic science (Holton, 1978). It was instructive to watch how students coped with data that appeared to contradict their misconceptions. Some students rounded off their observations to match their erroneous preconception (for example, 12.4 became a convenient 13). The usual number of students did not read the directions carefully and therefore carried out the experiment differently; for example, they observed the number of cycles in 10 seconds, rather than the number of seconds for 10 cycles. Such alternative procedures normally increased the variability in the students' results, inevitably favouring the students' preconceptions. Arguments over a result sometimes ended by students repeating the run. But whether it was repeated or not, students still deleted the data they did not like, just as famous scientists like Millikan did (Holton, 1978). Similar incidents occurred when the experimental results were graphed and interpreted. (Rounding off also took place simply to achieve highly consistent results; for instance, 11.5, 12.0 and 12.5 all become 12.)

It was interesting to watch when two different research teams obtained similar results but reached different conclusions. Such discrepancies became evident in the international conference. For example, the group investigating mass of the bob and the group investigating the shape of the bob usually obtained results of equal variability. The first group, however, would conclude that mass <u>did not</u> affect the period while the second group believed that shape <u>did</u> affect the period. By confronting all students in the class with this incident, teachers forced them to account for its occurance Judgements, which students had made implicitly, began to emerge explicitly. The criteria used subconsciously became conscious. The effect of faith in data and faith in individuals became apparent, as did the investigator's biases. ("Parachutes slow you down, so a bulky bob must slow the period down!") Scientific data did not speak for themselves and most students reluctantly began to realize it.

Students tended to support their biases by <u>explaining</u> that the period <u>ought</u> to be affected, for instance, by the mass of the bob. Their logic naturally dealt with explanatory statements (scientific theories) and not with descriptive statements (scientific laws, the objective of "Fast Swing").[1]

In addition to investigator bias, there were other authentic, subjective elements in the simulation. Occasionally students expressed their opinion about another team's results by making perjorative comments about the students on that team; not untypical behaviour in scientific circles (Watson, 1968). Different lab techniques reflected different abilities of craft and therefore produced

[1] Once students are able to make the distinction between these kinds of statements (Ziman, 1934), they will be able to increase their understanding of the kind of knowledge generated by science. They will be prepared to examine such questions as, "Is evolution an explanation or a description?"

different experimental results (Ravetz, 1971). The arguments that erupted among students allowed teachers to reinforce concepts about the subjectivity inherent in the epistemology and sociology of science.

The discrepancies between (1) the data students collected, and (2) what students thought was logical, raised the ultimate issue: Which should one believe, the data or the explanation? The resolution of many STS issues may hinge upon this very question. The answer, in the restricted context of "Fast Swing," involved assessing several human aspects of science: the craft of the investigator, the reputation of the investigator, the biases or beliefs of the investigator, and the uncertainty felt about the reliability and accuracy of the data. Even greater complexity is found in socioscientific issues (Aikenhead, 1985a). Thus, the awareness of authentic science that emerges from the "Fast Swing" simulation may be thought of as a prerequisite to dealing with the complexity of STS issues.

Although the human aspects of science were experienced first hand in "Fast Swing", they had to be made explicit for students during class discussions. One grade 9 class insisted on repeating the experiments on the bob's mass and displacement in front of everyone. This decision came after the teacher had dismissed the class the day before leaving them with a slightly unsettled feeling about their Law of Swinging Bodies. The discussion that ensued from their repeat performance provided rich illustrations of the nature of science. These students learned more about the epistemology and sociology of science than students in another class which spent less time on such inquiry and less time on the discussion questions that followed the simulation (Aikenhead, 1984).

The simulation provided different experiences for different classes. Discrepancies differed. Biases differed. The craft ability of students differed. This unpredictability appeared to be attractive to some teachers but unattractive to others.

There were subtle differences built into the materials for the more careful and talented students to discover. For example, similar results were obtained from manipulating two different variables; string length and the distance between the top of the string and the middle of the bob. Yet for the students who completed the optional activity of graphing the <u>square</u> of the period, one research team obtained a straighter line than the other research team. Not only did students debate who had the straighter line, but they debated whether straightness was a valued criterion (an argument reminiscent of Kuhn's "extraordinary science," 1970). Incidents such as these provide opportunities for values clarification and for students to learn what values guide scientific decisions.

Teachers will decide whether or not to pursue these teachable moments. The classrooms participating in the field trials all experienced far more teachable moments than a teacher had time to address. Understandably, the issues that were of greatest importance to the teacher were the ones that received the class' attention. The teacher guide for Scientific Decision Making describes other events that may be anticipated during the data collection phase, the "international conference," and the structured discussions that follow the simulations.

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Bull. Sci. Tech. Soc., Vol. 146-157, 1987. Printed in the USA.
0270-4676/87

STS TEACHING: THEORETICAL PERSPECTIVES AND CLASSROOM PRACTICE

Sarah F. Perkins and Margaret B. Powell

Introduction

There is little doubt that science and technology touch the lives of each human being, in basic ways, everyday: they affect the manner in which we obtain food, transportation, clothing, housing, media. In The God that Limps, Colin Norman (1981) describes the impact of science and technology on humans today. He writes:

> Science and technology stand at the center of many of the critical issues facing society in the final two decades of the twentieth century. The arms race, the energy crisis, the problems of producing sufficient food, shelter, and material resources for a world population that will swell to 6 billion by the year 2000--all have technological dimensions. Small wonder, therefore, that science and technology occupy a prominent position in the hopes and fears of many people (p. 16).

Given the apparent failings of much science education, Norman's assessment points to a troublesome paradox. While science and technology are at the heart of many of the critical issues facing society today, science and technology programs in schools seem to be falling short of providing a majority of students with sufficient background to make informed decisions (National Science Board Commission on Precollege Education in Mathematics, Science and Technology, 1983).

This two-part paper addresses the necessity we see for STS teachers to design courses and programs which change science learning to better address the needs of both science majors and non-majors. We believe that to make needed changes in science learning it is essential for science educators to identify problems in science teaching and begin to generate solutions. Teaching science (and we include STS when we say science throughout this paper) needs to be more than lively presentations from a teacher's repertoire of tricks and stunts. We believe to make lasting change, science educators must begin to identify theoretical ideas of science and learning that give them guidance in developing program and classroom practice. Part I of this paper addresses the need for science educators to think theoretically about science and learning. Part II presents ideas on how to implement theory in classroom and program practice.

Background

We have identified two levels of curricular design considerations in science curricula. These are:

1) functional: Specifying how courses and curricula actually function and affect students (e.g. deciding what courses should be taught in the major); and
2) theoretical: Identifying the underlying theoretical perspectives or guiding principles of science and of teaching science.

It appears that much of the change in science curricula at all levels is occurring at the functional level through changing and adding course content and offerings, with little or no attention paid to the theoretical level.

While change at the functional level is often expedient, it is the underlying theoretical constructs which provide lasting change. They provide a direction for change and a yardstick for evaluating change. Theoretical constructs underlie all programs. But, when consciously articulated, we believe they serve to guide educators' observations, thoughts and actions. These underlying theoretical constructs are, however, difficult to change, particularly when unacknowledged.

Therefore, we have come to realize the importance of identifying theoretical perspectives which are guiding our teaching. We have categorized the theoretical considerations important to us as STS teachers into four majors areas:

1. examining how learning takes place;
2. examining the nature of science;
3. examining science as process; and
4. examining relations between science and democracy.

In the remainder of Part I, we present the theoretical considerations which we believe are essential in underlying our current teaching.

(1) Examining How Learning Takes Place

What one believes about learning is important in determining how one teaches. We believe that the more science educators understand learning and understand their own beliefs about learning, the easier it will be to design and implement classroom practices which are consistent with their understanding.

While there are many theories explaining learning, from our experience, what we believe is predominantly taking place in schools today is behaviorist and reductionist teacher behavior based on assumptions like:

1. students come to class with little or no useable knowledge about a given subject;
2. learning can take place with passive, non-participating students;
3. accumulation of factual information is more important than learning about one's self, about how to get along with others, or how to learn; and
4. teachers should take a position of authority since students are obvious subordinates and should be treated as such.

There are educators today making significant challenges to such views. For example, Frank Smith (1975), a Canadian psycholinguist, and author of the book *Comprehension and Learning*, wrote about learning:

> . . . the only effective and meaningful way in which anyone can learn is by attempting to relate new experiences to what he knows (or believes) already. In other words, comprehension and learning are inseparable (p. 1).

And, on the teacher's role Smith wrote that

> The role teachers have to play in providing information is delicate as well as vital. What is the right kind of information for a child to receive? And when is the right time for him to receive it? What in fact does a child who is learning require of an instructor? To answer this question, we must again take the perspective of the child. (p. 225)

Smith emphasizes that teachers need to help learners be actively engaged in their learning. He also urges teachers to consider their learners as sensitive individuals who need help making meaning from their learning experiences rather than as subordinates.

Smith's view of learning suggests the need for learners to collaborate, to raise questions, to make predictions, hypothesize and engage in modifications of existing cognitive structures. He defines learning as the changes that take place in one's existing cognitive paradigms. He does not, like the behaviorist, believe language is an accumulation of facts and information, an intake procedure. Rather, he sees language as a means of restructuring of one's view of the universe and all the phenomenon therein. Thus, understanding how language is acquired is related to understanding learning.

Likewise, Novak and Gowin (1984) building from Ausubel's theory of ". . . meaningful learning . . ." suggest that

> to learn meaningfully, individuals must choose to relate new knowledge to relevant concepts and propositions they already know. (p. 7)

Crucial to Novak and Gowin's theory that learners can construct their own meaning is the role of the teacher who they believe must work to provide the kind of instructional approaches most appropriate to helping learners see connections, draw relationships, find and articulate patterns. Thus, important to effective learning and teaching is understanding how parts of a whole are related and being able to articulate those relationships.

Botkin, Elmandjra and Malitza (1979) offer additional challenges to the traditional behaviorist beliefs about learning. These authors suggest that learning is not merely an accumulation of facts and information, memorized in sequential or chronological order. Rather, they establish goals for what they call "innovative learning." They two key ingredients for "innovative learning" according to Botkin et al. are anticipation and participation. Anticipation is defined as:

> . . . the capacity to face new, possibly unprecedented situations; it is the acid test for the innovative learning process. It is the ability to deal with the future, to foresee coming events as well as to evaluate the medium-term and long-range consequences of current decisions and actions. (p. 25)

Participation, according to Botkin et al. is essential because of what it does for the learner and for the teacher. For the learner, participation means developing skill in collaborating, in working with others to locate and solve problems. It is active engagement in the learning process. It demands frequent use of language. It engages the learner in those skills necessary in an academic setting.

Skill and practice in participation is essential, the authors explain, because most people want to participate in decision-making. Participation, therefore, requires that the school setting and teachers help students learn how to develop a common understanding to a problem. When this step occurs, a solution becomes more obvious to the learners.

> Creative participation thus emphasizes problem detecting, problem perceiving, problem formulating and common understanding, and is not restricted merely to problem-solving. (p. 30)

What these authors offer for science educators is a context for examining learning. And while identifying and examining one's own beliefs about learning, we believe it important for science educators to also examine their beliefs about the nature of science.

(2) Examining the Nature of Science

Some of the difficulty science educators face in designing and evaluating science courses and programs is occasioned by the diversity of views about the nature of science itself. The difficulty can be compounded when science teachers do not recognize that such diversity exists.

Schwab (1978), in an article titled, "The Nature of Scientific Knowledge as Related to Liberal Education," documents the diversity of beliefs about the nature of science. He shows that the diversity of beliefs about the nature of science exists on at least three dimensions:

1. diversity of doctrines concerning the nature of science;
2. broad diversities in science, stemming from espousal by scientists of different doctrines of method;
3. specific diversities in patterns of inquiry related to differences of subject matters and problems in the several sciences (1978, p. 98).

Thus, STS teachers who wish to awaken their learners to diverse views of the universe and wish to provide experiences through which their learners encounter different ways of solving problems and wish to stimulate students so they can create solutions to problems which have not yet arisen and wish to challenge views that science is some sort of panacea to all the world's problems must realize there are many views of science. STS teachers must therefore develop meaningful and relevant ways of helping their learners discover the many different views of the nature of science.

These different views about the nature of science challenge, to varying degrees, the empiricist perspective which has dominated the teaching of science. The empiricist tradition assumes that:

- terms get their meaning by establishing causal links between sets of impressions or sense-data;
- a meaningful proposition must be testable by reference to observation and experiment;
- the existence of certain fundamental universal laws is a given; and
- the search for knowledge is a neutral process and is not concerned with choices of values.

However, non-empiricist positions include questioning: the social uses of science (feminist and critical theory), the neutrality of science, the existence of universal laws, causal links between sets of impressions or sense-data (Bhaskar).

Science educators who plan science and technology programs for today and the future need to operate in their science teaching from a multi-dimensional perspective that can come from seeing from more than one perspective. Recognizing a variety of perspectives helps in critiquing the whole enterprise of science and technology with a more tolerant and divergent perspective.

If college science programs are to be designed to prepare students to see from more than one perspective, and to see interrelationships, they must include multidimensional views of science and the world, and faculty must engage learners in tasks which result in students seeing and articulating relationships.

(3) Science as Process

James Botkin, Mahdi Elmandjra, and Mircea Malitza (1979), in their book, *No Limits to Learning*, identify other problems with perceptions concerning science-problems with implications for science education. They write:

> One of the main problems of science and technology comes from their public image as an end product instead of a process of learning. Science itself is first and foremost the process of making and unmaking hypotheses, axioms, images, laws, and paradigms rather than products--it is a learning process. . . It's [science's] role, orientation, and distribution result from our learning capabilities, our value systems, and our culture. If our learning were self-reliant and operating effectively, many of the problems associated with science and technology would disappear (p. 111).

It seems as though science program planners need to understand that science is more than an outcome, more than learning how to get the answer after following the directions of some predetermined lab exercise. Thus, according to Botkin et al., science is a process of discovery. However, the excitement of process is all too often, mechanized and reduced to cookbook surety in classroom laboratories around the country. Bybee, Hurd, Kahle, and Yager (1981) suggest that, at present, most science activities do not qualify as problems or investigations. Rather, they are exercises students perform to illustrate concepts in a textbook:

> . . . present science laboratory experiments are confined rather than open ended; they confirm the structure of a discipline rather than present knowledge in a personal and/or societal context; they are short term rather than long term; they emphasize "scientific methods" rather than creative problem solving; they occur in a laboratory facility rather than in the environment and community of the student; and finally, they are directed toward conclusions rather than decisions (p. 307).

Botkin et al. clearly define one of the major misconceptions science program planners have about science which is looking at science as an "end product instead of a process of learning." They believe rather that science is an ongoing process of discovery, hypothesis testing, observing, and synthesizing information.

4) The Relation of Science to Democracy

We believe that an understanding of the relationship between science and democracy must guide our teaching. In the context of a STS curricula, three issues emerge:

i) the need for democracy which recognizes the dignity of persons;
ii) the need for science literacy in political democracies; and
iii) seeing key values of democracy as essential to the practice of science.

The first issue concerning democracy deals with the democratic ideal of respecting the individual. Arthur Wirth (1983), in his book *Productive Work - In Industry and Schools*, writes of what he calls a "neglected part of American experience":

> . . . the democratic ideal: having respect for the dignity of persons, having confidence that people of diverse abilities and roles can communicate to create answers to problems of living (p. 7).

This is what STS is about: respecting the dignity of individuals and groups of individuals and assisting humankind in our search to answer the problems of living together on this planet in harmony. And thus, the importance of understanding the concept of democracy as it relates to science and technology.

What Wirth sees as missing in schooling as well as in other aspects of our lives is an image of human beings Ernest Becker (1968) calls homo poeta, people, as meaning makers and creative problem solvers.

Acknowledging the dignity of persons as "meaning makers," is an important consideration for STS program planning not only for the nurturing of the individual learners within science programs, but also for the recognition that key characteristics of scientists, creative thinking and making meaning are, according to Becker, inherent in all persons.

At the foundation of any STS course or program is a basic concern for the involvement of each individual in his/her society in the decision-making processes, in fulfilling responsibility toward other members of the world community.

Our second issue addresses the need for individuals to be literate in science in order to be able to function in a political democracy. Political issues involving problems in science and technology confront legislatures at national, state, and local levels at ever-increasing rates. A 1981 survey published by the House Committee on Science and Technology reports on more than 100 significant issues before Congress including soil erosion, water, pollution, nuclear weaponry (SIPI, 1981, p. 1). Who will be making the important decisions involving these issues? How informed are they? How informed is the public to make these judgments which will have long-term impact nationally and globally? It would appear that the complexity of contemporary life demands a new look at science education for the prospective science major and non-major.

Physicist Robert R. Wilson (MANAS, 1981), who headed research at the Los Alamos Laboratory in the late 1940's and early 1950's, believes that it is essential that non-scientists have the capacity to make critical judgments involving science and technology. He writes:

> Non-scientists must come to realize that they bear the responsibility for the problems and must somehow learn to control science and the technology it spawns if they are to survive (p. 1).

Questions science educators must ask include: Are our science programs helping our students to be more informed about how science is transforming the world in which they live? In what ways can science programs help students learn how to become better-informed citizens in a political democracy?

Our third issue concerning democracy in the practice of science is addressed by scientists such as Bronowski. In his book, *Science and Human Values*, Bronowski (1956) explores how key values of democracy are inherent in the practice of science itself. According to Bronowski, basic values of democracy such as independent thinking and tolerance for different ideas and perspectives are fundamental in the process of "doing science." Independence, he writes, can only be preserved in democratic communities where each individual has freedom of thought, freedom of speech, freedom of inquiry, and freedom to be tolerant. Bronowski concludes that democracy is requisite to the success of the work of scientists:

> The society of scientists must be a democracy. It can keep alive and grow only by a constant tension between dissent and respect; between independence from the views of others and tolerance for them (p. 62).

It would appear that a program designed to teach students the values and methods of scientific inquiry ought to embrace the key values of individual inquiry, collaborative criticism, and evaluation.

Conclusion

Science programs do need to change to better address the needs of our science majors and non-majors will face in today's technologically and scientifically based society.

Our science programs and teaching must be grounded in a firmer foundation than a mere repertoire of flashy gimmicks. Science educators must gain an understanding of their own beliefs and theories about the nature of science and learning in order to help themselves address the students' needs.

Developing and teaching STS programs is important if we want to help students learn to integrate and apply their educational experience to real-life situations. Program development, however, must be carried out at both functional and theoretical levels. And while it is difficult to address the theoretical constructs in curriculum planning (when faculty are unprepared to do so), theoretical constructs are foundational to programs.

Part II: Classroom Practice in a STS Program

The substance of the ideas in Part II of this two-part paper rest in our assumption that effective educational practices imply a theoretical framework; embedded therein are basic beliefs. We suggest that effective program planning takes place when faculty plan consciously from a set of beliefs--in our case, beliefs about learning, beliefs about the nature of science, beliefs about the process of science and beliefs about science and democracy.

Very significant to our work have been recent discoveries we've made from reading about the nature of science and about learning theory. We have become fascinated with the possibilities of looking at teaching biology through the lens of learning theory. In the remainder of the paper, we will: A) describe how our current teaching practices in Biology Field Study evolved; B) tell how we match beliefs with classroom practice; and C) illustrate some of our thinking and how it has influenced our procedures and teaching style in our Biology Field Study course. We might add that both of us use similar methodology and style in the courses we teach independently of this team-taught course. We have found that what we do in a teamed learning-teaching program does transfer to our other teaching settings.

How Did We Get Where We Are?

Before our decision, some five years ago, to teach together, we both had: 1) experienced dissatisfaction with the kind of teaching and learning we had experienced ourselves as students; 2) been actively seeking new thoughts and methodologies to inspire our teaching; 3) sought dialogue on subjects related to teaching and learning; and 4) had separate but similar experiences of success in a variety of co-teaching situations. Our learning has continued to be a series of beginnings and self examination characterized by:

(1) questioning,
(2) observing our students in the classroom setting,
(3) recording notes on their comments, performances and behaviors,
(4) reading and then preparing lists of beliefs to examine,
(5) hypothesizing,
(6) creating activities designed to test hypotheses and move student thinking and behaviors in new and yet systematic ways,
(7) creating the types of activities which will cause students to react with one another,
(8) learning how to plan and replan daily and weekly from the immediate needs that arise in each lesson,
(9) conferring and collaborating with one another,
(10) soliciting regular and on-going feedback from ourselves and our students for the purpose of reassessing our beliefs and our effectiveness in matching our beliefs with our teaching strategies.

The items in this list describe in what appears to be an orderly sequence of steps a discovering process. However, the steps have neither occurred in an orderly sequence nor systematically. This list is our attempt to articulate what has become for us very tacit: our process.

Because of working together to answer such questions as how does learning occur; how do we know when we are seeing our learners learn; what do our activities do to stimulate learning; what are the relationships between how we teach and how our students learn biology, we are different people today than we were five years ago. Our questioning, reading and program designing has led us to such useful concepts as:

(1) inspired teaching inevitably involves uncovering myths about learning,
(2) science is far more than an accumulation of data for the purpose of drawing further conclusions,
(3) science is a perspective on life, the universe and man, which (while not thought of as very useful by the general public) is actually vital to the survival of the planet,
(4) learning is discovering and then applying those discoveries in personal and communal ways.

Therefore, these new concepts have impelled us to explore specific ways of restructuring, replanning, and reorganizing what we do as field biology teachers in our Field Biology class. Science education has become for us far more than asking students to memorize, repeat, and listen to long lectures.

For us, biology is a means of assisting students in:

(1) learning how to raise questions and find excitement in questioning,
(2) willingly exploring life survival needs, skill, processes and assumptions,
(3) thinking critically and creatively,
(4) discussing ideas, details, conclusions, assumptions, discoveries,
(5) identifying the relevance of science in their lives,
(6) exploring similarities between different world peoples and their political, economic and environmental systems,
(7) understanding local, regional and global problems, resources issues and trends from a biological perspective,
(8) realizing the ethical and moral implications of biological field study today and tomorrow,
(9) practicing regularly the following:
   a. observing,
   b. data collecting,
   c. discussing,
   d. drawing conclusions from the data collected, about observations made and about charting done,
   e. discovering, experimenting,
   f. designing experiments, hypothesizing and
   g. verifying,
   h speculating, predicting, estimating,
   i. seeing and stating relationships,
   j. appreciating ones self as group member and scholar.

Therefore, the question for us has become how do we teach if these are our goals? We can no longer plan and deliver lectures or set up gimmicky cookbook style experiments. What then do we do?

Basically, we create and design activities which we believe help us implement our basic beliefs. To this end, we start by listing our basic beliefs. Then, together we study those belief statements and ask, "What would we have to do to demonstrate this belief?"

Because we are teaching in a field biology context, we work with such local context as pond ecology, photosynthesis, pollution, habitat, migration of eagles in our area of the Mississippi River Valley. Therefore, we constructed a planning diagram for ourselves that looks as follows:

Course Content	Basic Beliefs	Activities
Ecosystems	1. beliefs about learning	1. questioning,
Pond Ecology	2. beliefs about science as process	2. listing, categorizing
Eagles	3. beliefs about the nature of science	3. field work
Photosynthesis	4. beliefs about the relation of science and democracy	

This model is a sample. The format remains the same as we plan our courses. However, the content shifts regularly. We look at each content item in light of each of the four major beliefs. We then attempt to create activities which will help us filter each topic or piece of content through each of the beliefs.

We ask ourselves, in planning each activity: 1) Have we accounted for our beliefs about learning, our beliefs about the nature of science, our beliefs about the relationship of science to democracy? 2) Will we be able to teach pond ecology through questioning, charting, listing, mapping, measuring, etc.?

Crucial to the planning we do is a regular and ongoing study of our beliefs. We work from the framework of the four categories of beliefs outlined in Part I. Therefore, in the remainder of the paper, we have listed pertinent beliefs from which we operate and activities we believe have resulted from our attempts to apply our beliefs in the classroom.

The four categories we use for planning are:

1. beliefs about learning,
2. beliefs about the nature of science,
3. beliefs about science as a process, and
4. beliefs about the relationship between science and democracy.

Matching Classroom Practice with Selected Basic Beliefs

(1) Beliefs About Learning

(a) Insights into the nature of learning can come from our understanding of language acquisition because understanding how human beings process language is to understand something about the basis of thinking.
(b) Learning is meaning making.
(c) Individuals who are engaged in reflecting on their learning while learning, learn more effectively.
(d) Learning is a product of experience.
(e) Learning is an interaction between the world around us and the theory of the world in our heads (Smith).
(f) Learning is the modification of cognitive structures. Therefore, we believe learning occurs when new categories are made. Learning occurs when learners are able to distinguish new concepts. Learning occurs when the relationships between concept categories are developed and/or modified (Smith, Novak and Gowin).

(2) Beliefs About the Nature of Science

(a) Science education ought to include exposure to the wide diversity of views about the nature of science.
(b) There are deep differences among scientists about the nature of science and its subject matter.
(c) The notion of one science methodology is limited and unrealistic (Schwab, Bhaskar).

(3) Beliefs About Science as a Process

(a) Science is more than an outcome, more than learning how to get the answer after following directions of some predetermined lab exercise.
(b) Science is an open-ended process of questioning and discovery.
(c) Science is a word used to describe a whole orientation to learning about the physical and natural universe including man (Botkin, Bybee).

(4) Beliefs About the Relationship Between Science and Democracy

(a) Learners need to be science literate for their own protection and enlightenment as participants in a democracy.
(b) Learners in a democracy need to have first-hand practice in participatory democracy skills such as active listening, paraphrasing, probing, questioning, summarizing, defining key terms, collaborating in small and large group work, decision making, priority setting, appreciation for fellow team members, articulation of one's ideas in front of others (Wirth, Bronowski).

Matching Beliefs With Classroom Practices

(1) Beliefs About Learning: Practice

Because of our beliefs about learning, we do the following in the classroom:

(a) Have students work in pairs or other configurations of small and medium-sized groups, talking and discussing in structured ways in order to accomplish a given task;
(b) Have students engaged in learning about and practicing paraphrasing, summarizing, questioning, probing in pairs, or other configurations of small groups;
(c) Have students respond to activities by reflecting verbally and in writing (small groups or with the whole class) to such questions as: (i) What was the purpose of what we just did? (ii) Describe some of the outcomes you see from this activity. (iii) What thinking skills did you use in this activity? (iv) How does this activity relate to other things we've been doing in the class?
(d) Have students list, sort, categorize, and chart;
(e) Have students set up, design, implement and carry out field research in pairs or small work teams, guiding them with group planning sessions and evaluation sessions;
(f) Have students participate in observation, prediction, experimentation, interviewing, consultation, and group research instead of listening to lectures;
(g) Have students make observation visitations throughout the local region for the purpose of outlining and listing problems that seem pertinent to study; collecting ideas for possible research, then learning how to propose a study, design that study and implement that study;
(h) Have students draw relationships in their study to larger world issues by assigning readings from newspapers, by identifying similarities and differences in characteristics, features, and variables;

(i) Have students define, describe and discuss the process;
(j) Have students choose, decide, set priorities;
(k) Have students study, discuss, and analyze parts and wholes and their interrelationships.

(2) Beliefs About the Nature of Science: Practice

Because of our beliefs about the nature of science, we do the following in the classroom:

(a) Have students respond to certain problems and topics from different points of view (example: list the ways in which a traditional field biologist would respond, list the ways an ethnographer might respond);
(b) Have students design methodology for carrying out an assigned research study, compare differences and similarities between group plans, list and compare problems with each methodology, analyze differences, list advantages of each;
(c) Have students list their beliefs about science and do a personal life search for origins (a roots study) of the evolution of those basic beliefs; compare lists with others, raise questions, probe, read to match beliefs with various accepted positions,
(d) Have students define issues and then list concepts embedded within issues; further, have students locate and list facts supportive of their description of the issues;
(e) Have students make comparisons of different views, different texts, different methodologies and list or chart differences and similarities, then, have students draw conclusions and/or make assumptions about those similarities and/or differences;
(f) Have students engaged in many different ways of defining key terms and concepts; conduct word searches with research books, including a thesaurus;
(g) Have students locate, state and analyze patterns, trends and relationships.

(3) Beliefs About the Process of Science: Practice

Because of our beliefs about the process of science, we do the following in the classroom:

(a) Have students explore what they thought to be factual (assumptions) with what they observed and discovered to be true; have students set up their comparisons in charts or other types of pictorial designs. Share those models with one another. Raise questions.
(b) Have students draw diagrams and pictures of their concepts and then share those diagrams, refining, redesigning and then talking about similarities, differences, contrasts, trends, patterns, useful areas for possible future study;
(c) Have students write reflectively before plunging into an activity everything they think they already know about that topic, or how they are perceiving the value of that topic, or their questions or reservations about that topic; reviewing or assessing what they know before actually getting into the topic;
(d) Have students respond to open-ended frames such as, Because of .. I believe ...
(e) Have students generate questions, using models for effective questioning;
(f) Have students list benefits and advantages to every point of view, to each side of each issue,
(g) Have students respond in writing or verbally in small and/or large groups to such questions as, Why are we having you do this? What do you see to be the meaning for this activity? What meaning did you make of this? What was the author's meaning?

Conclusion

Because we have had so much success and satisfaction planning our teaching-learning experiences from a selected set of beliefs, we are offering our approach as a viable option for people interested in considering our hypothesis that effective program planning takes place when faculty plan consciously from a set of beliefs.

We are not suggesting that our method or our conclusions are the only effective ways for making needed changes in science education today. However, we are reporting that the method we have developed for ourselves (planning for teaching by studying a set of belief statements, then attempting to match our classroom practices with our basic beliefs) works for us in our setting.

Student feedback gathered informally on a daily basis by talking casually with students while moving about the learning environment much the way an effective elementary teaches does, indicate, as do our formal student evaluations, that students feel good about what they are learning. Feedback shows students understand their role in their learning experience, can measure their learning and accumulation of information, do recognize more skill and expertise in analysis, questioning, problem posing and solving, concluding, and writing, and can discuss as effectively as a group of upperclass biology majors such topics as photosynthesis, wintering habits of bald eagles in the Mississippi River Valley, pond ecology, snow, water.

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Bull. Sci. Tech. Soc., Vol. 7, p. 158, 1987. Printed in the USA.
0270-4676/87

THE STS ONE-YEAR COURSE: EARLY EFFORTS

John L. Roeder

I started teaching one-year STS courses before I even knew what they were. Then I met Dick Brinckerhoff. It was at a meeting in New York -- we were trying to recall the other day whether it was AAPT or NSTA -- but I found myself at a session at which he and Arthur Compton were talking about Exeter I and its recommendation to infuse societal topics into science courses. I realized then that I had been teaching courses in which the interaction of science and society was an integral part. Not that I had thought of them in terms of STS. It was simply that upon coming to The Calhoun School I had seen many students graduate without being exposed to the ideas of physics or chemistry, which I regard as an important part of our cultural heritage. To remedy this situation in the spirit of "relevance" then prevalent, I offered courses based on Dietrich Schroeer's Physics and Its Fifth Dimension: Society and John Hill's Chemistry for Changing Times. I also became involved in team-teaching a course on "Critical Social Issues," where as a result of the first long gasoline lines I taught about energy. The students in "Physics and Its Fifth Dimension" and "Chemistry for Changing Times " have subsequently been succeeded by students in physics and chemistry -- possibly because they wanted their transcripts to colleges to reflect these more conventional titles -- and my teaching about energy has expanded into a new one-year STS course called (for lack of a better title) "Energy for the Future." As does Evergreen College's course "Society and the Computer" for communications, "Energy for the Future" begins by examining our use of energy in the past before progressing into the present and prognosticating about the future. I refer to it as an energy-focused physical science course, for hands-on activities are employed to teach relevant concepts in science. In fact, the suggestion to give an energy focus to a physical science course came from the author of a controversial editorial in a recent issue of the Teachers Clearinghouse Newsletter, Lys Waltien.

Then in the fall of 1981, I was invited to speak about my STS courses at a meeting of the Association of Teachers in Independent Schools in New York City. There I met Irma Jarcho and Nancy Van Vranken and found that other teachers were also teaching one-year STS courses. As you may know, this meeting led to the formation of the Teachers Clearinghouse, and we're looking forward to celebrating our fifth anniversary next month.

Having taught "Energy for the Future" for the past nine years, I have been casting about the idea of revising the course to include other aspects of technology. Being approached by a publisher to write a book based on Blocks G, H. I, and J of the New York State Junior High Science Syllabus (physical science plus STS) gave me the opportunity I was looking for. In addition to energy, I now plan to include communications and materials. Although the publisher later put the project "on hold," I still plan to continue with it to teach next year -- a course called (again for lack of a better title) "Energy and Technology for the Future."

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Bull. Sci. Tech. Soc., Vol. 7, pp. 159-166, 1987. Printed in the USA.

TECHNOLOGICAL LITERACY IN THE CURRICULUM: A VIEW FROM FAIRFAX COUNTY, VIRGINIA

John T. Driscoll

Fairfax County (VA) Public Schools, one of the largest districts in the country (161 schools and 127,914 students), serves an affluent community which has traditionally held high expectations for its school system. There have been many attempts over the past several years to initiate technological literacy programs within the Fairfax County school curriculum. Those who are interested in technological literacy can learn much from the Fairfax County experience; not only from the system's successes, but also from its mistakes. Before venturing into a discussion of examples, however, it will be useful to establish some conditions which are necessary for successful implementation of technological literacy programs.

There are at least six conditions which must exist before either technology or the study of the effect of technology on society will be integrated into instructional programs.

1. Community awareness of and concern about the issues inherent in technological literacy.

2. Effective educational leaders who not only galvanize community concern into involvement and support, but who also have the vision and fortitude to countervail against the interial forces in education that resist meaningful change.

3. Creative teachers who are not afraid to experiment with new materials and methods are the true change agent in American education. They must be located and recruited.

4. Sufficient resources, both financial and human, must be available. Not only must new instructional materials and equipment be purchased, but outside experts may have to assist in implementation.

5. A commitment to staff development must be made. Curriculum innovation often requires extensive modification in patterns of instructional behavior. Significant additions to teachers' instructional repetoires cannot simply be ordered, but must be supported by long-term training.

6. Strong curricula must be developed that not only achieve technological literacy objectives, but which are also "user friendly." In order to meet this sixth condition a dynamic curriculum development process, one which is organized both to facilitate and act upon input from the community, educational leaders and teachers, must emerge.

This network of conditions is useful in evaluating Fairfax County's experience with technological literacy in curriculum.

"Man In His Environment"

By the fall of 1971, when Fairfax County's Robinson Secondary School first opened its doors to students, there existed a national consensus concerning the importance of environmental education. It was thus not surprising that an early centerpiece of Robinson's instructional program was an interdisciplinary (Science and Social Studies) course for intermediate students called "Man In His Environment." The objectives of this course went beyond introducing the scientific method, placing man in an environmental context, and teaching students scientific concepts embedded within enviornmental issues. The course was also planned to demonstrate the social and environmental effects that man and his technology produce.

Under the leadership of its first principal, Sam Coffey, Robinson was to become a "school for the individual." Each faculty member had accepted, upon assignment to the new school, a commitment to team teaching, flexibility, innovation and experimentation. Mr. Coffey's dream was to have interdisciplinary teams of teachers provide instruction to relatively small "families" of students. It was for this reason that Mr. Coffey saw "Man In His Environment" as an important first step toward achieving his vision for education.

In the spring of 1971 Mr. Coffey recruited two "master teachers" to chair the Science and Social Studies departments and charged them to plan and develop the "Man In His Environment" curriculum. During that summer the two chairs brought in several of the course's teachers to help with the planning process. The library's initial acquisition budget was devoted to material in support of the course.

Yet, although there was community awareness and support, an exceptional educational leader, teachers who were unafraid to experiment with innovation, and a substantial supply of resources committed to the course, "Man In His Environment" was phased out in the fall of 1973. What happened?

It is true that while the level of interest in environmental issues remained high, the intensity of interest had begun to wane. It is also true that Sam Coffey retired in the spring of 1973, and that some curriculum specialists and others outside the school had chosen to snipe at the course rather than use their expertise for its improvement. There is no doubt that these events contributed to the course's demise. The "bottom line," however, was that the teachers could not or would not work together to ensure the success of "Man In His Environment." What had been planned to be an interdisciplinary team quickly became a league with two teams. These teams competed as much or more than they cooperated.

There are several reasons why the teams failed to merge. Noone was "in charge" and there was no mechanism to "bridge" between the disciplines. Since each discipline has a different method for constructing a knowledge base, and hence a different "world view," neither team could agree with the other about either content or methods. Absent a mutually-agreed-upon decisionmaker, preferably one who could also serve the bridge function, unified curriculum decisions were seldom made. A second factor relating to this issue was the failure of the planners to provide sufficient time or resources for staff development. Teaming, even within a single discipline, takes specialized skills which must be developed over time. No effort was made to train the teachers how to work together across disciplinary lines.

Another cause for the failure of "Man In His Environment" was the requirement that the curriculum be developed as the course was being taught. "Plan today/deliver tomorrow" is usually a recipe for disaster in curriculum development. The fact that teachers from the two disciplines were not given a common planning period exacerbated the teaming and curriculum development problems.

"The Voyage of the Mimi"

An interesting counterpoint to the experience with "Man In His Environment" may be found in yet another environmental science course currently being offered on a pilot basis in four of the County's intermediate schools. When curriculum specialists at the Department of Instructional Services (DIS) set about the task of reinvigorating seventh grade science, they received reports from personnel at the Office of Instructional Technology (OIT) concerning an innovative prototype that was being demonstrated at various conferences. That program was Bank Street's "The Voyage of the Mimi." The course, which has a significant technological literacy component, combines text and videotape with computer based activities including simulation, logo, turtle graphics and interface equipment.

In this case, leadership from DIS and OIT energized public and school-based support. "Voyage," however, is unlike "Man In His Environment" in several important respects. First, the course is neither interdisciplinary nor team taught. Selection of teachers for the pilot was based on past curriculum involvement and on interest. Teachers were given training in a summer institute and through follow-up workshops during implementation. Staff from both DIS and OIT is readily available for consultation and technical support. Finally, while it is possible to modify the course to conform to local needs, the curriculum is fully developed and ready to be delivered.

News of the successful pilot of "Voyage" has been received enthusiastically by many other intermediate school principals who are trying to locate resources with which to include the course in their instructional programs. It will be interesting to observe whether the conditions which were met to ensure success of the pilot can be maintained throughout wider scale implementation. Of particular importance will be teacher training and outside technical support.

Technological Literacy: The Deck and Burkholder Years

Technological literacy moved from the computer science labs and into general discussion within Fairfax County schools in 1980 when Linton Deck was hired to be superintendent. Instructional technology and the issue of technological literacy were central to Dr. Deck's agenda. He used the term "techno-peasants" to describe educators who failed to comprehend the profound affect that technology was having on society and its educational institutions.

The impetus generated by Dr. Deck's leadership resulted in several important developments. The Office of Instructional Technology was created as a separate operating organization. Computer literacy for teachers and students became an important goal. Systemwide staff training in computer literacy was initiated.

Although Dr. Deck's tenure as superintendent was brief, his successor, Jack Burkholder, did nothing to inhibit the movement toward technological literacy. Under Mr. Burkholder's leadership, a three year Instructional Technology Plan for FY 1984 - 86 was adopted by the School Board. The major initiatives in this plan were computer literacy in grades K-9 and computer science and business data processing programs.

Perhaps of greater significance than these curriculum initiatives was the effort on the part of DIS and OIT to improve the level of teacher technological literacy. Faced with severe resource limitations, staff from DIS and OIT actively pursued additional funding from outside sources for teacher training and curriculum development. Two programs which emerged from these efforts were Project LITT and the IBM Model Schools Computer Literacy Program.

Project LITT (Learning Improvement Through Technology), funded by the U. S. Department of Education, was directed toward discovering ways to improve instruction by integrating technology. The emphases of Project LITT were in problem solving, science and writing. The grant was used not only to put computer hardware and software into schools but also to provide training for teachers with access to the equipment. These teachers were then encouraged to experiment with applications of technology to curriculum.

The IBM grant put computers in five County schools; one high, one intermediate and three elementary. With the encouragement of Dr. Lecos, the Assistant Superintendant for Instruction, the three elementary schools integrated IBM's Writing to Read into their instructional programs. The intermediate school incorporated its equipment into a Project LITT writing program. The high school is experimenting with instructional applications of the technology.

As a quid pro quo for receiving the IBM grant, Fairfax County agreed to provide facilities and staff development. In an effort to meet the terms of this agreement effectively, a portion of Project LITT and IBM funds were used to create the Professional Development Center (PDC), a centralized location where teachers could be trained to use the technology. The PDC has become an integral part of the County's long term technological literacy strategy; find creative teachers, get them appropriate equipment and materials, and devote sufficient resources to training.

The Thomas Jefferson School for Science and Technology

Along with the technological literacy initiative, both Dr. Deck and Mr. Burkholder supported greater cooperation between the schools and the private sector. An outgrowth of these dual thrusts was the Thomas Jefferson School for Science and Technology. A brainchild of Dave Sawyer, Assistant Superintendent for Management and Information Services, "High Tech High" gained initial support from Dr. Deck and Mr. Burkholder. The national consensus which emerged in the wake of "A Nation At Risk" demanded that bold steps be taken to improve science and technology education. Virginia's governor Robb indicated his desire to develop magnate science and technology schools throughout the state. The local business community created the Fairfax County Schools Foundation in order to raise additional funds for technology education, and it donated several million dollars worth of equipment to the project. It was the combination of these forces which led to the dedication of this new school in 1986.

"Applied Economics"

It was these same set of forces which led Fairfax County to adopt Junior Achievement's Applied Economics (AE) curriculum as part of its Program of Studies. AE is the first social studies curriculum to integrate technology. Technological literacy is a specific course objective. Computer hardware and software is provided with the package of course materials. Course activities have been designed which utilize these materials in order to reach both economic content and technological literacy objectives.

As is the case with "The Voyage of the Mimi," the success of AE can be attributed to the fact that all six conditions for curriculum innovation have been met. There is strong community support for the program, especially from the private sector. The leadership of Mr. Burkholder overcame many of the obstacles that arose as the program moved beyond its pilot stage in 1984. Resources to support the course are provided by the local business community. Teachers are trained by local Junior Achievement program managers. The curriculum, which has gained national renown for excellence, is developed through a dynamic, interactive process which has yielded high quality materials for both students and teachers.

Technological Literacy: The Spillane Years

Dr. Robert Spillane replaced Mr. Burkholder as superintendent in 1985. Dr. Spillane's agenda is directed toward improving teacher performance and upgrading the teaching profession. Fairfax County is currently piloting, under Dr. Spillane's direction, a performance-based career ladder system for teachers. When this new evaluation/compensation program is implemented next year, it will require both a reallocation of existing resources and a substantial allocation of new resources.

A shift in emphasis from technological literacy to teacher productivity and performance has been accompanied by diminished community support for instructional technology. This shift is nowhere more apparent than in last year's debate over the proposed Instructional Technology Plan for FY 87 - 89. The plan called for $15.3 million in additional resources over three years to support integration of technology across the curriculum. Not only did several members of the School Board express strong reservations about the utility of instructional technology but, in a stunning reversal, the County Council of PTA's -- for the first time in its history -- actively worked against a budget request.

A substantially revised three year Instructional Technology Plan for FY 88 - 90 was presented to the School Board in January of 1987. This plan, calling for approximately $4.9 million in new resources over the three years covered by the plan, reflects both new budget priorities and a reduction in public support for technology in schools. It is of some significance, given Dr. Spillane's interests, that a large portion of these funds are to be used to enhance teacher productivity.

Lessons from Fairfax County's Experience

Although these are but a few examples drawn from Fairfax County's experience with technological literacy in the curriculum, they clearly demonstrate that the six conditions noted earlier--community support, educational leadership, creative teachers, appropriate resources, staff and curriculum development--are each necessary (but none is sufficient) to assure effective integration of technological literacy into the classroom. Only in the cases of "The Voyage of the Mimi" and "Applied Economics," in which all six conditions have consistently been met, is there clear evidence of success. In the case of instructional technology, diminished public support and leadership with different priorities will result in far fewer opportunities for experimentation and innovation.

It will be instructive to track the progress of the Project LITT initiative over the coming lean years. Although a lions share of the new, scaled-back instructional technology budget has been allocated to support programs begun with Project LITT funds, there is as yet no clear curriculum focus for these programs. If the Project LITT initiative is to survive, then well developed curricula must either be located or created and then integrated into the Program of Studies.

Of special import to those interested in technological literacy is "Man In His Environment." The interdisciplinary nature of this course not only makes it different from the other programs cited above, but also means that it more closely conforms to the demands inherent in technological literacy curricula that seek to unite science and social studies. The lack of success of "Man In His Environment" can be traced to poorly planned staff and curriculum development activities. Beyond these shortcomings, and of equal or grater significance to interdisciplinary curricula, was the failure to provide both an appropriate "bridge" mechanism between the disciplines and a legitimate decisionmaker. Those who are interested in interdisciplinary approaches to technological literacy should therefore add "bridge mechanism" and "decisionmaker" to the list of conditions necessary for curriculum innovation.

Acknowledgements

I wish to express my gratitude to the following individuals who shared their knowledge and insights with me as I prepared this paper.

David Caughey
Science Department Chair, Robinson Secondary
Michael Chuey
Guidance Director, Robinson Secondary
Victor DiGiosia
Assistant Principal, Robinson Secondary

Francine Gallagher
Fairfax County Office of Instructional Technology
Barbara Leibbrandt
Fairfax County Department of Instructional Services
Phyllis Sullivan
Social Studies Department Chair, Robinson Secondary

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Bull. Sci. Tech. Soc., Vol. 7, pp. 167-172, 1987. Printed in the USA.
0270-4676/87

THE ROLE OF THE SECONDARY SOCIAL STUDIES CURRICULUM IN DEVELOPING TECHNOLOGICAL LITERACY

Charles S. White

Introdution

"Literacy" is a not buzzword for schools today. This is evident from the number of "literacies" that are advancing claims on the traditional subject-matter territory of the pre-college curriculum. Typically, each subject area of the school is asked to play a role in the achievement of these "literacies." Such is the case with "Technological Literacy" and the social studies curriculum. Focusing on the secondary curriculum only, this paper examines whether social studies should play a role in the development of technological literacy, and whether social studies is equipped to play a role in the development of technological literacy, specifically at the secondary level. The former task requires the formulation of a defensible rationale for social studies becoming involved in such a literacy effort, given the fundamental purposes of social studies education. The latter requires the design of a curricular framework within which the social studies' role may be most effectively performed, consistent with the content and methods of social studies education at the secondary level.

Rationale

The Nature of Technological Literacy

A person who is technologically literate is one who is comfortable living in a technologically-rich environment. This suggests a certain level of knowledge about technology and its impact on his or her life, as well as a level of skill in discussing and deliberating issues that are science- and technology-based. Technological literacy also suggests a level of comfort in employing a wide range of technologies in daily life, though this third point is not the focus of this paper.

Where Technological Literacy and Social Studies Meet

The relevance to social studies of achieving technological literacy was presented most cogently in an ERIC paper by John J. Patrick and Richard C. Remy titled Connecting Science, Technology, and Society in the Education of Citizens (1985). Educating for good citizenship has been a central purpose of education from Plato's Republic to the present. One notion inherent in some conceptions of self-government is that of active, informed and effective participation of citizens in the governng process. This idea is represented most clearly by the participatory democracy theories of John Stuart Mill, Rousseau, and Jefferson. Participation of the nature advocated by these theorists requires that citizens be (1) sufficiently informed on matters and issues that have arrived in the political arena, in order (2) to make rational decisions about those matters and issues with enough confidence (3) they are likely to act on those decisions (to participate) in a manner most likely to affect policy (effective participation). While certainly applicable throughout the school curriculum, the effort to prepare citizens in these three respects has traditionally fallen most heavily on social studies education.

Remy and Patrick pointed out, however, that the social effects of science and technology have greatly complicated the development of good citizens, as described above. Social issues relating to advances in science and technolo_ are growing in complexity, and the task of becoming informed on these issues requires a broad interconnection of knowledge fields in the school curriculum. Finally, Remy and Patrick noted the negative effects of science and technology antogonists. Represented in part by advocates of such psuedo-scientific positions as "scientific creationism," these antagonists misunderstand (or misrepresent) the nature of science and scientific inquiry, and generate suspicions that militate against a clear understanding of sience- and technology-related issues on the part of citizen decision makers.

In sum, if citizens cannot comprehend s-_ial issues because of the complexity wrought by science and technology, they cannot make rational decisions about these issues. Without confidence in their own decisions, and without understanding and tolerating the tentative nature of decisions made under circumstances of uncertainty, citizens will choose not to participate, or their participation will be ineffective in influencing the course of social and political policy. A reasonable conclusion to draw is that social studies education ought to be intimately involved in the development of technological literacy, since such knowledge and comfort are fundamental to good (effective) citizenship and, thus, fundamental to the purposes of social studies education.

Curricular Framework

Having argued that social studies should play a role in technological literacy, it is necessary to examine what the nature of that role should be, particularly within the secondary social studies curriculum. Again, Patrick and Remy (1985) provided a useful curriculum framework for contributing to technological literacy, and have done so recognizing the central content and methods of social studies education.

Three Elements of the Framework

Patrick and Remy presented a persuasive argument against a proliferation of interdisciplinary courses and in favor of incorporating threads within existing, distinct subjects that are likely to integrate the sciences and the social studies. In the former case, both teachers and students tend to find the demands of these courses overwhelming. Students find themselves studying concepts and issues that have been removed from their original context, and thus are deprived of sufficient understanding of the foundational disciplines on which the course is based. Teachers are hard-pressed to acquire sufficiently broad knowledge .o tie disparate disciplines together coherently. Moreoever, an historical perspective is frequently under-represented in such courses. The authors recommended, instead, linking science and social studies courses by two kinds of integrative threads: "cognitive skills in decision making and content themes pertaining to social issues in science and technology" (p. 45).

Given the earlier rationale-building discussion, I believe a third integrative thread is essential to an adequate curricular framework: participation skill development. Too frequently, decision-making ends with a statement of action one would or might carry out or lobby for if one were to participate in the political process. However, political participation is not an innate tendency of citizens, and involves knowledge and skills quite different from those likely to be addressed within other components of science or social studies courses. Moreover, participation is not an end in itself, but carries with it strong education effects, magnifying the impact of the two threads proposed by Patrick and Remy. The educative benefits of participation figure prominently within participatory theories of democracy (Pateman, 1970). In addition, the combination of social issues, decision making, and participation are well-represented within social studies education, particularly in what Barr, Arth, and Shermis (1977) referred to as the reflective inquiry tradition. (For a discussion of theoretical and philosophical links between participatory democratic theory and reflective inquiry, see White, 1985.)

Secondary Social Studies and the Curricular Framework

For a number of reasons, the secondary social studies curriculum provides a fertile field for cultivating technological literacy. Students at the secondary level are more able to manipulate fairly large amounts of data, and to analyze that data based on concepts that have matured over their school years. Expressing a high need for relevance, secondary students can be more readily drawn into an examination of science and technology issues than their younger counterparts. Making decisions on social issues that "count," and engaging in participation activities that attempt to influence public policies they view as important are experiences in which secondary social studies (and science) students can channel considerable energy.

Social Issues

A focus on social issues in social studies is extremely appealing among a significant subset of social studies professionals. In the November/December 1986 issue of Social Education, Engle and Ochoa proposed building a social studies curriculum around significant social issues and problems, with a heavy emphasis on decision making. Indeed, one would be hardpressed to find anothe reconceptualization of social studies that is more congenial to fostering technologcial literacy than this one. Nonetheless, even if one assumes little change in the current scope and sequence of social studies at the secondary level, a significant range of science and technology issues can be addressed.

World History and American History Courses. Paramount among relevant issues are the ways in which science and technology affect society, both in the past and present. For the former, World History is a natural locus of explorations on this issue. Examining the impact of the power loom on the emergence of the Luddite Movement is a case in point. Of course, World History courses also provide opportunities to examine the history of science and scientific inquiry, a point stressed by Patrick and Remy (1985). U.S. History is similarly ripe with science- and technology-related social issues. One area I find particularly interesting at the moment is the effect of science and technology on interpretations of the Constitution, an appropriate area of examination during upcoming bicentennials.

American Government and Civics. A study of the Constitution, of course, is also central to American Government and Civics courses. These courses offer numerous opportunities to explore science and technology issues. Consider the topic of political participation of citizens. Computer-based technology has made interactive television a reality, with the QUBE system of Columbus, Ohio, a useful example. It is technically possible for people to "vote" on referenda from the comfort of their easy chairs by pushing a button and sending a signal to a central facility. Imagine the potential for citizen participation: the pure democracy ideal of ancient Greece, where representatives are no longer needed to express the popular will and individual citizens vote on national legislation. The issue: given the chance to vote on hundreds of issues, great and small, how many of us would take the time to research each issue rather than cast our votes hastily and thoughtlessly? If it was easy to cast a ballot for President at home, rather than having to go to the polling place and fill out a ballot, would the result be more uninformed citizens voting? On the other hand, given our faith in the educative powers of participation, perhaps such direct participation would enhance the knowledge and wisdom of the citizenry.

Consider another issue relating to American government and civics courses: the extent to which the government places undue faith in technological solutions to difficult domestic and foreign policy problems. The Strategic Defense Initiative might be an exemplary case in point. In the context of public schools, some would suggest that computer literacy efforts represent a desire to find a technological panacea for that institution's current woes.

Sociology. The application of science and technology has raised a number of ethical, legal, and moral issues in areas one might associate with the subject matter of sociology. For example, when does the noble prolongation of life change to the demeaning prolongation of death? Who shall decide which patient receives the exotic and enormously expensive medical procedure while the other patient dies? How does the quality of social interaction change when telecommunication permits invisible dialogs and telecommuting? Are we at risk of becoming so dependent on technology that we are helpless in its absence (when the calculator's battery dies)?

Economics. In economics courses, the use of technology to improve productivity carries with it a host of social issues. Shall we permit the widespread increase of "steel-collar workers" (robots) to displace human employees? What limits shall we place on programmed trading in the financial markets? How shall we balance the "externalities" of technological progress (e.g., pollution, unemployment) with American's qualtiy of life?

Global Studies. A fascinating area of study called geophysiology views the globe, and its thin atmospheric envelope, as a total living system, of which humanity is only one small, though influential part. Given the power to permanently alter the "geophysiology" of the global environment, what limits shall we place/can we place on the application of science and technology to avoid dooming ourselves to extinction? To what extent can we depend on future scientific and technological advances to balance the ill-effects of current applications of science and technology?

Law-Related Education. New technological developments generate new legal questions, challenging existing conceptions of justice and fairness. How far shall the protection of intellectual property extend? Shall it extend to the "look and feel" of computer software? Shall it extend to new genetically-engineered life forms? (Shall these be copyrighted or patented?) What is the legal status of a frozen *in vitro* embryo when both biological parents ar deceased?

The social issues enumerated above only begin to represent the scope of technology- and science-related issues relevant to existing courses within the secondary social studies curriculum. Each issue ultimately resolves to a call for a decision, demanding the application of effective decision making skills.

Decision Making

Decision making is a skill and, as such, can be taught and and can be practiced by application to social issues. As a skill, the process of decision making can be reduced to a series of steps that, if followed, are likely to result in a rational decision. One useful tool in teaching the process of decision making is the decision tree, provided by Remy and La Raus (1978) and derived from the decision sciences. The tree illuminates four basic elements in decision making: (1) discovery of the need for a decision, (2) identification of the important goals and values relevant to the decision, (3) identification of alternative courses of action, and (4) prediction of the consequences (positive and negative) of alternative courses of action in light of the goals and values identified.

As clean as this conception of decision making process may appear, we must consider (as Patrick and Remy do) the realities of citizen decision making. The decisions citizens make are fraught with risk, in that the consequences of alternative courses of action are not predictable with certainty. Moreover, circumstances may change such that, given the same occasion for decision, a different alternative might be chosen. This latter point underscores the tentative nature of citizen decision making, and the need to emphasize a willingness to reassess past decisions in light of new information.

Within the context of social issues, decision making of the nature described here represents a useful link between science and secondary social studies:

> Science, or more precisely the methods and results of the many sciences, contributes vital knowledge about the possibile consequences of science- and technology-related decisions. The social studies contributes ethical and value perspctives to the decision making process. They shed light on the moral, social, and human values outside the realm of science that are involved in such choices. They help decision makers -- whether they be individuals or groups -- rank and select among preferred outcomes and make value judgments. They can also contribute knowledge about the hsitory of an issue and the public policy processes associated with it. (Patrick & Remy, 1985, p. 53.)

Participation

The third and final element of the curriculum framework is political participation, another skill area largely ignored in the secondary social studies curriculum but crucial to a complete preparation for effecting democratic citizenship.

Much of what passes as instruction for participation reduces to descriptions of a narrow range of activities (like voting), and typically vague recipes for actions of questionable effectiveness in influencing distant policy makers. Such practices do not instill a high sense of political efficacy among the secondary student population. It is not surprising to find, then, that few students in a national survey believed they could help solve social problems related to science and technology (Hueftle, Rakow, and Welch, 1983).

Two approaches to participation skill development may help reverse this sense of helplessness for secondary social studies students. First, instruction in political participation should advance on two levels, described by Newmann (1980) as communal (local) participation and societal (national) participation. This duality recognizes the very different participation environments at the local, proximal level as opposed to the national, distant level. Participation activities and strategies that are appropriate and effective at one level are distinguished from those that are more appropriate and effective if employed at the other level. For example, active participation in a political party might be the most effective means to influence societal-level (national) policy, while neighborhood canvassing might be more likely to influence communal-level (local) policy.

Second, recognizing the dual nature of participation, the secondary social studies curriculum should provide opportunities for students to become involved in both communal and societal participation activities. One provocative example is offered by Engle and Ochoa (1986), who recommend that students be able to pursue "citizen internships." These internships would allow regular participation in some civic activity, most likely of the communal type. Internships, and other vehicles for genuine political participation, recognize the educative benefits of participation. Moreover, they allow students to achieve a sense of completion and closure, by initiating actions derived from their analysis of science- and technology-related issues and their decision making deliberations.

Summary

The case has been made for the secondary social studies curriculum to play a significant role in the development of technological literacy. Doing so is consistent with the purposes of social studies education, and can be accomplished without doing violence to the fundamental content and methods of the field. An effective role in STS is most likely to be achieved through a curricular framework that integrates science, technology and social issues within the context of existing secondary social studies courses. That framework uses science- and technology-related social issues as content, and decision making and participation skills as methods of understanding and acting on these social issues.

An effective social studies role in technological literacy should foster an ongoing alertness to social impacts of science and technology. This means focusing, for example, not on the automobile (the technology) but on the emergence of suburbs (the social impact); not on the atomic bomb, but on the arms race; not on atomic power, but on nuclear waste dumps; not on medical life-support systems, but on living wills. Finally, while the approach to technological literacy discussed in this paper should yield positive results in addressing these and other current social issues, the proposed curricular framework should also sharpen students' awareness of issues yet to be identified -- issues precipitated by now-unforeseen scientific achievements and new technologies.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 173-177, 1987. Printed in the USA.
0270-4676/87

WEBBING CURRICULUMS: STS APPLICATIONS

Edward R. Fagan

Background

Science, Technology, and Society (STS) is defined as the understanding of how science and technology shape and are shaped by society. Implicit in the definition is a concern for the problems/opportunities science/technology create, and how citizens can most effectively relate to them. The acronym connotes much more, but the teaching application embedded in STS philosophy is that any high school subject can use STS concepts and instructional techniques to deepen students' viewpoints about the effects of modern technology on their lives without sacrificing their attainment of academic excellence.

That philosophy is not new. In the first edition of The English Journal (1912) Edwin Hopkins' lead article complained about the imposition of college curriculums on high school programs and, recommended as counter point, "practical" curriculums; that is, those based on problems posed by the then increasing industrialization and its potential for affecting educational changes.

From Hopkins' day to the present, tensions between academicians and pragmatists concerning curricular reform have taken bizarre twists. At present, popular concerns for a "basic skills" curriculum triggered by students' "poor" performances on standardized tests and by commissions which identify education as being "at risk" are challenged by other commissions which insist that students' undergraduate college education is "too narrow" and that high school students' limited knowledge of science may be partially explained by the atomistic way the sciences are taught, that is, by not presenting common concerns between the sciences and technology.

One organization which has the potential for bridging this gap is STS which had its beginnings with C. P. Snow's The Two Cultures and Jacques Ellul's La Technique which was translated into The Technological Society in 1964. Those authors' early concerns about technology were fueled by later books such as Deschooling Society, Silent Spring, Future Shock, Whole Earth Catalog, Small Is Beautiful, The Human Prospect, The Limits of Growth -- all of which helped to spawn STS programs on college campuses during the sixties and early seventies. Today (1987), 1,000 colleges have courses in STS; 50 universities have established departments or programs dedicated to STS ideals including Stanford, MIT, Vassar, Wesleyan, and Lehigh.

American and Canadian high schools, too, have been responding to the influence of STS programs -- an influence Great Britain has implemented since 1977 and which is currently affecting science programs throughout the United Kingdom (UK). Canada, perhaps because of the destruction caused by acid rain and other technological influences, has implemented a tenth grade STS curriculum throughout the Province of British Columbia for the 1986-87 academic year. If successful, other Canadian Provinces may adapt the STS curriculum for next year.

Applications

Topics generally found in STS curriculums might include: acid-rain, the computer revolution, hazardous waste disposal, high-tech and the balance of trade, health care costs, genetic engineering, small scale agriculture, automation and similar matters. Some of these topics have obvious science/social studies contents, but all of these subjects can be handled by all disciplines in any high school, provided that teachers are willing to plan, cooperatively, with their colleagues. In some cases, this planning means team teaching; in other cases it may mean applying the "writing-across-the-curriculum" idea; that is, every teacher in every discipline a teacher of writing. In still others, it may mean developing correlated teaching units, for example, Colonial Literature and Colonial History, "sets" in mathematics and "sets" in descriptive linguistics.

Since the aforementioned STS topics have built-in biases favoring science and technology, let's use a more common unit topic "Records" as STS exemplar. When broadly defined, records can apply to just about every subject in any school, K-12. Once defined, contents and techniques for teaching the records unit will be applied to the following disciplines: Arts, Early Childhood, Health and Physical Education, Industrial Arts, Language Arts, Mathematics, Science, and Social Studies. There will be overlaps in such a presentation, but where interdisciplinary studies are concerned, such overlaps are expected and appropriate.

Depending upon students' grade levels and backgrounds, discussion and demonstrations of their experiences with all kinds of records - first as a term and then as a concept - can provide a foundation for shaping the records unit.

Students' daily experiences with records probably begin with the vinyl or plastic disks which their favorite singers turn into albums; or perhaps their experiences come from their use of floppy disks with computers. Similarly, asked to record something on a tape, on a stenographer's pad, students recognize the verb form of record. Then, generalizing beyond those experiences, there are a myriad of meanings which cover everything from archives to cave paintings.

In fact, everything has a record: physical objects (stones, walls, desks, chairs) through carbon dating; ideas (truth, beauty, courage) through time-changed sociological descriptions of those abstractions in different cultural epochs. With such breadth as a baseline, let's now explore the application of the records unit to the previously mentioned disciplines in the order they were mentioned.

Arts (A)

There are media within the arts which can be bonded with other disciplines. These include film, videotape, drawing, calligraphy, print making, graphics, fabric design and composing (sound tapes for mood, for example). Overlaps, as mentioned previously, are bound to occur with interdisciplinary approaches to instruction. But with records as focus for the above-mentioned media, some of the possibilities using just film might be - What are some common elements of film which make it a medium for record keeping? What other media have been used by humans to keep records? (Here, anthropology, archeology, history, graphic languages and the like can be bonded with the study of film.) Another tack might use bonding between film and the sciences: chemistry (film coating, silver nitrate); physics (levers and gears of the projector); mathematics (timing and calculations of frame speed for slow motion). Where other disciplines are involved, some form of team teaching or supervised independent study would seem advisable. If, however, such teaming would be impossible, then a writing-across-the-curriculum approach might serve to meld the disciplines by having some mutual arrangement for teachers of a given discipline to check the contents of same while language arts teachers and others check writing style and mechanics.

Early Childhood (EC)

Records, according to these children, might be realia; that is, the literal vinyl disks which tell stories, play songs or games, and/or carry on question/answer conversations. After a teacher-led discussion of records, students may identify common features which characterize many classroom records: that they have a pattern--beginning, middle, and end--; that they sometimes have a moral or message (Aesop, Grimm); that they have characters who are more alike than different no matter where the record was made.

These language arts discoveries about records in early childhood classrooms, can be enhanced by having students clip pictures from newspapers or bring to class family photographs. Then, these resources are used with the idea that students will create their own records--of their family, of some animal, of some incident, and/or of a tall tale or legend.

Depending upon the materials children use for their records, a number of interdisciplinary questions might be introduced. How would your record (story, tall tale, legend) be changed if the automobile had not been invented? If television had not been invented? If your baby (sister/brother) had not been born? If Black Africans had not been brought to this country?

Again, interdisciplinary bonding for early childhood would be a function of how much and what information was to be taught. Still, how cameras work, how newspapers can make so many copies of the same thing, what animals are in danger of dying out and why, how automobiles work, why people have different colored skin, what slavery was and a host of related interdisciplinary questions could be addressed. Delivery systems could be team teaching, field trips to museums/newspapers, films on ecology, speakers on ethnic differences and a host of other related activities--all involving records of one sort or another.

Health and Physical Education (HPE)

Records in this field are part of most students doily living. In every sport, records of some sort are established: batting averages, statistics on all phases of football, track, swimming and all phases of health. From growth records through infectious diseases to diets and similor programs, students are keenly aware of records.

As with the previous disciplines, the Health and Physical Education bonds are myriad: mathematics, for time and distance work; physics, for the principles of the lever in pole vaulting, high jumping, blocking in football; chemistry, with the effects of steroids, diets, fatigue; biology, with organ systems and their effects; foreign languages with vocabulary of sports; language arts with all forms of writing about sports. Depending upon time, objectives, and competencies, we can develop a range of instructional strategies which will broaden and deepen students' knowledge of records as the concept bonds with other disciplines. Abuses of records through disinformation about technology, drugs, popularity myths might also be part of a HPE unit on records.

Industrial Arts (IA)

Records in Industrial Arts provide a rich vein for interdisciplinary projects which can be mined to serve STS objectives in many ways. First, consider some of the materials used in the discipline: woods, ceramics, metals, plastics, hand/power tools, microcomputers and others. Then, consider IA perspectives necessary to deal with records about: cultural influences and tradition, people's needs, sparsity, density, climate, construction materials, social influences, economic factors. Any and all of these topics could involve other disciplines such as social studies, English, mathematics, the sciences, art, physical education and health.

A record of sparsity, for example, could be part of a social studies topic which showed that local customs demanded that field stone instead of wood or brick be used in building houses. That custom, in turn, could influence the popularity and education of the community's young men with masonary tools, particularly with regard to fieldstone. Within the community, the construction itself would require searching for deeds, surveying the land (math/geometry), examining the topology of the land (geography) for water supplies (hydrology) and drainage (ecology) drawing up contracts (social studies. business education) based on records of other contracts (history, civics). In short, IA, like the other disciplines, could become an integral part of the records unit. Field trips, the school as community, workshops, cooperative work programs are just a few of the instructional techniques which could be used with the IA center for a records unit.

Language Arts (LA)

Records, from my biased view as an English teacher, are pivotal to all units; that is, language arts skills are one means for record keeping in all disciplines. Could there be a mathematics, a chemistry, a physics without the specialized vocabulary of those subjects? Even in mathematics, the so-called word problems turn upon an effective comprehension of language.

Today, language arts are more broadly defined as "communication," a term which connotes non-verbal, graphic, oral and phatic (ritualistic) languages. The ubiquitous impact of language on human behavior is far-reaching but, coupled with world-wide media, its potential for mind pollution is enormous. As Huxley put it, "Words are the tools of tyrants of warmongers; they are the opiates in religion and entertainment; they are the palliatives in government and education, and they have seldom been so disasterously influential..." as they have been in the twentieth century .

Huxley's hyperbole aside, the examination of linguistic pollution in all disciplines from alpha to omega would deepen students' understanding of the word-webbing at the center of human discourse. Specifically, the distinction between fact and opinion in all sources of communication is one of the top STS priorities.

Our records unit, in this language arts context, implies the usefulness of some of our previous activities in other disciplines. In mathematics, the language of word problems; in the sciences, the vocabulary and descriptions of scientific phenomenon--especially, the language euphemisms used to mask nuclear survival risks; in social studies, the language of stereotypes and racism in arts and industrial arts, non-verbal and stylistic communications--all are LA bonded.

Mathematics

Records in mathematics, as mentioned earlier, involve conventional data: charts, graphs, statistics as well as the word problems so closely tied to the language arts. Too, the uses of microcomputers in mathematics and other disciplines adds another strand to our bonding possibilities. For example, composition/organization is common to all disciplines from art to zymurgy. Flow-charting with its organizational symbolism, computer languages with their special grammars, bond well with the sciences, social studies, early childhood, and other academic disciplines. "Set" theory in mathematics can be effectively bonded with "form classes" in descriptive linguistics; mathematical formulas bond well with symbolic transformational grammars. Industrial arts' concerns for measurement tie closely with several features of mathematics, particularly geometric designs. As with the other disciplines, mathematical delivery systems for bonding might involve team teaching, cooperative planning, field trips, community involvement and similar cooperative group approaches to concept sharing.

Science

Records, depending upon the particular science involved, range widely from astronomy to zoology, in the sciences. Common to all of them are systems and procedures which cut across all disciplines. We have only to decide which science and what other disciplines we want to explore in an interdisciplinary, STS application.

Records in biology can radiate in many directions but, for applications of bonding, consider the following exercise taken from the Pennsylvania Department of Education's Equal Rights: An Intergroup Education Curriculum (p. 150).

> Discuss the uses of the phrases environmental and social conditions in the modern world...What is a modern environment? What traits are necessary for survival in today's world? What traits were necessary 200 years ago...1,000 years ago...Is it true that biology is destiny?

Language arts, biology, social studies and subsets of those disciplines are implicit in the above-listed assignment. So, too, are the STS implications about the values and judgments central to answers one makes to the questions. Basic skills in each of the subjects are also inherent in the search for answers to the thought questions and to the implied applications of problem solving strategies.

Social Studies (SS)

Records in social studies are abundant because of the academic clusters within the discipline: anthropology, civics, economics, geography, history, political science and others depending upon classifications (psychology, social psychology). Numerous record forms an be used with SS subsets to examine archaic languages, historical chronologies, case histories, legends and similar topics.

Interdisciplinary approaches to STS objectives with SS as core might use the government publication Statistical Abstract of the United States to find national percentages of minority groups as compared to local percentages in nearby communities. Percentages, ratios, quotas could be mathematical spin-offs from the search of the statistical records.

Language arts spin-offs might come from an exercise where family names and origins for ethnic groups are examined to discover the contributions of those groups to modern American culture.

Summary

After defining STS and its goals with respect to interdisciplinary studies, we explored some of the means for using STS approaches to various disciplines in K-12 curriculums. Everyone agrees that the STS approach is not new. Today, however, growing concerns about survival in a deteriorating environment imply that any process which shows the common bonds of responsibility among all disciplines has the potential for improving students' academic bonding skills by showing them that each subject need not be a separate self-contained unit; rather, each subject could and should be linked to other subjects so that applications of all disciplines can provide a basis for our examination of technological applications to today's world.

Studies show that students who have been taught disciplinary webbing retain more of the subject than their counterparts who think that each subject is a separate, self-contained entity. STS as a content/process teaching philosophy is growing steadily world-wide, and it augurs a new generation of students -kindergarten through college - who are concerned about maintaining spaceship Earth in optimal condition against the mindless forces of technology.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 178-183, 1987. Printed in the USA.

DEFINITION OF STS: FOUNDATION FOR THE YOU, ME AND TECHNOLOGY CURRICULUM

Minaruth Galey, E. Joseph Piel and Leon Trilling

One of the many problems in public education is that of preparing students to live in our highly developed technological society. Their parents and teachers were educated for, and have lived in, the Industrial Era most of their lives and have little understanding of this information age.

The first recognition of this problem came with the support of the National Science Foundation for the Engineering Concepts Curriculum Project in 1965. That effort produced the first high school textbook dealing with the subject of science, technology and society, titled The Man-Made World.[1]

Renewed emphasis was given in 1973 when futurists like Daniel Bell and Harold Shore identified it as critical. As recognition of the need grew in public education, many educational approaches were developed across the subject matter areas of the secondary school level, and now, at the elementary levels.

One of the first ways to help science students understand this society was to include a lesson about the effects of a local technology in courses of science. In time, learning modules and units were developed and published to infuse societal issues into the science curriculum.[2] This new material added meaning to the students' understanding of science as well as of their society. As the interest and knowledge of some teachers grew, courses on topics of science and society were written and taught. Examples include: "Energy and Us" at Kelly Walsh High School in Casper, Wyoming and "Mankind: A Biological/Social View" at the Clarkstown High School in West Nyack, New York.[3]

In the social studies there was a similar pattern of infusion of science and technology issues into courses of history, American Government, etc.[4] In this curriculum area, the global nature of the impact of technology on society was emphasized.

In vocational education there began a major but evolutionary change from the craft approach of industrial arts to a curriculum of technology education to prepare young men and women for the work of our technological society. This new, developing curriculum con-sists of many courses, including an increased attention to math and physics. It also emphasizes the social impact of technologies.

A fourth approach to preparing students to live in this technological society has also been initiated. This effort introduces students to the whole field of science, technology and society (STS). This is a relatively new field of study which is directed to understanding the interactions among and between science, technology and the society.

This approach requires the addition of a new academic subject to the high school program. One group chose this direction for developing the "You, Me and Technology Project" (YMT). They would use the subject matter of STS to help students become effective citizens in this technological society. For that purpose they decided to develop the curriculum of an introductory course which would provide an overview of the entire field of STS as an introductory typically does. Because of the purpose of the course and the interests of the students, attention would also be directed to the effect of the interactions among science, technology and society upon individuals, their lives and choices. The decision to introduce students to the whole field of STS would provide a broad understanding, in addition to specific knowledge of separate STS problems, such as acid rain.

The YMT Project as a whole is described elsewhere,[5] and all discussion here is directed to the curriculum.

The term "curriculum" refers to the purpose, goals, objectives, subject matter content, teaching strategies, activities and readings for the students with some suggestions for evaluation. A curriculum is developed from a philosophy of education and from identified needs of individuals, society and/or the discipline. The philosophy of the YMT curriculum is based on Whitehead's advocacy of a multi-disciplinary curriculum that shows the interrelatedness of knowledge,[6] and Dewey's view that the study of society and social problem-solving are the unifying principles of curriculum organization.[7] The curriculum needs are: (1) to prepare secondary school students to work and live in a technological society; and (2) to meet society's need for competent citizens who can make intelligent decisions on technological and scientific issues.

The next step in curriculum development was the choice of topics for an integrated curriculum and the outline of content to be taught under each topic. The authors of this paper, the project director and her technical consultants, chose the topics to provide an overview of the field of STS in relation to the following items:

- Content areas of technology: systems, materials and energy
- Universals of technology for all cultures: communications, production and transportation
- Components of these universals: tools, machines, power, and energy
- Problems of today's society, including: productivity, conservation, protection of the environment, power generation, and social arrangements to fit its value to a democratic society
- Interests and needs of the viewing students

A number of topics were chosen for the integrated curriculum and the content outlined:

consumerism	information processing
technology revolutions	alternative energy sources
health technologies	global population patterns
agricultural technologies	communications technologies
transfer of technologies	transportation technologies
space exploration	risk and safety with technologies

The expert curriculum designers decided to define the field, following Bacon's elegant statement:

Human beings command Nature by obeying her.

"Obeying Nature" requires knowledge of the laws of nature which is science. "Commanding Nature" is to apply the laws discovered by science, through technologies in particular. "Human beings" refers to society. Bacon is also emphasizing that technology is a product of human effort, like a sculpture or a book, as opposed to being inhuman or somehow alien to the human race.

However admirable, this definition had limitations as a basis for curriculum content design. The designers then devised the following guidelines from their own research, study and readings. They have served through more than six years of the YMT Project's development as a highly satisfactory definition and are outlined here for students and teachers.

Principles of the Field of Technology and Society

About Technology

1. Technology is developed for a purpose.

2. Technology is increasingly based on the logic and methods of science.

3. Technology is increasingly complex, often developed as systems of technologies.

4. Technology requires ad hoc problem solving.

5. Feedback is a characteristic of technology.

6. Technologies can be transferred from one culture to another.

About General Effects of Technology

7. Trade-offs in technology, that is, benefits compared to cost in resources, values, and money, must be considered before and during the development of a technology.

8. Technology always carries a degree of risk, since we can never predict all of the effects of that technology.

9. Technology always produces changes in the physical and social environment.

10. Technology has produced great increases in the speed of communication.

11. Mass production is possible only through technology.

12. Technology is the means of manipulating materials, energy, and information.

13. Technology can lead to optimizing use of resources--labor, capital and energy.

About the Interaction of Technology and Society

14. Technology is an agent of social change.

15. Social, historical and cultural factors determine if, and how, a technology is used.

16. Technology has been a primary cause in the redistribution and growth of human populations of the world.

17. The development of technology is affected by individual and social motivations for innovation and social inertia.

18. Technology has contributed to the redistribution of wealth and social status in the United States and in other countries.

19. The balance of power between social groups and between nations is often shifted by the effects of technology.

20. The economic gap among nations has been enlarged by technology.

21. Political and military means are changed by technology whether for good or evil.

22. The whole context of political problems and discourse has been changed by technology.

23. Technology influences the leverage of leadership.

24. Mores are often changed in response to technology.

25. Technology typically poses new value questions.

About Interactions of Technology and Individuals

26. Technology has reduced physical labor for human beings.

27. Technology has increased the specialization of labor.

28. Individuals have new opportunities for jobs and careers.

29. Those new jobs require new skills or higher levels of skills.

30. There exists a love/hate relationship of human beings for machines.

31. Technology has provided an abundance of products and services, making individuals consumers at a high level.

32. Technology markedly increases the range of individual choices--of jobs, of materials, etc.

33. Technology has increased the interdependence of people in communities and among communities.

This list does not imply that all the principles carry equal emphasis in the introductory course developed as You, Me and Technology. Items 17-23 are used briefly because they require a great deal of background knowledge. However, Item 25 is so important that value questions are specified under every topic. Probably a whole STS program of studies could be devised with only a few additions to these guidelines.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 184-185, 1987. Printed in the USA.
0270-4676/87

TABULA RASA OR RESERVOIR

John Maryanopolis

Before we begin to look at the innovative educational concept of integrating science with technology and both of these pieces with society, we have to take a new philosophical view of education. We must reject John Locke's powerful view of the Tabula Rasa for another view. We must see ourselves as teachers responsible for tapping the reservoir of the mind. We should act on the assumption the talent is already there. This assumption as opposed to the blank slate assumption changes the way we teach. What if we see the role of the teacher to "draw out" as opposed to "implant?" Reservoir versus blank slate--draw out versus implant.

If we have a blank slate on which to write, we can divide education into segments allowing us to departmentalize education to the extreme point where we create a physical plant with halls used to separate curricula. There is the English section of the building, the science section, the foreign language section, the mathematics section, etc. The departmentalization has reached such a degree that students become upset if a teacher corrects a spelling error in a mathematics class or teaches a scientific point in an English class. They will argue against the "cross-over" teaching using the system we have created to defend their argument.

If we adopt the philosophical position that we have a reservoir to tap, we start with an integrated system. A system created from the understanding that science is language and language is mathematics and mathematics is art and art is history and each of these is an integral part of society. If our function as teachers is to draw out the resources in the reservoir of the mind, we are inhibited when we attempt to departmentalize education. We now start with an understanding that the raw talent is already in the mind of the student/child/human.

With this philosophical (if you will allow the buzz term) paradigm shift as a backbone to our teaching methodology, we easily create educational programs that address the concerns of STS. As teachers we now produce a program that integrates the arts, the sciences, the sociologies. We bring together a history teacher, an art teacher, a physical education teacher, a mathematics teacher, a science teacher, and a resource teacher to design a program integrating what used to be called "departments." Once we start to design the program for students we are confronted with our own teaching method of the blank slate and know we must change methodology.

We are now forced to approach students from the point of view of the reservoir. We are forced to see that all students/children/humans have a talent that can contribute to the whole project. The students with writing talent can aid the students with science talent and the students with physical talent can aid the students with design talent, etc. Suddenly! every student has potential worth and can contribute to the success of the project. Suddenly! everyone is potentially gifted. Suddenly! our job is to draw out the gift in each student. We no longer have to deal with the political or the psychological problem of identifying the gifted student/child/human. We let them identify themselves in the area where they can push the integrated project to a successful conclusion.

Rather than"implant" godlike on blank slates, our role as teachers is to draw out each student's talent, to tap a resource, to guide them towards self-reliance.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 186-196, 1987. Printed in the USA.
0270-4676/87

CONTENT APPROACHES FOR TECHNOLOGY EDUCATION IN THE SECONDARY SCHOOL OF AMERICA

Donald Maley

The issue of implementing technology education brings with it a variety of questions that need our attention as well as our resolve. The breadth and scope of the implementing problem is magnified by the breadth and scope of technology itself. Technology has become one of the most pervasive elements of the human existence in this latter part of the Twentieth Century. Technology has taken the human from the cave to the skyscraper or farther on to the space station; from the digging stick to the gang plow of the wheat belt; from the slow pace on the footpath to the supersonic speed of the SST; and from clay tablets to computer storage and information retrieval that reaches beyond normal comprehension.

A second dimension of technology education that goes beyond the study of technology is the issue of for whom is such education of vital importance or a necessity. Here again, there is no simple answer. As participants in a democratic society, one could generalize that all citizens in an advanced technological era should be technologically literate. This condition might give rise to a series of questions such as: Literacy regarding what technologies? To what degree or extent should or can one be technologically literate? Is there a point in technological understandings below which one would be classified as technologically illiterate?

Technology education has been identified as a "new basic" in our educational requirements. Others have labeled technology education as a component of the "New Liberal Arts Program" (Goldberg, 1986) or "Technology as a Liberal Art." (Kanigel, 1986)

The thrust of this presentation is not whether, or if, we should pursue this "new basic" in education. Rather, it is to examine some ways in which technology education can be implemented in the secondary schools in this country. It is ironic, but nevertheless significant, that this field of technology education is finally assuming national and international recognition as a "new basic."

The discussion that follows will be divided into five segments. The first four should contribute to the background for the suggestions regarding content development. (See Fig. 1) These four segments are:

1. The setting for technology education.

2. Student outcomes or expectations for technology.

3. Guidelines for technology education.

4. Technology education and the questions raised.

The fifth section deals with two different, but related, topics. They are: content models for technology education, and content implementing technological literacy.

Content for Implementing Technology Education

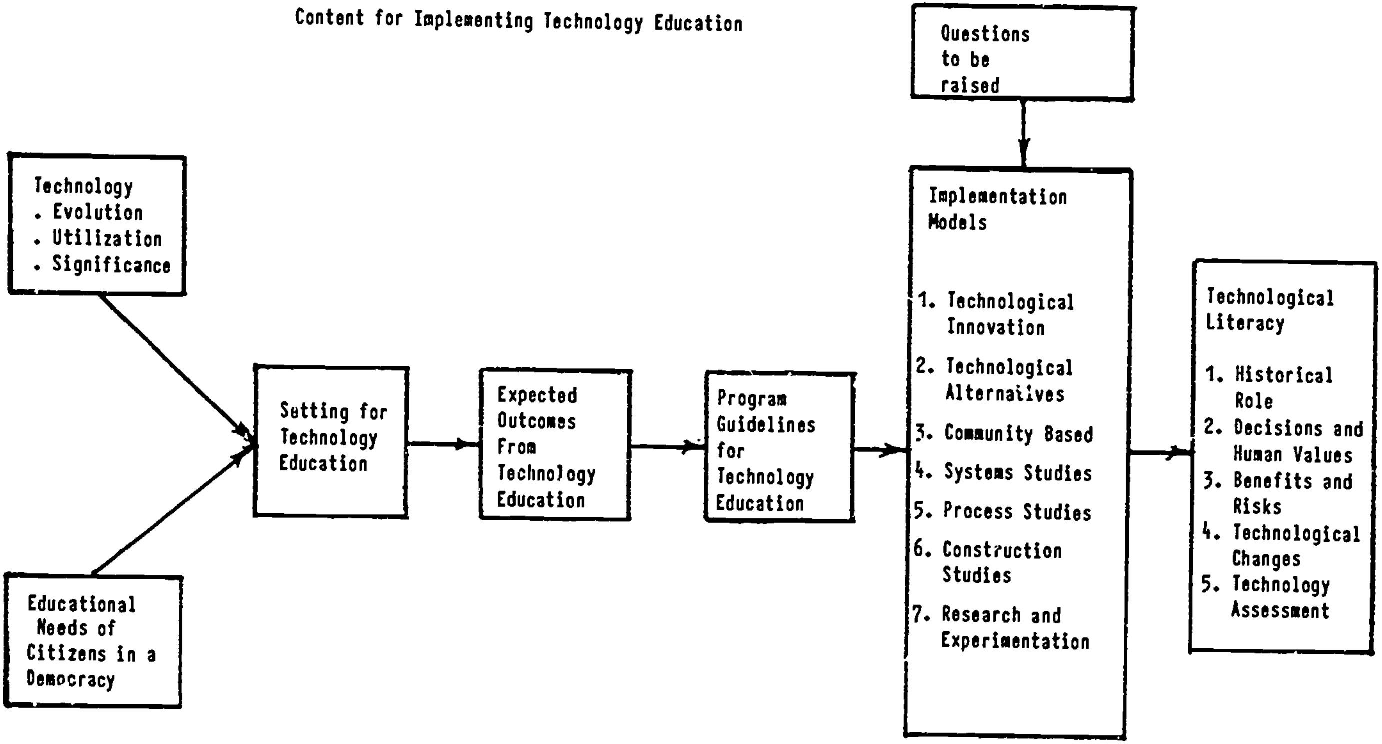

Figure 1.

The Setting for Technology Education

The first major point that must be made as one pursues the task of implementing technology education is tc define or describe the setting in which education is to take place. That is to say, that technology education does not occur in a vacuum. As an important dimension or a "new basic" in the school effort, technology education, if it is to be effective, must be perceived and carried out in the context of the modern school setting with its individual, local, state, national and international contingencies.

The following are some of the dimensions of the setting in which technology education implementation must take root as well as make its contribution:

1. There is a national commitment to the maximum development of each individual.

2. The governmental processes are based on the citizen's ability to make decisions related to the needs and desires of people as well as the national interest.

3. There is growing sensitivity toward a world community that has concern for the problems of hunger, health, water scarcity, pollution (including land, air, sea, and space), energy, industrialization, communications, standard of living, human rights, war and human annihilation.

4. There is a school population that consists of all levels of ability, as well as great diversity, in interests, motivations and aspirations.

5. There is a school system that functions in a highly pluralistic society.

6. There is a school system that has had strong traditions, many of which antedated the current national and international complexities.

7. The school functions in a fast-changing society characterized by an acceleration of technological innovation unprecedented in the history of humankind.

8. The school exists in a society in which there is a premium on the individual's ability to communicate, solve problems, make decisions, process information and interact with a broad range of technologies.

9. The school functions in a society in which the human has the potential to define and design the kind of a future that is desired.

10. The school exists in a knowledge-based society where knowledge and understanding, along with synthesis and decision making, become the essential ingredients of progress and plans that have far reaching implications for the individual and society as a whole.

Student Outcomes or Expectations from Technology Education

The second major point in the implementing process deals with the projection of student outcome or capabilities toward which technology education may be a contributor. This point addresses the personal (student) outcomes that educators directing or managing technology education programs might expect to achieve. It is important to know that there is, and must be, a direct link between the previous "setting" discussion and the expectations from technology education.

1. The student would develop a broad perspective on the role that technology has played in the evolving civilizations, past and present. (1)

2. The student would develop a capability for scientific inquiry and problem solving.

3. The student will develop an attitude of openness toward technology and not one of intimidation.

4. The student will develop an understanding of underlying science and mathematics concepts related to certain technologies.

5. The student will develop an understanding of the social and environmental impacts of selected technologies.

6. The student will develop and use a multi-disciplinary approach to the study of a given technology or technological innovation.

7. The student will develop an understanding of the relationships as well as impacts of technological decisions and human values. (1)

8. The student will develop an increased understanding of the changes occurring in current technologies. (1)

9. The student will develop an awareness of changes taking place in the present society because of technological innovations. (1)

10. The student will develop understandings related to the benefits and risks of choosing technologies. (1)

11. The student will develop a certain degree of skill in using a variety of technologies or technological innovations.

12. The student will develop a process of technology assessment for influencing the choice of future technologies. (1)

(Note: The items followed by the symbol "1" were paraphrased from a listing for technological literacy in the NSF publication, Educating Americans for the 21st Century.

Guidelines for Technology Education

The third step in the implementing process involves the establishing of a set of guidelines that would provide some direction for the actual implementation activities. The guidelines play a sensitizing role to the technology teacher or program designer to maintain an awareness of the elements that need to be included in the process of technology education.

The following is a listing of guidelines that may serve a useful purpose in setting the direction that the implementation phase of the technology education process may take.

1. Emphasis is given to the vital role that technology education has in the present and future societies.

2. Stress is given the role that technology will play in human survival and progress in the years ahead.

3. Technology education is for all students.

4. Technology education sholuld contain a strong and relevant experiential base.

5. Technology education should involve the total school, community, and the world beyond the community.

6. A multi-disciplinary approach is used in the study of technology education.

7. Technology education is conceived and implemented in a holistic frame of reference.

8. The processes of student inquiry are a focal point with emphasis on how the student achieved his/her answers or solutions.

9. Problem solving, inquiry, synthesis and analysis are important ingredients in the student's experiences.

10. The nature and quality of questions raised by the students are central to the quality of the experience.

11. The role of the teacher is one of stimulaiton, facilitation, advisement, and evaluation and management.

12. Stress is given to the student playing a major role in the learning process as well as the conduct of the educational activities.

The preceding items, in many respects, identify those qualities and characteristics that one might use in the identification of programs that are considered for implementing in technology education.

Technology Education and the Questions Raised

A critical area of the student's experiences in technology education relates to the nature of questions raised in the process of studying a given technology or technological innovation. The issue here is to go beyond the mere existence of "facts" artifacts, inventions or applications. It is necessary to probe more deeply into the logic, the human condition, the societal dimension or consequences, the ethics, legal or common good. Such questions might be along the lines of:

1. What are the alternatives?

2. What is the social impact?

3. What is the environmental impact?

4. Who should be involved in the decision?

5. What are the principles of science and/or mathematics involved?

6. What role has the technology or the innovation played?

7. What is the long-range impact?

8. What are the ethical, moral and legal issues associated with the technology?

9. Who should pay?

10. What if?

Such questions should be presented and used to probe beyond the surface and not to develop a negative frame of reference for the study. The goal of such points of inquiry with students is to open their thought processes and to develop their inquisitiveness related to technology.

Implementation Models for Technology Education

The fourth dimension of the implementation discussion is to examine a number of approaches to the conduct of technlogy education at the secondary level.

The implementation of technology education, with an interdisciplinary involvement, will be discussed with brief presentations of seven different approaches. These include:

1. a "technological innovation" study approach,
2. a "technological alternatives for the solution of major societal problems" approach,
3. A "community based" technology education approach,
4. a "systems" study approach,
5. a "process" study approach,
6. a "construction" study, and
7. a "research and experimentation" approach.

These seven categories provide some insights into approaches that have been used with success in technology education programs where there has been a strong interdisciplinary involvement. A brief commentary on each of these approaches follows.

1. The technological innovation study approach takes an important technological invention or development and uses it as a focus for the study of a host of interdisciplinary understandings. This paticular approach has been demonstrated successfully in the Maryland Plan (1973) anthropological unit approach to the study of technology.

The anthropological unit study of early technology -- tools and machines, power and energy, and communications and transportation, deals with many of the significant technological developments of prior generations and their contribution to the growth of civilization.

Examples of such technological innovations that would be the focus of study would include:

the lateen sail	the incandescent lamp	the cotton gin
the Wright Brothers' airplane	the catapult	the hydraulic elevator
the Persian waterwheel	the block and tackle	the trebuchet
the Newcomen steam engine	the camera	the telegraph

The monograph, Math/Science/Technology Projects (1985), published by the Internationl Technology Education Association contains pictures and examples of applications of mathematics and science, as well as social and environmental impacts of a number of these technological innovations.

Although the above are related to the anthropological unit approach, a similar kind of interfacing can be done with the same educational strategies directed toward contemporary units as well as futuristic units of study in similar topical areas.

2. The unit studies involving technological alternatives for the solution of major societal problems is a natural for the multi-disciplinary approach to technology education at the senior high school level. It is a program designed to bring the realities of the present and future into the laboratory and classroom.

The focus of the program, from a technology education persepctive, is to examine the technological alternatives presently available, as well as those projected in such areas as

a. energy development and utilization

b. transportation devices and systems

c. communication systems

d. trash and waste disposal and/or management

e. housing and living facilities

f. water development and utilization

g. production processes

3. The community - based approach is one that takes on a study of a local community's problems that may have a technology-based solution. This is where the students take an analytical look at their community with the objective to improve its functioning in one or a variety of ways. This process involves the students in making studies, interacting with different agencies, collecting data, making observations, hypothesizing, forecasting, synthesizing, designing, constructing, evaluating and presenting. The cross-disciplinary involvement is as rich as the broad interaction with the community. Some community problems with a technological "fix" may include such items as:

1. traffic flow and control,
2. water supply and development,
3. airport design,
4. transportation terminal design,
5. housing accommodations,
6. transportation systems,
7. power and energy development and distribution,
8. recreational and cultural facilities,
9. business and industrial development, and
10. people movers

4. The systems study approach takes a functioning component in a larger unit and attempts to provide for an improved understanding of the particular working system through the disciplines of mathematics and science and other areas of study.

An excellent example in this area is the water or liquid cooling system in an automobile. This is a common system whose understanding has many linkages with principles of science and mathematics. The following are some of the more obvious: principles of heat transfer, volume in relation to heat, conduction, convection currents, metallic properties, bi-metal interactions, chemistry of coolants, evaporating pressures, expansion and contraction principles, and many more. It is one integrated system in a machine that is made up of numerous systems.

- A similar analysis of mathematical and science principles may be made with regard to the propulsion system, suspension system, brake systems, and steering systems on an automobile.

- The modern airplane or jet aircraft is likewise made up of a series of systems that can be analyzed for their mathematical and science principles and concepts.

- Nuclear or fossil fuel power generation plant is another technological development that is composed of a number of connected systems.

5. The <u>process</u> study approach provides one of the most abundant sources of opportunities for the integration of mathematics and science principles and concepts for greater understanding of technlogy commonly used in the Technology Education laboratories in our schools. The <u>process</u> approach deals with a more micro form of technological involvement on the part of the student. It actually involves the forming, shaping, fabricating, and constructing processes commonly carried out by the student in the design, development and making of items in the technology laboratory.

The following examples are used to illustrate the <u>process</u> category for the integration of science and mathematics principles or concepts.

The brazing of materials (cast iron with a bronze rod, flux and oxyacetylene torch) is a classic example. Such a process opens the way for understandings in the areas of properties of dissimilar metals, heat exchanges, metallurgical properties of metals, expansion rates and calculations, oxidation, gaseous isolation, gas composition, molecular structure, gas consumption, material costs, and many more.

6. The <u>construction</u> study approach involves the application of mathematics and science and other disciplines in the planning, designing and evaluating of the object, structure, equipment or apparatus that the students are making. This is a much broader dimension of interdisciplinary involvement than the previously listed technical process elements.

- Architectural drawing, particularly the structural detailing of space, trussing, floor loading, footing design, concrete estimating, and roof design, provide excellent opportunities to use mathematics and science in practical applications.

- The design of structures in the form of bridges, trestles, hangers, television antennae, roof trusses, conveyor systems, water dams, wind generator supporting units, mono-rail systems and other such items are good potentials for meaningful application of principles and concepts from a variety of disciplines.

- Other constructions that would provide for a rich and effective use of mathematics, science and other disciplines would include such projects as:

ground effects machine	derby race car
hydro-foil craft	communications systems
airplane	furniture
laser beam	land vehicles
robot	water vehicles
automatic material handling system	developing items
	electronic control units

7. The <u>research and experimentation</u> or reserch and development approach to the study of technology, technological products and processes abounds with opportunities to integrate mathematics and science in practical and relevant applications. The R&E program has a long history of such meaningful use of these disciplines.

Such research and experimentation might be in the areas of heat treatment of steels, corrosion of metals, effects of heat on finishes, strengths of fasteners, strength of adhesives, fire retardants, heat collectors, qualities of fabrics, fadeability of colors, structure strengths, structure loading, power generation, photograph developing and printing, energy conservation, strength of materials, airplane wing design, airplane configuration, boat hull design, anti-fouling paints, barge designs, automobile designs, roof designs and many more.

The R&E and R&D approaches are particularly suited to the application of principles of physics and chemistry as well as applied mathematics, which can include various levels of statistics. Data collecting and data analyses are common to more R&E efforts. The scientific methods in conducting research, as well as problem solving, are important components of the R&E program.

Implementing Technological Literacy

Another focus that technology education may take deals with an emphasis on technological literacy. This direction likewise has enormous potential for implementation on a broad interdisciplinary base.However, the emphasis on technological literacy is more directly pointed toward the needs of citizens as functioning participants in the democratic processes in a society such as ours. One statement that focuses in this direction is contained in the National Science Foundation publication, Educating Citizens for the 21st Century, (Source Materials, 1983).

> Contributing to technological literacy is an understanding of: (1) the historical role of technology in human development; (2) the relationship between technological decisions and human values; (3) the benefits and risks of choosing technologies; (4) the changes occurring in current technology; and (5) an understanding of technology assessment as a method for influencing the choice of future technologies. (p. 74)

There are some relationships between these five elemens and the previously listed factors of math, science, social impact and environmental impact. These will be brought out in the ensuing discussion of each of the above points.

1. The understanding of "the historical role of technology in human development" provides the profession with a rich opportunity to demonstrate its capability in this area.

Implementation. The anthropological unit approach to technology education as contained in The Maryland Plan (1973) is a direct and proven implementation. The students select and pursue the study of a technological development (loom, cotton gin, trebuchet, Newcomen steam engine, waterwheel, windmill, turbine, catapult, etc.). This study involves library, museum, mail, and phone inquiry into the background of the technological item selected by the student. The student constructs a model of the item he/she has selected to pursue. The student also writes a report which contains, among other elements, such dimensions as a historical presentation of the item, scientific factors involved and social impacts.

2. The understanding of "the relationship between technological decisions and human values" is an area that has rich potential for implementation in technology education.

Implementation. Student activities in this area could center around community and city planning dealing with such technologies as transportation systems, housing accommodations, trash and waste disposal, communications systems and energy sources. Other projects could center around hydro-electric developments, airport and transportation center developments, mining and mineral extraction technologies, mining the ocean, pollution control measures, etc. Each of these would involve construction activities, student inquiry, interdisciplinary involvement, seminars, as well as written and oral reports.

3. The third area identified for technological literacy deals with an understanding of "the benefits and risks of choosing technologies."

Implementation. This area of technological literacy can be effectively implemented through a broad range of student inquiry and construction activities associated with energy development, transportation systems, water supply, housing, pollution, trash and waste disposal, communications and manufacturing processes. Each of the above has numerous alternatives that present varying kinds of risks to humans as well as the environment. Each of the alternatives has potential for exciting, interesting and challenging constructional activities. The processes for inquiry into the various technologies extend into the library, governmental agencies, private industry, community agencies, scientific and professional associations.

4. The fourth area deals with an understanding of "the changes occurring in current technology."

Implementation. This an excellent area of understanding that may be addressed through programs involving robots that are programmable, computer controlled robots, computer assisted drafting, computer assisted manufacturing, computer graphics, fiber optics in communications, laser beam technology, energy development technology, composite materials technology, quality control advancements and techniques, construction technologies, and a broad range of transportation technologies.

5. The fifth area deals with that very important dimension of "technology assessment as a method for influencing the choice of future technologies." Technology assessment involves the sensitivity, as well as capability, for making appropriate or effective judgments regarding technologies -- current and future. It is a process of analytically examining the merit and/or lack of merit in a given technology for a particular purpose.

Implementation. This dimension of technological literacy can be implemented by a wide variety of experimental involvement on the part of the student. As an example: the field of energy development is one in which the processes of technological assessment can be very effectively pursued. Such assessment may be carried out on a particular facet of energy development. The gasification of coal is such a unit within the spectrum of energy development technologies. An analytical study can be made of this unit that would deal with such factors as economics, pollution, efficiency, environmental impact, social impact, short and long range consequences, employment, technological dependencies, state and federal regulations, international trade, interstate transportation and economics, dependent industries, etc. There also is the issue of trade-offs involved in moving forward with such a technology.

The preceding example was with respect to a single technological energy development unit or component. Assessment analyses may also be made among a variety of technologies in a given area. Such an assessment in the area of energy development technology would include analyses or trade-offs between such technologies as sclar power, wind generators, wave generators, fossil fuel electrogenerator, gassification of coal, water power, deep ocean currents, fusion atomic energy, fission atomic energy, trash fuel consumption, etc. The same assessment elements previously mentioned may be used when making comparison assessments on any of the alternative technologies in a given field.

Other important areas beyond energy development technologies might include those in the fields of communications, water development, pollution control, housing, transportation, trash and waste disposal, construction, and manufacturing. All of these have alternatives within their respective fields.

The cited models and suggestions for programs in technology education are by no means the only forms that such instructional designs may take. The field of Technology Education with its laboratory facilities may well stress and carry out programs that have a strong experiential base. Other fields may take on different approaches. The role of the student in the process is primary and the level of involvement by the learner in the learning process must be a prime consideration. The processes through which the student studies technology and its many dimensions, may, in fact, be more important than the content that is learned, for as we all know, the product of education is people and the content is prone to change.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 197-205, 1987. Printed in the USA.
0270-4676/87

VALUE CLARIFICATION: A STEP TOWARDS TECHNOLOGICAL LITERACY

James R. Gray

"What is life all about?" "Where do I fit in?" "How can I find meaning?" "Where did I come from?" "Where am I going?" "How do I get there?"

These are a few of the many questions being asked by young people in today's contemporary society. Their attempts to answer these and other like questions are compounded by the sophisticated, complex, and often contradicting nature of modern social life. The manner in which our youth are phrasing the questions differ from group to group, individual to individual, but the essence of the questioning remain the same. The emphasis is upon the dilemmas, moral dilemmas, created by an advancing technological capability and the social responsibilities associated with that capability.

Dilemmas

A moral dilemma is a situation that elicits moral decision making and moral judgements on the part of the individual. As such, a young person must make a choice between conflicting values about what should be done and what is right in a moral dilemma. Youth are often faced in life today with chooses between what is clearly the right and what is clearly the wrong use of Technology. These are not moral "dilemmas." A moral dilemma is created from the fact that two or more "rights" exist and the individual must choose among alternatives.

The young adult's concerns of today are directed towards the great mobility, wide variety, and more impacting change present in today's world as a result of our advancing technological abilities. They see the drastic difference between what has been the human existence and what now represents our world. They feel the pressures placed put on them by society, but are not ready to shoulder the responsibilities represented in asking moral questions. They are a generation confronted not by to few solutions, but by to many choices. They are a generation charged with making decisions about issues and problems never before called into question. This places them within a social environment which confronts them with a wide variety of moral dilemmas. What then must our educational institution do to assist these young people in their search for plausible answers?

Curriculum Approach

Today's students are bombarded with decision making situations which present themselves as a direct result of the modern technological society we have created. This has produced a social need to better understand the role of Technology in human affairs. "Human Affairs" refers here to the value dilemmas which center the youths attentions upon difficult public choices. Such choices as nuclear science, recombinant - DNA, and microelectronics exemplify challenges that their values and the institutions which rest upon those values cannot easily master; of toxic waste, biohazards, and data privacy are related problems of our technological advancement that will not yield to purely technical solutions. The very nature of these arenas calls for human judgements unique unto our time.

Some curricular efforts in the discipline of Technology are being aimed at producing educational programs that foster within the learner a sense of social awareness of themselves, modern technology, and the physical environment. Many educators have stated that such an awareness is a prerequisite to the goal of technological literacy; or an individual capable of sensing problems, identifying alternatives, and choosing solutions when confronted with the many "dilemmas" of today's technological world.

In order to successfully promote technological literate we must approach both the technical and social aspects and address the resulting value dilemmas.

Curriculum Content

At the base of all social dilemmas we can find the concept of "value". Values form the foundation of all human relationships. It is important to realize that individuals are not born with values. Values are acquired through the process of socialization, which is heavily influenced by the environment one grows up in. Sociologists have stated that most individuals value systems are well formed by the age of eighteen.

A value is the fulfillment of a concept or idea held by the individual and support by the group they live in. It is the personal worth or importance we give to our ideas, concepts, or objects which represent to us these abstract notions. Whenever a moral judgement takes place a judgement is made in comparison to the value concept or idea. Whenever a thing or situation fulfills our idea of it, then it has value to us. If it lacks some quality of our idea, then it lacks value. In either case, our values guide and to a large extent determine our relationships to ourself and others.

Specific value types originate by applying the idea of value to different areas of life. An array of categories can be identified defining such value realms (see table 1). Each of the value realms has its own value orientation. They offer alternative value perspectives by which we judge moral dilemmas. When we view a moral dilemma from predominately one realm, our behavior is controlled by that value perspective or realm. Likewise when a person experiences value interrelationships, two or more realms are utilized to value. When these realms are or seem to be contradicting we find ourselves confronted by a value dilemma. Ethical guides are often formed and utilized by individuals as aids in making decisions pertaining to value dilemmas (see table 2). How to approach such value realms and the resulting dilemmas becomes the focus of curriculum efforts aimed at addressing the goal of technological literacy.

Table 1

VALUE REALMS

VALUE CAT.	FOUNDATION
TECHNICAL	BASED ON PHYSICAL FACTS &/OR LOGIC
ECONOMIC	BASED ON MARKET VALUES, DETERMINED BY SUPPLY AND DEMAND
SOCIAL	BASED ON GROUP & INSTITUTIONAL NEEDS
PSYCHOLOGICAL	BASED ON PERSONAL NEEDS OF INDIVIDUALS
POLITICAL	BASED ON GENERAL WELFARE NEEDS OF THE STATE
LEGAL	BASED ON WHAT THE LAW REQUIRES
AESTHETIC	BASED ON BEAUTY
ECOLOGICAL	BASED ON LIVING SYSTEMS AND THEIR ENVIRONMENT
ETHICAL	BASED ON WHAT IS BELIEVED TO BE RIGHT AND WRONG
SPIRITUAL	BASED ON WHAT "GOD" HAS REVEALED

Table 2

	Ethical Guides
GOLDEN RULE	DO UNTO OTHERS AS YOU WOULD HAVE THEM DO UNTO YOU
PUBLIC WELFARE	ACT TO PROVIDE THE GREATEST GOOD FOR THE GREATEST NUMBER
JUSTICE FOR ALL	TREAT ALL HUMAN BEINGS WITH FAIRNESS -- "IS IT FAIR TO ALL?"
LONG RANGE UTILITY	ACT TO PRODUCE LONG RANGE BENEFITS FOR INDIVIDUAL/GROUP
GENERAL LAW	"SUPPOSE EVERYONE DID THIS?"

Instructional Approach

The first and foremost question in the minds of most teachers is "HOW TO"; how to carry out activities in the classroom so students will become involved with Technology's content. In this case the teacher is concerned with how to approach value dilemmas within the classroom. Few efforts have focused upon these social aspects, with little development of instructional materials. To date little instructional methodology concerned with social values is available to Technology teachers for use in the classroom.

In order to develop material that would promote social awareness of Technology, we first need to identify the many areas in which student foster values concerned with the content of Technology. Some of these areas would be:

Politics	Leisure Time
Religion	Health
Work	Money
Family	Friends
Material Possessions	Culture

Students are asked everyday to make decisions pertaining to these and other areas which affect how they think, believe, and behave. An descriptive list could be made dealing with how Technology interplays with each area (see table 3). How might we make our students more conscious of this interrelationship and their part in it?

Four approaches to the solution of this question are available to us. Three of these have evolved over time and are the effects of the socialization process in general.

Table 3

TECHNOLOGY	VALUE	IMPACT
Communication	Political	Impacts of mass telecommunication of public opinion
Production	Religion	Impacts of materialization and secularization upon cultural "World View"
Occupation/Career	Work	Changes in skill requirements and job description effecting social concepts of role and role expectation
Transportation	Family	Mobility, impacting extended family group and single family structure
Medical	Health	Impacts of transplants, body parts, death
Production	Money	Impacts of international economy and since of national sovereignty or freedom

1. MORALIZING is the inculcation of the adults values systems to the child's. Moralizing is an approach which states that, "What has been good enough for Mom and Dad is good enough for Junior."

2. MODELING is where a paradigmatic attitude is taken. The adult projects the ultimate image through his/her actions for the child to emulate.

3. The LAISSEZ-FAIRE approach allows a free hand on the part of the adult for the child to choose among a multitude of values to hold.

Each of these approaches have advantages and disadvantages. The overwhelming problem with each is the time and control they require to be successful in a classroom environment. The fourth, and seemingly more appropriate to Technology teachers, is the VALUE CLARIFICATION approach. This approach aids students in identifying and answering their own value questions and helps build a value system within the individual. The major concern of the value clarification approach is not content, rather it is directed more towards the process of valuing. The emphasis is upon the value of valuing which allows Technology to supply the content to be address.

A majority of the work accomplished in this approach is based in Louis Raths's seven step Valuing Process (see table 4). Much has been written about Raths's work and its ability to approach Valuing within the classroom. The advantage which this process holds is its approach to valuing and its ability to allow for the development of instructional activities within the discipline of Technology. The categories of Prizing, Choosing, and Acting allows the students to explore the contradictions between their words and behavior.

The Value Clarification approach does not instill any particular set of values. Rather, the goal of the Value Clarification approach is to help students utilize a process of valuing in their own decision making; to apply these valuing steps to already formed beliefs and behavior patterns and to those still emerging. It therefore allows the learner to examine the distinctions between what they value technologically and what they say they value socially.

In the book Value Clarification: A Handbook of Practical Strategies for Teachers and Students, 79 instructional strategies are outlined which, when modified, can aid Technology teachers in this process. Value Voting, Alternative Search, and Removing Barriers to Action are three strategies that have been altered to assist teachers address values and Technology in the classroom environment.

Table 4

VALUING PROCESS
PRIZING ONE'S BELIEFS AND BEHAVIORS
1. PRIZING AND CHERISHING
2. PUBLICLY AFFIRMING, WHEN APPROPRIATE
CHOOSING ONE'S BELIEFS AND BEHAVIORS
3. CHOOSING FROM ALTERNATIVES
4. CHOOSING AFTER CONSIDERATION OF CONSEQUENCES
5. CHOOSING FREELY
ACTING ON ONE'S BELIEFS
6. ACTING
7. ACTING WITH A PATTERN, CONSISTENCY AND REPETITION

Conclusion

As one can see, strategies should be selected to complement the three major categories of Prizing, Choosing, and Acting upon values. Any strategy used should be appropriately designed for the particular age group for which it is intended. The key factor here is the realization that the student is the value holder and only when he/she is able to identify this will further action be helpful.

Many different strategies can be developed to aid the learner in this value process. Their use can be incorporated into the Technology instruction as a five or ten minute introduction or conclusion to a unit. The teacher might elect to interject a strategy whenever it seems appropriate. Whatever the method used, such instructional development efforts are vital if we are committed to the goal of Technological Literacy.

STRATEGY: VALUE VOTING

PURPOSE: To aid students in publicly affirming values. To show the many different positions taken on technological issues and values.

PROCEDURE: The teacher reads aloud one by one questions which begin with the words, "How many of you ...?" For example, "How many of you like to go on long walks or hikes?" After each question is read the students take a position by show of hands. Those who wish to answer in the affirmative raise their hands. Those who choose to answer negatively point their thumbs down. Those who are undecided fold their arms. And those who want to pass simple take no action at all. Discussion is tabled until after the teacher has completed the entire list. (Students may pass during any value activity).

SAMPLE VOTING LIST: Prefaced by, "How many of you ...?"

COMMUNICATION:

1. enjoy watching movies on TV?
2. could do without a telephone for a week?
3. like reading a good book?
4. would write a letter t a friend far away?
5. would like to be a radio dis-jockey?

TRANSPORTATION;

1. enjoy taking long walks?
2. would favor gas rashing?

3. perfer a bus ride to a car ride?
4. think thew government should help the railroad?
5. would like to take a spaceship trip?

PRODUCTION:

1. would be willing to work on an assembly line?
2. think that factories pollute too much?
3. plan to work in (local industry)?
4. think that there are too many different types of cars on the market?
5. would build your own home?

NOTE: Teachers should take part in the voting. Try 10 items as first. A short list is best. Let the students make up their list after a while. Make list of questions appropriate to grade level. Try a few items before a unit, then repeat afterward.

STRATEGY: ALTERNATIVE SEARCH

PURPOSE: This activity is designed to provide students with practice in searching for alternatives.

PROCEDURE: The teacher may start out by saying that for many people life is just a collection of accumulated habits. This should lead to discussion of life styles and of the importance of considering alternatives to the way we live. The teacher then presents the students with a value issue or life problem--little or big--that may touch their lives.

The students are asked to individually brainstorm as many alternatives to the problem as they can think of in the time allotted--three to five minutes--depending upon how long it takes the students to run dry.

The students are then formed into groups of three or four. Acting as a team, they are to develop a list of alternative solutions by combining their individual lists, and by adding any solution generated in the group setting. When the group exhaust all the alternatives they can think of within the time allotted--ten minutes--they are to choose the three alternatives they like best and rank order these.

The groups are then to report their results to the class as a whole. Discussion may follow. The teacher may ask if any of the students would consider using any of the new alternatives in their lives.

The teacher may suggest that the student write down the suggested alternatives on the following chart and check the appropriate columns. This encourage students to consider each alternative more carefully.

	ALTERNATIVE	I'LL. TRY IT	I'LL CON-SIDER IT	I WON'T TRY IT
1.	____________	______	________	______
2.	____________	______	________	______
3.	____________	______	________	______
4.	______ ___	______	________	______
5.	etc...			

SAMPLE LIST OF VALUE ISSUES:

1. Ways to personnally stop polluing our environment.
2. Ways to avoid a traffic problem in a large city.
3. Exciting things to do with our leisure time.
4. Ways to earn a living.
5. Ways to solve the "energy crisis."
6. Things for the government to do to improve the environment.
7. Ways to communicate with people better.
8. Ways to control industrial growth.
9. What to do when you feel Technology is out of control.
10. Ways to make a contribution to our community.

STRATEGY: REMOVING BARRIERS TO ACTION

PURPOSE: This strategy is designed to help students identify and remove barriers to action which often block and plague their value development.

PROCEDURE: The teacher asks the students to write at the top of a paper some action they would like to take or decision they would like to make. It should be an action which they are having some difficulty taking or which they fear to take. Then they are to draw a line lengthwise down the middle of the paper. On the right-hand side of the paper they are to list all the perceived or real barriers, both within and outside themselves, which seem to be keeping them from acting. On the left-hand side of the paper they are to list steps they could take which might help remove or reduce each of the barriers. Finally, on the back of the paper, they are to develop a plan of action for actually removing the barriers.
The task may be done individually or in small groups, with each of the group members taking turns having the focus and receiving help from the group. The group helps in the listing of barriers to action, steps to be taken to remove or reduce the barriers, and in developing a plan of action.

NOTE: The Alternative Search lists can be used to foster this activity.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 206-210, 1987. Printed in the USA.

TECHNOLOGY EDUCATION: MORE THAN A NAME CHANGE

Paul Cummings

Introduction

This article in intended to give a picture of how a school division moves from a traditional program in industrial arts towards a technology-based program. Notice the phrase *towards* technology-based is used, as opposed to *being* technology-based. Change is an evolving process. It takes time and a plan to change. Technology education is more than a name change.

History

Industrial arts was first taught in Newport News, VA, by Professor Joseph A. Schad. Coming from Oswego, NY, Professor Schad began in 1935 teaching his students the value of planning, making working drawings, and other project skills. His training and background at Oswego gave him the necessary skills to be successful in both the Hampton, VA, and Newport News school systems. He was noted for setting high ideals for students and staff under his direction. Joseph V. Dellapenta, Schad's classmate from New York, followed his leadership for the next 35 years in Newport News. Dellapenta began the move to new courses in 1973 when he brought Don Maley's "Maryland Plan" to Newport News. This strategy emphasized the unit approach to teaching industrial arts. With Dellapenta's retirement in 1976, a plan was developed to add four new courses to the curriculum: Construction Technology, Communications Technology, Manufacturing, and Power and Transportation. The four-year plan was implemented at a cost of $160,000.

Curriculum Overview

Technology education in Newport News Public Schools begins with a nine-week course in the sixth grade for all students, except those enrolled in band. Seventh and eighth graders take one-semester courses in Exploring Technology or Manufacturing.

The high school program begins in the ninth grade with survey courses in either Power and Transportation, Communications, or Construction Technology. Tenth graders can begin to specialize in the areas of Drafting, Electronics, Woods, or Metals Technology. All instruction is competency-based. This means the curriculum addresses four guidelines issued by the Virginia Department of Education:

1. Competencies are specified to students prior to instruction;
2. Competencies are role relevant and derived from the profession;
3. A system exists for documenting student competencies;
4. Criterion reference measures are developed for each performance objective.

Developing these standards over the past eight years have produced curriculum written around performance objectives. Teachers and students are held accountable for mastering and teaching from the curriculum.

Middle School Curriculum

The sixth grade Introduction to Technology program is activity-based to provide students with experiences in both production and communications. The production lab is equipped for plastic forming, as well as woods and metals processing. The communications lab is equipped for photography, graphic arts, technical drawing, and electricity/electronics. The twelve competencies in this course are divided evenly between production and communications. A component of this course is career exploration in communications, construction, power and transportation, and manufacturing. This aspect gives students some experience with job titles and tools of each trade. Another competency also familiarizes students with potential course offerings in the high school program. High school technology courses are related to career clusters.

Exploring Technology is a semester-long course for seventh and eighth graders and uses the unit approach to teaching technology. This "Maryland Plan" technique involves students in the learning process by requiring them to make decisions about their topic selection. Students must then use problem-solving skills to arrive at an answer. This technique places more responsibility on the learner to do independent research. This course also introduces new processes in graphic arts and photography.

Manufacturing at the eighth grade level focuses on product development and the production of a product. This course can take many different directions depending on the product selected for manufacturing.

Robotics and computers have been introduced at the basic level. Students are learning the concepts of a pick-and-place robot. The computer is being used to assist instruction and management.

High School

In the high school technology program, students progress from exploratory to technical offerings. Ninth graders have three course options: Construction, Communications, or Power and Transportation. From these survey courses they can continue their studies with courses in Basic Technical Drawing, Electronics, Woods Technology, Metals Technology, Graphic Communications, Computer Electronics, or Principles of Technology.

All drawing courses were articulated in 1981 between the five local school districts and the regional community college. This agreement allows students to receive advance college credit for these skills. Articulation provides students with a real incentive to continue their education in a college setting.

Summer Staff Internships

Three years ago, when the "high tecn" craze hit, the Newport News Public Schools purchased CAD systems and robots to stay abreast of current technology. The school division also recognized that teachers needed to remain up-to-date. For instance, there was a need--and a desire--for teachers to learn about computers. With the help of the NASA Langley Research Center and Newport News Shipbuilding Company, Newport News began a summer internship program. NASA's interest in the project was equal to ours. They wanted the teachers of future technicians to have first-hand experience in space technology.

Many details had to be worked out, including a legal contract between Newport News School Board and NASA. The basic agreement identified the areas where teachers could work, the length and the number of days, and procedures in the event of injury. Teachers were compensated by the school board at the school system's per diem rate. All of the school division's industrial arts teachers were asked if they were interested in the summer experience. Teachers were also asked to express a preference in a work area In the first year, 1983, there were three areas:

1. Material fabrication, model shop, and electronic fabrication;
2. Engineering, computer-aided drafting (CAD);
3. Operational support, wind tunnel operation.

Sixteen industrial arts teachers worked at NASA-Langley for two weeks. All teachers were assigned to a supervisor in their work area. In all assignments, efforts were made to provide the teachers regular work schedules and job responsibilities. In material fabrication, teacher assignments included learning and operating a computer-controlled numerical milling machine, testing bonding processes, laminating epoxy-graphite to a model, etc. In electronic fabrication, teachers used a computer to develop integrated circuits for production. Drafting teachers for the first time ever, worked on NASA's CAD system. Teachers working for the operation support directorate ran wind tunnel tests and operated expensive test models.

As a part of their internship, teachers were asked to develop and present a ten-minute presentation on a topic related to their work experience at NASA. The last day of work was "show and tell" when all of the interns met to give their presentations. NASA videotaped them for future use.

This August marked the fourth year of the project. Twelve teachers from Newport News--along with others from around the state--worked at new areas of NASA-Langley. At the same time, we had a similar program with Newport News Shipbuilding. Specifically, teachers worked in the welding school and the apprenticeship programs.

The internship programs have been successful because teachers have had valuable training in certain high-tech skills. But more importantly, the teachers now are able to describe to students their experiences working at exciting and challenging careers. At NASA, teachers were entrusted with the testing of a space shuttle model which cost $2.5 million. And until one goes to the bottom of a shipway and looks up at the newest nuclear-powered aircraft carrier, it's difficult to describe the thrill and hard work it takes to build ships. Newport News teachers now can share that thrill with their students.

Master Technician (2+2): A Peninsula Project

In 1984, a regional group of business and industry representatives realized that drastic changes were needed in the training of workers for the high-tech occupations of the future. This group, which was made up of representatives of 35 local companies, also included members of the five area school systems, the local community college, and the area vocational center. For the first time, industry and education was deeply involved in a project that had a common goal. Education wanted to help the individual student be successful in an uncertain future and business wanted an employee that could "think and do." Industry needed workers with stronger foundations in basic technological skills than was currently available. The Center for Occupational Research and Development (CORD), conducted a national study that revealed this same problem. CORD concluded that 50% of high school students are not prepared for either work or college.

Furthermore, current thinking is that education in the "technological basics" will help prevent the retraining problems found in later life as new technologies replace existing jobs. Workers with a more rounded technical base will be able to easily slide from one occupation into another. A robotics technician, for example, would be able to use expertise in mechanics and hydraulics in both manufacturing and servicing.

With the support of many states, a high school level course was developed to teach "applied physics." This course is a departure from the "traditional" high school physics content--laboratory exploration of properties of force, heat, light, etc. The new course (Principles of Technology) has reorganized the content around principles of physics and technology needed in the workplace.

The single "Principles of Technology" course could not entirely solve the retraining problem. What was needed was a program to produce a "Master Technician." The Virginia Department of Education provided support, leadership, and funds to develop a model for implementation. The program gives students a four-year curriculum at the high school level in six courses in technology education. The ninth grade would take Power and Transportation followed in the tenth by Mechanical Drawing. Two years of algebra are required to meet college requirements. Principles of Technology will be a basic course sequence. Electronics will be taught two years with an option for students to study at the vocational center. A course in Materials and Processing will be offered to eleventh graders. After graduation, the student can enter the employment market or continue on to a community college or university. At this point, students are much better prepared to complete a two- or four-year degree requirement. Many students take three years to complete an associate degree. Business and industry are receptive to this Master Technician (2 + 2) at whatever level of education. In some cases there are company programs to pay for college courses.

This model of technology education could have a significant impact on high school choices. Parents and students are learning they can pursue a technical career field without given up college. This new program will give students an opportunity to become Master Technicians. It combines two technologies, electronics and mechanics and 24 high school credits with a community college associate degree. In 1990, when the first graduates emerge, they will be ready to meet the future and its uncertainties.

Transition: Industrial Arts to Technology Education

Today, Newport News is in the middle of a transition from traditional industrial arts to technology education. Teachers have implemented new courses that are current in content. A change that would add more content in technology is also underway. Teachers recognize that the project method is an excellent method for teaching technological concepts such as creative problem-solving and critical thinking skills. Students also are beginning to conduct experiments at the middle school level with lasers, fiber optics and simple CAD programs. This is a change from the middle school program of 1981 that had a main purpose of career orientation. Technology education is a broader concept than industrial arts. In Newport News, technology education teachers will continue to teach students the materials and processes of industry, but add to it the development of technologies in the four clusters, the social/cultural impacts of technology, and the thinking skills needed to use technology to improve our environment.

What Next?

Technology literacy is coming to Newport News elementary schools as they begin a pilot project this fall. The curriculum was developed by NASA and Virginia Tech to teach technological literacy to fifth graders. This course, Concepts in Technology, will be used to reinforce the Virginia Department of Education's "Standards of Learning." This program will help students relate technology to other subjects such as science, math, and social studies. For instance, when students study a community through a map or model, they will add electrical service, telephone lines for communications, and a rapid transit system to avoid traffic problems. Critical thinking skills like inventing, brain-storming, and problem solving are some of the activities emphasized in this program.

Summary

The Newport News Technology Education program is proud of its progress and tradition. A strong foundation in the basics is being used to teach problem solving and critical thinking. A plan gave us direction and goals with which to build a bridge of transition. A transition from a strong 1935 traditional program to a future-oriented technology-based program is taking place in Newport News. The traditional program has served a vital need, yet we must prepare students who will live and work in the 21st century.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 211-215, 1987. Printed in the USA.
0270-4676/87

SOME PERCEPTIONS OF THE IMPLICATIONS OF HIGH TECHNOLOGY FOR MINNESOTA SCHOOLS

Sandra B. Westby

Advances in technology are accelerating the momentum for change in all sectors of society. There is at present a lag time between the actual development and implementation of new technology and the public consciousness of the issues involved. The rapid rate of social change, however, emphasizes the critical role of the educational system and the need to continually estimate and evaluate direction to best serve the common good. Forty-five influential Minnesota leaders in education, business/industry and government were interviewed on issues related to education and the changing economy.

Background

The technology driven wave or revolution taking place in our society has implications for all of us as we move from the industrial era to what is commonly called the information age. The impacts are not clear, but one dominant stream of thought suggests that new cechnological developments trigger changes in the nation's economy which affect both institutions and individuals. For example: a) the computer has and will cotinue to revolutionize much of the production function of the workplace as it encapsulates and displaces many traditional physical and mental tasks (Rumberger, 1984), b) as more sophisticated equipment becomes available, the displacement will escalate and the economic picture will project different images of the employment scene, c) resulting in the creation of new demands on the labor market and the system of education as job categories are created or become obsolete, d) and affecting the individual with different career choice and lifestyle possibilities that may require a different set of skills, attitudes, values and behaviors as the social change evolves.

As advances in technology accelerate the momentum for change in all sectors of society, one of the basic issues in this evolution continues to be--where shall the social emphasis of school life and work fall and what are the educational policies which correspond to this emphasis (John Dewey, 1940, Education Today). Of primary concern in this era of multi-directional accelerated change is the need for vision and research to provide a framework for long range planning and compatible coherent social outcomes. Policymakers, in the meantime, modify old and institute new directions given the knowledge at hand.

Three basic assumptions governed the disposition of this study: a) an economic, high technology generated transformation is taking place in our society with resulting implications for work and concomitantly for education, b) development policies in education are acts of choice between objectives, between patterns of resource allocations, strategies of implementation and different predictions of outcomes (Weiler, 1979), and c) leaders and their perceptions are important forces in new issues that affect society (Jaher, 1973; Zaller, 1984).

Methodology

Education has multiple constituencies and leaders in 1) government, 2) business and industry, and 3) education are in position to influence state legislation, the employment arena and the educational process. Exploratory research was conducted with forty-five influential Minnesota leaders on issues related to education and the changing economy. The leaders were heads of school districts, colleges and universities, high technology corporations, government agencies and legislative committees influencing education. Responses to interview and survey questions, a demographic questionnaire, and the field notes of the researcher formed the data base. Qualitative and quantitative methods were used to compare and contrast the collective responses of the groups. Significant statistical group differences were found on eleven items, including the scale score correspondence of current programs and needs.

The interview schedule included literature based questions relative to a) the correspondence of current educational programs and the needs of an information society, b) the most important challenges faced by the system of education to the turn of the century, c) funding priorities, d) the interrelatedness of education, advances in technology and the world of work, and the need for federal or local efforts in this regard, and e) the possibility of predicting primary high technology applications and then anticipating the needed skills and abilities, among others. Highlighted here are the results from three of the questions.

Results

Leaders from the three groups were asked to respond to a two part questi n on the correspondence between current educational programs and the needs of an information society. The narrative responses to the question concentrated in four areas and recognized:

a) the lack of public consciousness and understanding of the fundamental changes taking place in our society,
b) the importance of education as basic to productive membership in society and the divergent views on the quality of that process,
c) the need for institutions and programs to be cognizant of and relevant to contemporary needs, and
d) the divergent views on the responsibility of the student and/or the institution for the learning that takes place. On a scale of 1-10, the business/industry group gave a decidedly lower rating to the correspondence between programs and needs than did the education and government groups.

Leaders were asked to rate on a scale of 1-10 the interrelatedness of advances in technology, the system of education and the world of work. A one-way analysis of variance test was used with these data and no statistically significant difference was found in the way the groups responded. Some of the leaders chose to interpret this question at the structural or institutional level of use of technology, particularly computers, while others saw technology as an integral part of all society. One high technology corporate leader observed the interrelationship was: "Fundamentally a 10, structurally a 4. Fundamentally they are intimately related. Our institutions, however, are not."

Leaders were also asked to respond to a question regarding how accurately we can anticipate the abilities and skills which students will require for jobs available in the next decade. No statistically significant difference was found between groups. A corporate executive pointed out that new employment possibilities are economic and political issues more than they are scientific issues and while one may be able to forecast the scientific advancements that are appropriate and possible, many of those will depend on what the government policy is at any particular time. Ninety percent of the respondents believed, however, that abilities and skills could be somewhat or quite accurately anticipated. Many saw basic skills, an attitude of flexibility, an element of creativity, the need for self-esteem and continuing education as important for individual success and societal development. As part of the packet of survey questions, the leaders were asked to specifically rate competencies and skills that, in their view, will require increased or decreased emphasis over the next decade. Significant differences in responses by the three groups were noted on writing/spelling/grammar, arithmetic, oral communication/speaking, economics of business, and civics/government. (See Table 25-1)

Table 25-1
K-12 Skills and Competencies Emphasis Charted

		Schools	Government	Corporations
Reading/interpretation	n	15	14	10
of blueprints, inst. etc.	x	3.60	3.92	4.00
Writing/spelling/grammar		15	14	11 *
		4.00	4.28	4.72
Arithmetic		15	14	11 *
		4.06_1	4.35	4.72_2
Science		15	14	11
		4.20	4.50	4.63
Technology (application of		15	14	11
basic and applied science)		4.40	4.42	4.63
Typing/keyboard skills		15	14	11
		3.46	3.57	3.63
Metrics		15	14	11
		3.46	3.07	3.27
Human relations		15	14	11
		4.13	4.07	4.18
Ability to participate		15	14	10
in decisionmaking		4.13	4.28	4.30
Flexibility-ability to		15	14	10
acquire skills/jobs change		4.66	4.78	4.70
Oral communication/speaking		15	14	11 *
		4.13_1	4.50	4.72_2
Economics of business		15	14	11 **
		3.53_1	3.71	4.27_2
Civics/government		15	14	11 **
		3.20_1	3.78_2	3.45
Word and information		15	14	11
processing		3.73	3.92	3.72
Business and industrial law		15	14	11
		3.00	3.14	3.00
Foreign language		15	14	11
		3.93	4.57	4.18
Use of tools		15	14	10
		2.80	3.00	2.80
Computer literacy and applic.		15	14	11
		4.13	4.07	4.36
Specific job skills		15	14	11
		2.80	2.71	2.81

(Wisconsin Parker Project's permission to use instrument)
(45) * p less than .05 ** p less than or equal to .06
much more = 5; more = 4; no change = 3; less = 2; much less = 1.
Note: subscript 1,2 denotes pairs of groups significantly different at the .050000 level. Note: writing/spelling/grammar were inadvertently left out of the post-hoc analyses.

In summary, the responses to these particular questions revealed a troubling diversity on the issues of the correspondence of current programs and the needs of an information society; the structural or fundamental, application or implication, interpretation of the interrelatedness of advances in technology, education and the world of work; and the significant differences revealed in the skills and competencies emphasis as charted. The data suggest a need to expand the public consciousness of the technology-laden issues shaping the future of our society.

The data from the full research study support the need to surface the issues, support research and development in all related areas, and understand and articulate the forces of change that impact education and require new processes, programs and emphasis.

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Bull. . i. Tech. Soc., Vol. 7, pp. 216-217, 1987. Printed in the USA.
0270-4676/87

SETTING THE S.T.S. AGENDA IN K-8

Herbert D. Thier

The quality of science learning can be enhanced by science teaching that focuses on the interests, needs, and concerns of the learner and the society he or she lives in. That is why taking a science-technology-society (STS) approach in our science teaching will improve the quality of science education for learners of all ages. Focusing on K-8 we start with youngsters at the age of curiosity and wonder (observe the typical kindergartner walking down the street), and work with them through the natural emergence of the age of social consciousness and social concern (recycling center leadership frequently peaks in 9th grade). We have the privilege of introducing young learners to evidence-based decision making, an essential behavior for effective citizenship in a free and democratic society. Few K-8 learners approach the world from an abstract or theoretical point of view. Actually, their learning about and growing understanding of themselves and their surroundings is based primarily on their experiences.

At the same time, egocentric and very concerned about peer relationships, young learners are complex, and at times, confusing to adults. What stands out is their intensity of interest in a topic until they change their focus to something else. The modulated, socially acceptable adult approach of showing surface interest in many things, while carefully concealing one's real interests and feelings, is not the usual approach of K-8 learners. It is these developmental characteristics of youth that make the usual "school science program" with its helter skelter rush from one topic to another (check the typical sixth grade table of contents) so boring and uninteresting for so many young learners. Outside of school, they are curious, investigative, and to say the least, highly interested in themselves, each other, and the environment. Essentially, K-8 learners live as scientists (investigative, curious, etc.) and find the little that schools usually offer as science, a strange abstract exercise, in which they are asked to learn (memorize) many new disconnected facts and an unbelievable amount of disconnected vocabulary. Taking a laboratory-based approach to "school science" helps greatly, since at least the learner experiences the topics as a basis for learning. However, the learner frequently finds these lessons still episodic and disconnected from real life. Taking an STS approach, even with the youngest learner, enables us to relate the experiences so essential to science learning to issues and interests that are real to the learner. For example, the introduction of magnets and their attraction and repulsion found in almost every elementary science program can be carried forward and enriched for the learner by investigating and exploring the use of magnets in the daily life of the learner. The direct and provocative challenge question--"How would your day change if there were no magnets?" can encourage thoughtful investigation, interesting discussion, and a real emphasis on the role of magnets in the life of the child. Some of these investigations can be carried out directly by examining refrigerator doors, motors, etc., while others will require going to printed and other media resources, therefore, illustrating the diversity of types of evidence we use when we investigate in science. "What would <u>life</u> be like without magnets?" is a different and more abstract question that encourages the learner to come to grips with this basic example of technology in the broader sense of society as a whole instead of just him or herself.

These two questions, related to one of the most frequently taught topics in elementary and middle school science, clearly illustrate the challenge in setting the agenda for STS in K-8. Not needed is a set of "new" topics with more disconnected facts and vocabulary. Rather, we need to examine each and every topic that we now teach and consider essential, and ask: How does this relate to the life of the learner and the society he or she lives in? If, as a start, we can come up with a couple of provocative questions similar to the ones about magnets and motivate learners to use a wide variety of resources and experiences to answer such questions, we will have made a real start in setting the agenda for STS in K-8.

The emphasis, especially at this age, must be on the SOCIETY part of the STS triad. The differentiation between science and technology is an abstraction not clearly understood by many young learners. They are interested in and concerned about the world around them and its interesting mix of science and technology. Our responsibility is to help them experience and understand the science and technology in their lives, while relating it to the personal and societal issues of interest to the learner. Our goal is to have them mature into citizens, who use evidence to consider all scientific and technological issues in regard to their total effect on society. If we do not emphasize the societal issues with these young learners, they will continue to grow up believing science is something that takes place in school and is unrelated to life. This can lead to decision making based on emotionalism and persuasion rather than evidence, and that can be dangerous to the health of a free and democratic society.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 218-224, 1987. Printed in the USA.
0270-4676/87

A TECHNOLOGY STRAND IN ELEMENTARY SCIENCE: IS IT DEFENSIBLE?

Ted Bredderman

The arguments for or against the broadening of the elementary syllabus to include technology education have been joined at two broad levels, should technology be included and can it be included? The critics of movement in this direction range from those who see it as sowing in the young the seeds of materialism, commercialism and acceptance of a technocracy, to those who argue it adds to the problems of an already overburdened curriculum and underprepared and overworked elementary teacher.

The nature of what is being proposed surely needs a clear definition before decision makers can be expected to endorse it. Thus, I have chosen to present the outline of a possible technology strand in terms of goals and means and the accompanying defense. The first question is that of goals. I propose that a technology-based curriculum might enhance three broad goal areas: (i) cognitive content and process, (ii) social context understanding, and (iii) personal satisfaction.

Because of the cognitive and personal satisfaction area provide background for considering social issues, at the elementary level the greatest stress should be on these. More specifically in the cognitive area the curriculum should work to:

1. provide an expanded set of concepts and language with which to think and communicate;
2. sharpen and broaden general reasoning and problem-solving abilities within technological contexts; and
3. reveal how all available intellectual resources are brought to bear in solving problems, regardless of the subject matter area from which they come.

These types of goals are very consistent with the present trends in other areas of the elementary curriculum and have been justified over and over again by educators and the community at large.

The goals which relate to personal satisfaction with involvement in the cognitive and contextual components might include goals to:

4. improve student self confidence in their ability to understand, to a greater extent, even the complicated technology which surrounds them in their everyday life; and
5. provide early contact with the nature and breadth of careers related to science and technology.

The final set of goals would stress how technology plays a role in life outside the classroom. In particular, a technology strand should:

6. increase the relevance of classroom experiences by using them to improve understanding of commonplace technology;
7. provide an accurate view of how problems are generated out of human need; and
8. provide an accurate view of the role that technology plays in meeting human needs and in creating human problems.

All three goal areas--cognitive, social context and personal satisfaction--have to be addressed in the curriculum. Without the cognitive component, accomplishment of the other two is really not possible, but it is the context and personal goals which provide reason to work on the cognitive aspects.

These goals are defendable in the elementary grades primarily because they would bring the curriculum more in line with the everyday experience of the child and begin to give a glimpse of the world of work options which the child will eventually face. More than ever before, the child is immersed in an environment shaped by human technology. Any list of career opportunities shows that many more students will be involved with using and improving technology than with adding to our knowledge base of nature.

A technology curriculum strand should reinforce much of what is presently incorporated in effective, up-to-date elementary science curricula. But, in addition to reinforcing the processes of inquiry and the principles of natural phenomena, students should be given a chance to use and study the products of technology with a broader purpose in mind. Greater stress should be placed on ingenuity, inventiveness and problem solving. Learning how to meet given output specifications, to maximize effects, or not to exceed the limitations of materials, should be dealt with as explicit objectives. Learning how devices can function to extend human sensing ability, and to increase human effectiveness in terms of control, speed, strength and endurance should be included. How to deal with the fact that there are usually several ways of accomplishing the same effect and that each has advantages and disadvantages in terms of resource expenditure, direct benefits, and side effects should be a continual challenge to students. In all cases, these ideas should not be taught as abstract concepts but in the context of working on immediate tasks or problems.

Another consideration is the role such objectives could play in reinforcing already established educational goals. Technology-based problems have a concrete quality which is especially useful at the elementary level. For example, the solving of technological problems in the elementary school setting is used in some schools as points of application for decision making, creativity, and social skills. Thus, student teams challenged to build long bridges, or support heavy weights with seemingly inadequate materials or to design rubber band powered cars or paper airplanes for distance races encourage students to test their problem-solving skills. These types of tasks presumably improve problem solving if some preparatory attention is given to the cognitive ingredients of good problem solving. Once again the importance of the cognitive components, including knowledge, concepts and skills, is underscored. It has to be kept in mind that the specific cognitive outcomes which foster problem-solving goals in technology remain to be defined and that, at present, there is very little research which can inform this process.

In addition to contributing to established curriculum objectives in the cognitive area, technology might be promoted as a way of increasing motivation. Capitalizing on technology to interest students in other curricular areas can be justified only if it proves to be at least as attractive to students as the content of those other areas. There is some evidence that it might have a slight edge in this regard. In the third survey of science, by the National Assessment of Education Progress administered during 1976-77 to about 2500 students, questions asked of 9- and 13-year-olds regarding the relationship between science class and the real world had generally positive results. About 73% of 9-year-olds and 57% of 13-year-olds agreed with the statement that what was learned in science classes was useful in everyday life. Forty-seven percent of 13-year-olds said that they would like to work at a job that let them use what they know about science. About 45% said they would be interested in working in a laboratory while 65% said they would be interested in designing and building things. Nearly 70% of the 13-year-olds claimed that they always or often try to figure out how things work. More than 55% said they had tried to fix something electrical and about 58% said they had tried to fix something mechanical, many times or more than twice. About 97% of both 9- and 13-year-olds said they had taken something apart to see how it works. About this same percentage said they also would like

TABLE 1

Percent Response on Selected Items from 1976-77 National Assessment of Education Progress. Based on a national sample of about 2500 students at each age level.

What has been your most favorite subject at school?

Age	English/LA	Social Studies	Nat. Science	Math
9	24	3	6	48
13	15	13	11	19
17	16	13	12	13

Much of what you learn in science class is useful in everyday life.

	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
13	15	42	20	17	5
17	14	39	19	23	5

Would you like to work at some job that lets you use what you know about science?

	Definitely	Probably Yes	Not Sure	Probably No	Definitely No
13	18	31	24	19	8
17	15	24	26	23	12

Tell if you would be interested...

working in a laboratory.

13	17	29	26	19	9
17	12	31	22	23	12

designing and building things.

13	37	30	18	10	6
17	30	33	19	13	5

Do you think scientists should be given money to study ...

things which may be useful someday?

13	35	59		5	1
17	39	57		4	0

how the continents move around?

13	23	42		26	9
17	22	45		23	10

How often do you like to try to figure out how things work?

	Always	Often	Sometimes	Seldom	Never
13	30	42	23	7	1
17	18	47	27	7	1

How often have you tried to fix something electrical?

	Many times	Not very often but more than twice		Once or twice	Never
13	23	29		31	17
17	29	32		28	12

How often have you tried to fix something mechanical?

13	34	24		27	14
17	42	24		22	11

Have you ever taken something apart to see how it works?

	Yes	No
9	71	26
13	81	16
17	85	14

Are the things you learn in science useful to you when you are not in school?

9	74	23

Would you like to take something apart to see how it works?

9	76	20

Have you ever experimented with batteries and bulbs?

9	51	43

Would you like to experiment with batteries and bulbs?

9	56	39

to do so. While most questions which proposed hands-on activity had high positive responses, those involving technology were especially high. It looks like elementary children would vote for including technology in their education.

The Delivery System

The broad goals might seem reasonable but so are many goals which are not presently part of the elementary curriculum. Many noble goals never make it to the classroom because reasonable ways of accomplishing them in the classroom cannot be devised. There is a small set of features which common sense tells us a good program should have.

1) The program should be a supplement to existing curricula. It would be inappropriate to replace large portions of present quality programs with one having a narrower orientation. A supplemental program has the opposite effect; that is, it serves to broaden the curriculum.

2) The supplemental program should be highly flexible, consisting of fairly small modules or units. Some units should be written to be used with programs which provide no preparation in technological concepts while others pick up where existing programs leave off regarding technological ideas. Finally, a set of optional alternative units would be useful to branch students into areas of specialized application and interest.

3) The program should give students the opportunity to handle and study, from a technological standpoint, simple forms of devices with which they come in contact in their daily lives (see Table 2): simple cameras, musical instruments, hand calculators, watches (electronic and mechanical), blow driers, curling irons, stereo boxes, tape recorders; or serve as the goals of science: telescopes, microscopes, thermostats, weather instruments, volt-ohm meters and so on.

4) The program must be designed for all students. Avoiding the temptation to appeal to only brighter students, boys, or tinkerers, will be essential. Providing ways of checking student progress and enrichment and remedial activities will help to address individual student differences.

5) The program should provide sufficient guidance for the teacher so that he/she

TABLE 2
Common Non-Electrical Devices Which Elementary Students Could Study, In Terms of Components, Functions, Simplicity, Tolerances, Materials, Etc.

Coach's whistle	Soap dispenser/hand soap	Mechanical pens	Door bumper/spring type
Pitch Pipe	Glue dispenser caps	Faucets	Music boxes
Balloons	Bird feeders	Screw top jars	Wind-up toys
Aerosol can	Salt & pepper shakers	Bumper jack	Wind-up clocks
Syringes	Basket drain-kitchen sink	Reclining chair	Bamboo curtains
Toilet plungers	Bottle top dispensers	Extension leaf table	roman shades
Paper airplanes	Kerosene lamps	Folding clothes pole	Drape traverse rod
Door closers,	Propane torch	Shoe trees	Garden hose holder
pneumatic type	Alcohol burner	Convertible couch	Garage doors, lift type
Percolator	Cigarette lighter	Postal scale/balance	Clothesline pulleys
Tea kettle whistle	Egg beaters	Gateleg Tables	Roll top on desk
Kites	Drill brace	Foot pedal waste basket	Venetian blinds
Suction cup, holders	Trailer hitches	Eyeglass frames	Guitar
Musical recorder	Adjustable shelf brackets	Folding jack knife	Violin
Cleaner sprayer bottle	Key locks	Lever-operated sink top	Toy wagons
Fireplace baffles	Lunch pail latch	Drop leaf table	Bicycles
Pinwheels	Zip lock bags	Folding chair	Carpet sweeper, hand
Hand air pumps	Clothes hanger; wire	Playground swing	Roller skates
Sailboat	Belt buckles	Jingle bells	Carriages, strollers
Ball point pens	Door bolts	Piano	Golf cart
Socket wrench, ratchet	Hook & eye latch	Door knockers	Caster, swivel
Ice skates	Teeth braces	Cow bells	Drawer guides, w/wheels
Paper cutter	Ski bindings	Lever oil can, squirt can	Swivel chair
Safety razor	Magnetic catches	Shower heads	Unicycles
Wood plane, hand	Hinges	Water gun	Globe
Fingernail clipper	Tent pole, adjustable	Rolling pins	Skateboard
Coffee griner	Door safety chain	Shade roller	Tricycles
Paper hole pnch	Key rings	Roll paper holder	Folding snack tables
Can openers	Window latches	Paper/plastic wrap dispenser	Plier, nut cracker
Pencil sharpener	Snaps for clothing	Spring cup holders	Scissors
Pepper grinder	Canning jars, clamp lid	3-ring notebooks	Pruning shears
Circular knife	Zipper	BB gun	Pliers
sharpeners	Velcro fastener	Door catch, spring type	Post hole digger, hand
Small pet bottle	Lift type cork screws	Clip boards	Watch band, metal
feeders	Tripod	Bathroom scales	expansion
Toilet bowls	Screw, nut cracker	Paper clamps	Folding ironing board
Flour sifters	Vise	Pants hangers	Clothing snap attaching
	Tennis racket frame	Paper stapler	tool
	Molly screw	Spring clothespins	
	C-clamps	Postal scale/spring type	

feels comfortable teaching the units. This is perhaps the most difficult requirement to fulfill knowing the preparation of teachers in science and technology. Keeping materials and teacher guidance as simple as possible will be a continuing challenge for developers.

6) The materials needed must be available locally or, if necessary, in the form of a low-cost kit. The kits might include enough materials for students to work in small groups with some of the same components being used in many lessons. In more advanced lessons, students might be led to construct, from the accumulated components, a complex device, requiring several technologies. As a whole class activity, this could require the coordination of the efforts of several sub-groups of students, resulting in the sharpening of communication and organizational skills.

Some may be disillusioned with commercially delivered curricula involving materials but, apparently, there still is a market incentive to offer material packages. In 1985, there were about 22 commercially available elementary science programs which spanned grades 1 through 6. This number was down from five years before when there were 19. The greatest loss occurred in the number of programs which relied on a text without commercially available laboratory materials. This category went down from 14 to 6 programs. During the same period the number of programs with commercially available laboratory materials actually increased from 13 to 16. These figures suggest that programs which provide laboratory materials packages, at least as an option, have had a substantially better survival rate in the school marketplace than those without. In addition to texts, activity books, and materials packages, by 1985, five publishers were selling computer software with their programs.

It is likely that the experiences found in activity-based programs such as ESS, SCIS, SAPA and other programs do provide a starting place for a technologically based curriculum. What is needed is a curriculum designed to capitalize on such experiences by extending them and by applying what is gained to understand existing technology and to foster inventiveness.

Teachability

A supplemental curriculum in technology at the elementary school level is likely to draw critics who claim that the curriculum is not teachable at the elementary level and should be reserved for later schooling. It could be argued that technological devices are often too complex to be understood by elementary-age children and that because the nature of many of the basic phenomena (current, light, heat, magnetism and sound) are not directly observable, young children will not be able to learn the content. Neither complexity nor understanding the unobservable are new problems for elementary science curriculum development. The way in which they were handled in the innovative, NSF-supported programs seems like a reasonable solution. In these cases, the complexity of the systems to be studied was dealt with by introducing simple components first and gradually combining these into ever more complex units. Elaborate systems were analyzed only by the late elementary grades. Thus, for example, in the SCIS program, children begin by examining organisms. Later they work with environmental factors and communities of organisms and only by 6th grade do they study these elements in an integrated way as the total ecosystem. A similar progression is evident in the SCIS physical science strand starting with examining individual material objects, space, time, energy and by 5th and 6th grade, complex systems containing all of these components. Before new levels of complexity are introduced, concepts are taught which serve to generalize the experiences to that point so that the students have integrating ideas available to reduce the complexity of the systems which are subsequently presented. Concepts, such as object, interaction, system, energy transfer, life cycle, population and environment all serve to consolidate understandings and reduce complexity.

The technology strand should attempt to reduce the complexity of technological systems which might be studied both by (1) introducing technological components in a cumulative fashion from the simple to the complex, and (2) by teaching concepts which serve to consolidate previous ideas. As components are explored their function should be stressed. When the same component is later seen in a new more complex device, its function would then already be familiar and the function of the new device could be the focus of study at that time. The inclusion of this new device in an even more complex system would serve to illustrate how complex technological devices gain new functions by combining the functions of simpler components. Block diagrams of complex devices could be used to illustrate the chaining of functional components.

The second potential problem, unobservable phenomena or "black boxes," likewise has been addressed previously as an elementary science curricular problem. If one tracks any phenomena deep enough in search of explanations, a black box will eventually be encountered. Every object a child (or adult) picks up contains uncomprehendable phenomena yet there is almost always potential for greater understanding of the object. The question for elementary curriculum developers has always been how complete an understanding to expect from children. It is reasonable to assume that almost all elementary children are in or below the concrete operational level of development and thus are limited to understanding ideas rather closely associated with direct experience. Thus it should generally be expected that they are capable of generating inferences based on observations but not based on other inferences.

As a result of the limitation, posed by the development of the child, programs which are successful in developing understandings are devoid of explanations of atomic and molecular theory and concentrate, for example, on ecological biology rather than cellular biology and physiology. Again, in the SCIS program the "energy sources" unit illustrates how an invisible entity "energy" can be treated in terms of the observable objects with which it interacts. Energy "sources" and "receivers" are identified without attempting to have students conceptualize "energy" itself. In like manner, although with different objectives in mind, teachers using ESS and SAPA have students work with batteries, bulbs, wires, magnets, etc., searching for observable interactions and developing rules for connecting components to get certain effects. Batteries and magnets, per se, remain "black boxes." The proposed curriculum should apply similar restrictions, for the most part, avoiding explanations based on underlying invisible phenomena. Instead, the focus should be on studying how various technological components interact and only in the most advanced lessons, asking students to propose models which might help to explain observations.

I have tried to show that there are objectives and methods of trying to accomplish them which hold promise for a technology strand in elementary science. But, I have cautioned that, until the details are spelled out, it is unreasonable to expect the rank and file to endorse the idea. The filling in of the details will require further proposals followed by discussion at all levels of the interested educational community. In addition, as the goals are clarified, research, curriculum development and teacher training efforts will be called for. This is obviously an undertaking which will consume many educator years and will, I suspect, be successful only to the extent that it is shaped by children and teachers.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 225-232, 1987. Printed in the USA.
0270-4676/87

INCLUDING SCIENCE/TECHNOLOGY/SOCIETY ISSUES IN ELEMENTARY SCHOOL SOCIAL STUDIES: CAN WE? SHOULD WE?

Gerald W. Marker

Science and social studies educators alike lament the small proportion of the elementary curriculum devoted to their respective subjects. Both groups easily document their cases, leaving one to wonder why anyone would propose that the two groups join in pushing for the inclusion of science/technology/society components in an already crowded curriculum; yet that is exactly the proposal around which this paper is constructed.

Why S/T/S in the Elementary Curriculm?

The focus of the curriculum in the elementary schools today is upon reading, writing, and mathematics, an emphasis re-enforced by state competency testing programs. How then can it be argued that room should be made for S/T/S issues? Shamos sets forth one reason:

> *Times are changing. We are moving into a more pronounced technological age, one in which technology promises to touch more closely the lives of most people. The work place generally will expect from its employees a better understanding of technology than ever before. Thus where there were few, if any, incentives in the past for one to become literate in science, there may be very compelling reasons in the future for widespread technological literacy.* (1)

Quite simply, the world rushes on; technology increasingly inserts itself into all aspects of our lives. In most cases technology enriches and smooths our daily endeavors but technology also carries with it unanticipated side effects and/or hidden costs. As technology becomes increasingly complex, people feel a growing sense of being powerless, a sense of being the victims of technology rather than its masters.

The notion that people would shape their own destiny rather than leaving it to the will or fate of some superior power is a relatively recent development. The idea that we do have some responsibility for our fate may even be a contributing factor to the feeling that our world has gotten so complex that events are now out of control.

This tight link between technology and progress confronts policy makers the world over but in democratic societies such as ours, it brings with it special problems. (2) A key assumption of democracies is that the general population should directly or indirectly have a hand in making public policy. The notion that each should have an equal voice in decisions is deeply embedded in our values. But as issues become increasingly complex, uninformed votes threaten the very principles which make them possible. The decision, for example, of whether to build another fire station in a rapdily growing part of the city is of a quite different level of complexity from one involving the best way to dispose of PCB contaminated soil. Anderson has characterized the dilemma of uninformed participation as a "double-edged sword."

There are those among us who would solve this dilemma by having us return to simpler times but for most of us such proposals are not attractive options even if they were possible. Besides, one need only recall high infant mortality rates, long days of heavy physical labor, and plagues that swept entire populations to remember that while life in the "good old days" may have been simpler it was not necessarily better. Technology seems here to stay.

Technology may be here to stay but it is hardly neutral. Rather, as has already been suggested, our world of technology is full of what Robert Hanvey has called "surprise effects" which present us with some very tough choices. For example, our nation runs on electricity; no one suggests that we abandon its use. But, how should we generate that power? Coal fired power plants appear to cause acid rain, nuclear power may be unsafe, oil and natural gas supplies are on the decline and increasingly under the control of other nations. There is no easy or obvious choice.

Clearly technology plays a role in shaping our values but so too do our values shape the future of both science and technology. Technology now makes host parents and sperm banks possible but the future of such activities lies not so much with science and technology as with the social context in which they exist.

The distinction between social and scientific issues becomes increasingly blurred. If we are to continue the practice of allowing the general population to participate in making social policy we simply must increase the level of technological literacy of our population. The remainder of this paper will set forth the argument of why elementary school social studies should be a part of that effort.

Major Goals of S/T/S in the Schools

If one accepts the preceding arguments then it follows that one of the major goals of today's education should be to produce citizens who are technologically literate. The National Science Teachers Association has described a person with such literacy, but from a social studies perspective what does it mean to be technologically literate? (3)

First, and perhaps most importantly, it means students who understand the link between technology, themselves, and society in general, not just their society, but all societies. This means not only understanding how technology affects their lives in 1987, but how it affected the lives of their ancestors.

Second, elementary students need to understand the relationship between technology and social change. They need to understand what is meant by the notion that while necessity may be the mother of invention, culture is often the mother of necessity.

Third, they need to understand that most S/T/S issues involve conflicting assumptions, interpretations, and options. They should know that few issues are as simple as they seem while at the same time realizing that what they know and feel about S/T/S issues does make a difference.

Fourth, they should not feel powerless in the face of complex S/T/S issues. They should have the necessary data collection and decision making skills to enable them to make intelligent choices among options and to know when they should defer decisions to others.

Finally, youngsters should come to value a scientific approach to understanding their world and universe. They should see that human behavior is governed by principles, principles which can be discovered by those same humans. Human behavior in all its aspects should not be seen as a mystery but as the result of the interaction of social, cultural, and biological forces.

If the elementary school curriculum could contribute these five elements to the technological literacy of children, those of us interested in S/T/S would be well served.

The wonders of technology and its impact on the lives of those who use it is nothing new, despite what elementary school youngsters may believe. Shamos said it well:

> *The development of civilization since the Middle Ages is closely linked with the history of technology -- much more so than with the history of science and mathematics -- for since that period nations have encouraged industrialization by granting exclusive rights to monopolies for the development of innovative products or processes. This led in the Renaissance to the establishment of the first modern patent system, which ultimately provided much of the incentive for the industrial revolution and the setting for contemporary science. Thus, there is a strong rationale for understanding the role played by technology in the development of modern civilization, and its probable role in the future evolution.* (4)

Donald Manley has suggested that if students are to understand how we came to what we are today, they should study the impact of major technological developments. He suggests three major units:

1. The development of tools and machines and their contribution to the growth of civilization.

2. The development of power and energy and their contribution to the growth of civilization.

3. The development of communication and transportation and their contribution to the growth and development of civilizations. (5)

Manley goes on to suggest, for example, that the unit on power include concepts such as sail, waterwheel, steam engine, electric motor, paddle wheel, treadmill, battery, windmill, generator, turbine, and internal combustion engine. Each of these inventions had a major social impact, including some which were unanticipated. Many of the concepts proposed by Manley are already included in elementary social studies units, although their present purpose may not be to illustrate the relationship between technology, society, and social change.

Sara Anderson has suggested a slightly different approach for obtaining an historical view of technological innovations. She lists ten questions which students can ask when they study a past technological innovation.

1. List all the effects you can think of for one technological innovation introduced into our culture during the past 85 years.

2. Categorize the effects on your list according to whether they were planned and/or foreseen by those who introduced or eagerly adopted the innovation or were unplanned or unforeseen.

3. Indicate which effects were felt only in a local area, which were felt regionally, nationally and globally.

4. Divide the effects on your list into those you consider "positive," that is benefitting people in general and "negative," that is those which were harmful.

5. List four factors you consider essential to a good quality environment for human beings, and which influenced your choices in item #4.

6. Which subgroups in society benefitted most from the innovation you are

assessing? Which subgroups of society bear (or did bear) the majority of the burdens of the negative effects? List two reasons for the inequitable distribution of benefit and burden.

7. What was the time lapse between (a) the scientific or technological discovery which made the innovation possible and its widespread introduction or adoption? (b) Between the planned benefits and the appearance and/or awareness of the burdens?

8. (a) What actions have been/are being taken to alleviate the burdens? (b) Who (government, industry, consumers) are taking these acitons? (c) Who is paying the cost of alleviating these burdens in money? (d) Who is paying the cost of alleviating these burdens in quality of life?

9. What area of CHOICE did the innovation open up for individuals?

10. What choices did the innovation open up for society in general (seen most likely in legislative and judicial decisions)? (6)

While different in their specifics, both Manley and Anderson show us how history can be used to help children understand how closely coupled are technology and social change, how technology almost always involves a series of trade-offs and unexpected side effects. By modifying an item or two, Anderson's list of questions could also be usd to think about proposed innovations.

Since history is widely taught in the intermediate grades, the perspective being proposed here could be accomplished with a shift in emphasis from wars, capitols, presidents, and exports to the relationship between society and technolgy.

Elementary social studies also includes a considerable emphasis upon other cultures. Typically the focus of such units of study is upon the diversity of how humans relate to their physical environment. Without major adjustments the focus could shift to how other cultures deal with technology. Students could see how the introduction of "foreign" technology such as snowmobiles in Lapp society or transistor radios in India have ramifications beyond those planned or itended. Once students understand such a perspective they can be helped to turn it back upon an analysis of their own culture and its relation to technology.

The economics of technology has already been suggested. Technology always involves the allocation of resources. For example, is the development of a Star Wars defense system more important for the society than providing catastrophic health insurance for older citizens? Is the reduction of acid rain more important than holding the line on electric rates?

The politics of S/T/S also has a place in the social studies curriculum of elementary schools. At the base of all political systems is the process of allocating power. Technology has always been linked to the power allocation process. History is full of examples of where power went to those who could take it, and weapons often provided that means. Today the control of, and access to, information greatly influence the distribution of power. Even struggles over whether we should have a nuclear based, highly centralized system of energy distribution or a decentalized, appropriate technology system are in some ways a debate over political power and control. (7)

After history, more time in elementary social studies is spent on what could be classified as geography than upon any of the other social sciences. Place names receive much attention, as do exports and imports. Food, clothing, and housing seem to get a lot of attention. Again, current practice lends itself to the inclusion of an S/T/S perspctive. For example, the technology of air conditioning now allows habitation where before only adventurers cared to live. Refrigeration allows the worldwide movement of food products so while diets are still distinctive, technology is making them less so.

In short, history and the social sciences (social studies in the schools) bring a somewhat different perspective to S/T/S issues. While it is perhaps natural for people in the sciences to view the field as SCIENCE/Technology/Society those of us from the social sciences probably view the concepts in their reverse order, i.e., Science/Technology/SOCIETY.

The Very Special Area of Values and S/T/S

This section appears near the end of this paper for good reason; no area has caused those of us in social studies more grief than this one. (8) Value analysis and value clarification have appeared on more school board agendas during the past few years than I care to remember. One is tempted to simply forget it, to believe that if we could accomplish the other S/T/S related goals outlined earlier in this paper that we would have done enough! But the truth of the matter is that for most social studies educators preparing young people for democratic citizenship is probably THE most important reason for teaching social studies in the schools, either elementary or secondary.

The argument has already been made that S/T/S issues present democratic societies with unique problems. The general public finds itself taking positions on issues that are very complex, that carry with them all sorts of surprise effects, and about which the experts themselves cannot agree. It is in such a context that the society turns to the layman for a decision.

It is unrealistic to expect the schools to give students a level of technical knowledge which would permit them to make truly informed decisions over the entire range of areas represented by S/T/S issues. About all that can be hoped is that students can learn how to make such decisions and to practice those skills on a few issues so that the issues themselves are somewhat less mysterious. Besides, who among us would be willing to predict the specific choices which will await today's elementary age students by the time they become adults?

Patrick and Remy have described how "decision tree" strategies can be employed to develop the alternatives involved in civic decision making. The "tree" is rooted in the occasion for a decision. The occasion might be the issue of how to dispose of spent fuel from nuclear power plants or what to do with toxic waste produced by the manufacturing process? Students then explore the values and goals that pertain to the decision opportunity. What, for example, should be the predominant value regarding the nuclear waste issue? Is halting the production of waste so important that we should abandon generating electricity with nuclear power and live with the consequences, whatever they are? Or do we continue with nuclear power but force each state to store "its fair share" of the waste? If all states do not possess equally suitable storage sites, is the value of "equal distribution of risk" more important than effectiveness of storage?

The third component of the decision tree process is that of developing alternative responses to the decision opportunity. What are our options when it comes to storing nuclear waste? How do other nations cope with their storage of such waste? Can science and technology come up with still more options?

The final component of decision trees deals with the likely consequences, both negative and positive, of the alternatives identified in component three. It is at this point where students begin to get some idea of the interconnectedness of alternatives. They can begin to see that the choices are seldom between right and wrong but more often between good, better and best or bad, awful and worst.

There is no shortage of issues on which to practice the application of the decision tree process. In fact, science and technology are natural generators of highly controversial public issues. It is not important that students resolve the value dilemmas associated with each of these issues. What is important is that they can learn and practice the skills needed to deal with such issues.

Helping students learn to sort out and predict the consequences of various value positions will always be seen as threatening by some parents. Clarifying one's own values and speculating about the implications of applying them is a corrosive process if the values in question are dogmatically held. The best we can hope for is teachers who understand the difference between value analysis/clarification and value indoctrination and who practice the former rather than the latter.

Can We Move S/T/S into Elementary Social Studies?

Earlier sections of this paper have dealt with the questions of why and how S/T/S issues should be made a part of social studies in the elementary schools. But what is the likelihood that what has been proposed will actually happen? Shamos said it very nicely.

> *The educational battlefield is littered with the pronouncements of those who have sought to persuade the U.S. public that understanding something about science is the sine qua non of an educated person. To date all efforts to develop such literacy have failed, including the massive effort that followed Sputnik, and there is no reason to believe that new attempts to achieve widespread public literacy in science will be any more successful. Two reasons for this stand out above others: First, the public remains unconvinced that the effort it must expend to gain a reasonable understanding of science is actually worth the prize. Clearly the average educated adult in the United States manages quite well in our society with little or no understanding of science, or for that matter, of mathematics beyond simple arithmetic. Knowledge of these disciplines is not perceived by the public as being essential to either the "good life" or to a successful career outside of science. Nor is there any stigma attached to being ignorant of science ... Thus there is no incentive for the average U.S. citizen to become literate in science, either for economic reasons or because of peer pressure. (9)*

One need only substitute S/T/S for science in the Shamos statement to see what we are up against. The rationale for including S/T/S issues in the elementary curriculum has already been stated. But HOW we go about it can increase our chances of success.

If S/T/S is to have a chance in the elementary schools it will not be as a new course! As stated at the very outset of this paper, science and social studies already receive a meager share of the elementary curriculum. The allocation of additional time to either subject is unlikely.

There are at least two points of entry for S/T/S content other than through a new course. One is a different focus for existing topics and units. The second is the insertion of new topics into the social studies curriculum.

Much of what goes on in elementary social studies is structured around unit topics or "problems." Examples of units would include: Families Around the World; Producing Food, Shelter, and Clothing; How Our City is Governed; and The Industrial Revolution. Typical "problems" include: How Do Poeple in the Cities Get Their Food?; How Do We Make and Enforce Rules?; and How Have Ethnic Groups Contributed to Our Heritage? But these topics and problems could just as easily be ones tailored to S/T/S issues such as: What Causes Pollution and What Can Be Done About It?; Why Does Industrial Society Depend Upon Tools?; How Has Transportation Changed During the Past 100 Years?; Tools and Early Humans; The Role of Communication in Government; and The Global Supermarket. The focus of such units would be to develop the types of understandings and skills described earlier.

While new units and topics would be nice, they are not essential. Much of the current content of elementary social studies will serve quite nicely if we can get the focus shifted to technology and its relationship to society. A teacher can still teach her unit on "Transportation in the City," only now she can help students think about how streetcars changed the lives of city folks. A unit on "Modern Manufacturing and the Use of Robots" could lead to a discussion of the positive and negative consequences of robotics. A unit on "Communication in America" might probe into the changes brought to the American family by TV.

The point is that if we want to see S/T/S dealt with in the elementary schools we should infuse it into existing courses and topics rather than using the new course approach.

A Final Note

One might rightfully ask why the responsibility for S/T/S should be divided up among existing subjects such as science and social studies? Would it not be more efficient to create an interdisciplinary subject? While that might seem reasonable my response is that it probably will not work. School people think in terms of subjects. One of the things which has hampered my own field of social studies is that we cannot decide whether we are simply the sum of history and the social sciences or whether we are something unique. If we keep S/T/S as a set of topics and perspectives which we can fit into existing courses we have a chance. If not, our fate may be that of many previous "good ideas."

Notes

1. Shamos, p. 15.

2. An example of the cross-national nature of the problem can be found in the paper by Robert Smith.

3. Berkowitz reports the NSTA definition of technological literacy. It should also be noted that the National Council for the Social Studies has a standing committee on S/T/S issues and adopted S/T/S Guidelines which were published in the April, 1983 issue of Social Education.

4. Shamos, pp. 14-15.

5. Manley, p. 11.

6. Anderson, pp. 24-25.

7. Commoner.

8. For a more detailed discussion of the controversial issues problem, see the paper by Kay Cook.

9. Shamos, p. 9

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Bull. Sci. Tech. Soc., Vol. 7, pp. 233-238, 1987. Printed in the USA.
0270-4676/87

THE ELEMENTARY SCIENCE, HEALTH, AND TECHNOLOGY PROJECT - DEVELOPMENTAL APPROACHES IN SCIENCE AND HEALTH (DASH)

Francis M. Pottenger III, Donald B. Young and Marlene N. Hapai

The Curriculum Research & Development Group (CRDG) of the College of Education of the University of Hawaii, working with a consortium of educational institutions, is developing a sequential and integrated science, health, and technology curriculum for the elementary school, kindergarten through grade 6, known as the Developmental Approaches in Science and Health (DASH) project. This paper will deal with the structure of the consortium and the role it will play in the dissemination of DASH materials, the reasons for the development of the DASH materials, and the structure of the materials being produced.

THE DEVELOPMENT-DISSEMINATION CONSORTIUM

DASH is being undertaken by a consortium of educational agencies and organizations, members of which include the Curriculum Research & Development Group (CRDG) of the College of Education, the College of Arts and Sciences, the College of Public Health, the Institute of Astronomy, the Institute of Geophysics, the Institute of Marine Biology, the College of Engineering, and the College of Tropical Agriculture of the University of Hawaii; the Hawaii State Department of Education (DOE); the Hawaii Catholic School Department; the National Association of Laboratory Schools (NALS); and a regional distribution of cooperating universities and public and private schools

Curriculum Research & Development Group (CRDG)

CRDG is playing the role of lead agency in the consortium. It began operation in 1966 to design, develop, and disseminate curricula and to provide evaluational and policy research for the public and private schools of Hawaii with service to Micronesia, the Pacific Rim nations, and the mainland USA. In the twenty years of its operation, CRDG has produced over 200 programs that are in use in Hawaii and elsewhere. CRDG operates the University of Hawaii Laboratory School, which will be the site of first trial of materials.

Hawaii Participating Institutions

CRDG will be working cooperatively with the various colleges of the University of Hawaii offering consultancy on subject matter, and the Department of Education and the Catholic School System will be providing consultancy and cooperation in testing.

National Association of Laboratory Schools (NALS)

The National Association of Laboratory Schools (NALS) is the professional association of the nation's laboratory schools. It represents the nation's college and university-attached teacher training centers. NALS will provide a ready pool of university and college training centers to be brought into the dissemination activities of the project after the initial development period. Twelve NALS schools and companion public and private schools have been selected to act as initial trial sites and dissemination centers.

RATIONALE FOR DASH

Since the early 1980's both the popular and educational literature has been filled with doomful language about the state of teaching and curriculum in our schools. In Hawaii a most recent concern is for students-at-risk, those who are not "making it" in the present educational system, the potential drop outs, the teen-age mothers, the delinquents, and the marginally literate. All these categories of dysfunctional youth have been accusatively associated with what is happening and not happening to children in school. Fortunately, in Hawaii there is a maturing understanding that these children are part of a broader societal failure, and efforts are now afoot to coordinate the remediating efforts of many social agencies. Now education is being given its fair share of the burden of repair and prevention.

With this deep concern as a backdrop, DASH is taking the positive view that schooling can make a difference in the life of children. What is needed is an educational experience that deals with the real world in which children find themselves. The research literature bulges with studies of what can be done to improve education. A careful engineering of curricular materials that builds on what we know and is open to modification as research continues is now required. We in Hawaii are convinced that one of the places to start this engineering is in a program of science, health, and technology because the subject matter embraces a substantial part of the world that all children face each day of their lives. With this engineering challenge DASH has set for itself the task of squarely confronting the following taxonomy of deficiencies.

NEEDS

Technology Is Not Included in Current Curriculum. Technology, as a subject, is not normally recognized as a necessary part of elementary curricula. When technological content is included in text matter, little effort is made to separate its function from that of research science or to show how it relates to society's needs.

Science and Health Are Taught Independently of Each Other. There is a long-standing tradition of teaching health and science as separate subjects in the elementary school, and this has led to unintentional redundancy and confusion in content. Often because of differences in vocabulary, common shared subject matter is unrecognized by both pupils or teachers.

Science is Often Taught Exclusively Through Textbook Reading. Much elementary science teaching currently involves an aimless collection of descriptions about the things of science presented through readings in a textbook. Science is treated as part of the reading program where it is tolerated under the rubric of "reading in the content area." The investigation of natural phenomena and the logical building of concepts and skills unique to science are sacrificed to the need for having "interesting" language arts vignettes.

There is an Insufficiency in the Time Spent on Science and Health. Surveys of the total amount of time spent on science and health find that these are topics that are often given little coverage by elementary teachers.

Science and Health Are Seldom Sequentially Organized. Few schools provide for sequencing of science, health, and technology lessons within a grade level; fewer still, a sequential organization from grade level to grade level. Mathematics and reading are recognized as requiring a sequential developmental presentation to ground students in evolving levels of difficulty. However, science, health. and technology treated as a disjointed collection of facts denies the generative power of sequence and the need to offer manipulative and process skills in a developmental hierarchy.

Special Topics Are Seldom Interqrated with Science and Health Topics. In most states, legislatures and departments of education have mandated that schools teach special topics that bear on the science and health curriculum. These include environmental education, sex education, drug education, nutrition education, safety, first aid, energy education, women and minorities in science, career education, etc. These topics, for lack of curriculum design, become "add ons" inserted without logical connection to the remainder of the science or health curriculum.

Science, Health and Technology Are Not Integrated with Other Subject Areas. Though science, health, and technology are recognized in some schools as a rich souce of interesting reading content, their capacity to provide motivating and instructive articulated content with mathematics, social studies, art, music, and physical education is seldom tapped.

Science and Health Materials Are Not Designed for Heterogeneous Classes. Heterogeneous grouping is the most common organization of the elementary classroom, yet most science materials and health materials are designed for a relatively homogeneous population. Students are expected to be reading and performing mathematical operations at or near grade level, and the difficulties of students with poor spatial and psychomotor skills are basically ignored. The realities of the typical classroom cry for materials that can accommodate the wide range of abilities found in the normal classroom.

Lack of In-service Training in New Programs. A lack of in-service training typifies the vast majority of new program installations, and consequently failure rates of those that attempt new ways of interacting with students are as high as 95 percent.

Lack of Follow-up Inservice Support. It is becoming better understood that adequate preservice and in-service training are fundamental to quality elementary science teaching. Unfortunately, it is not generally understood that equally important to the success of newly installed programs is adequate follow-up in-service contact or coaching. There is strong evidence that to ensure that a new program is taught with fidelity, coaching must be maintained through the progressive stage of a teacher's maturation in the use of a new program.

Lack of Administrative and Parental Support. Many of the science programs of schools are understood by neither administrators nor parents. To gain entrance and ultimately long-term acceptance in a school, any program must be understood by both administrators and parents. The adminstrator must be sufficiently convinced of the quality and educational goals of the program to be willing to explain, and if need be, defend it to the community. Parents must be convinced that the program has goals that are worth the time the child will spend on the program. Few programs make provisions to educate parents and administrators.

Cost. Education remains one of the most costly enterprises of government. Changing the curriculum always requires major outlays of monies. In addition to the initial cost of new materials, there are hidden costs of yearly replacements and restocking consumables and the costs of training teachers and follow-up in-service. Major change in the curriculm is therefore resisted by school boards. New materials must be designed with cost containment in mind.

DASH GOALS

DASH goals for students are to

1. involve them in an authentic, concrete, hands-on, investigative, and understandable experience of the operations of science, health, and technology;
2. engage them in experiences that capture the excitement of discovery and exploration of natural phenomena, of invention and refinement of technological processes and products, of gaining rational control of their everyday environment, and of development of a capacity to think critically and solve complex problems;
3. create in them a sense of personal capacity to use the manipulative and intellectual skills of their science, health, and technological studies in a meaningful way in their own lives and foster a desire for further study in these areas;
4. develop in them an understanding of themselves and a personal commitment to the well-being of nature and our human community.

DASH'S curricular goals are to

1. provide sequential K-6 materials that build on the growing conceptual base and skill capacities of students;
2. integrate the now independently taught subject matter of health, science, and diverse special topics to expand and better use precious curriculum time;
3. expand curricular time by sharing content with such subjects as mathematics, language arts, social studies, physical education, art, and music;
4. articulate materials with programs designed for the middle school or junior high school;
5. provide materials with mechanisms to accommodate the range of abilities in the normal classroom;
6. provide mechanisms for the progressive revision and modification of the program to reflect evolving local requirements, technology, and pedagogic and learning theory;
7. provide a materials package that will be cost competitive with existing elementary science and health programs.

DASH'S goals for teachers are to

1. make science in the elementary school teachable by providing for program flexibility, minimum preparation time, use of new time-saving technologies for evaluation and record keeping, practical management strategies, and a simplified system for equipment and supplies aqusition;
2. make teacher training a requirement to gain access to materials;
3. provide training that will give direction and practice in using the activities of the materials, coping with classroom organization and management, and employing new insights into learning theory;
4. provide coaching follow-up services during the period of mastery and personalizing of the program;
5. provide preservice training materials for use in college and university preservice programs.

DASH'S goals for administrators, parents, and community are to

1. provide administrators a guide for supportive involvement with the program, including ways of evaluating teacher effectiveness;
2. provide administrators with background materials to explain the program to the public;
3. provide parents with background materials that explain the program and the role they can take in nurturing their child's interest in science;
4. provide mechanisms for local community participation in the program.

DASH'S dissemination goals are to

1. provide for rapid dissemination of the products of the project through a network of university and district-based demonstration-training-support centers;
2. provide for the localization of materials through a cooperating network of university centers.

<u>Student Products.</u>

There will be a student product for each activity. Part of that product will always be some written or pictorial record of what has been done in the activity. Collectively, these written products will make up the student's notebook, or personally written text. Other products will include oral reports, experiments, projects, invented devices, posters, foods grown and prepared, diagrams, displays, poems, and songs.

STUDENT MATERIALS

There will be six different types of student materials--the student book, the student workbook, the reference library, optional computer packages, catch-up materials, and special equipment.

Student book. There will be a student book for each grade level. It will be a compilation of the grade level activities and will include statements of problems to be worked at, any special instructions on how to carry out the activities, and descriptions of paper-and-pencil materials needed.

Student record book. The record book will include all of the data tables, cut-outs, drawings to be completed, and other paper materials that students will need to carry out the activities. As an expendable item the record book will provide the ingredients for the students' personal notebooks and will be designed to increase the life of the student books.

Reference library. There will be a program specific reference library of booklets which contain special instructions, useful references, detailed information, and extending activities, problems, and opportunities for invention. These booklets will also house biographies; tales about science discoveries and technological inventions; historical accounts of the uses of inventions; data collections on social issues of technological origin; readings on issues of social concerns about the impact of science and technology on environments and society; and problems and puzzles in science and science-related mathematics. These readings will support the hands-on component and will be the backbone of the shared language arts literature and social studies component. These booklets will be separate from the student book to give students the experience of going to "other" resources for information about topics.

Optional computer packages. There will be optional computer packages to be used with activities in which there is much data manipulation, nutrition being an example; complex and long-term data collection such as that on seasonal observations; simulations where there is need for information storage and retrieval; dynamic schematics for explanation of devices; and others as dictated by the emerging design of the project.

Teacher materials. Teacher materials will include a teacher's guide, storybooks, evaluation guide, film-strips, and a computerized record-keeping data management system keyed to an evaluation guide.

Teacher's guide. There will be a teacher's guide that will include instructions on how to direct each of the activities as well as special instruction on how to procure specimens, prepare sites, assemble equipment, and generally cope with the minutiae of teaching. The guide will contain blackline masters to make overhead transparencies. The guide will be the major instructional piece to be used in teachers' training.

Evaluation guide. There will be an evaluation guide with observational check lists, as well as practical hands-on and paper-and-pencil evaluations keyed to a concept and skills mastery list. This list will include the concepts and skills that the student should understand and be able to use.

Computer utilities. There will be computer utilities to assist teachers in data management and record keeping. These will be keyed to the ongoing class activities, the concepts and skills mastery list, and the evaluation guide.

TEACHER-TRAINING MATERIALS

Teacher-training materials will include the teacher's guide already described, a guide for trainers, a guide to in-service coaching, and a guide to preservice instruction in the use of the program.

Teacher-trainer guide. There will be a guide to instruct trainers in how to carry out teacher-training workshops. This will include detailed lesson plans to lead teachers through the activities and to develop an understanding of the learning theory assumptions and the style of pedagogy built into the materials as well as management procedures that facilitate program delivery.

Guide to in-service coaching. There will be a guide for field personnel working with teachers. This will include classroom observation instruments, compilations of the professional literature dealing with ways of upgrading classroom instruction along with suggestions for translating these into practice and suggestions for helping teachers to personalize materials.

Guide to preservice instruction. A guide will be produced for university and college in-servicing of professorial staffs and later as a text for preservice instruction. The guide will be produced after the completion of the materials package.

OTHER MATERIALS

Other materials will include a guide for administrators, a guide for parents, regionally adapted materials, and the project newsletter.

Administrator's guide. This guide will include materials and suggestions to help administrators monitor the program within the school, to give support to program teachers, and to explain the nature of materials and the program to the school's many publics. It will include statements of philosophy, examples of pedagogy, exemplary schedules, equipment lists, classroom observational instruments, answers to the questions most commonly asked by administrators and the public about the program, lists of groups or persons who can give aid and counsel, cross references to the parent guide, etc.

Parent's guide. This work will include a collection of information that will help explain to parents what their child is doing in the progr... and why. It will include answers to questions commonly asked by parents about the program and suggestions for helping students reinforce and extend the ideas developed at each grade level at home and away from home.

Regional adaptation materials. Materials will include adapted and alternative materials to be used where there are special environmental or technological differences. Development of these materials will rest with the cooperating universities.

Project newsletter. The project will publish a newsletter to keep professionals up to date in new developments.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 239-242, 1987. Printed in the USA.
0270-4676/87

AN INTEGRATED SCIENCE, MATHEMATICS AND STS PROGRAM FOR PRE-SERVICE MIDDLE SCHOOL SCIENCE AND MATHEMATICS TEACHERS

William J. Doody and Robert Snow

Potsdam College, a member of the State University of New York system, is perched on the northwest corner of the Adirondack State Park, closer to Ottawa and Montreal than to Albany or Syracuse. The tradition of the college is teacher education (it is the oldest unit in SUNY, having been founded in 1816), but in the '50's it began to establish a broad liberal arts program with particular strengths in mathematics and the sciences. During the '70's enrollment in Potsdam's teacher education programs dropped dramatically, but in the last three years that trend has reversed. Currently 176 undergraduate math majors and 60 science majors are pursuing teacher certification. Overall, 700 undergraduates are enrolled in teacher certification programs concurrent with their pursuit of a B.A. in a liberal arts discipline.

About 10 years ago Potsdam began to develop a small, team taught, freshman general education program which came to emphasize the role played by science and technology in the development of western culture. The program no longer exists but its legacy is a group of faculty from a number of disciplines (anthropology, political science, sociology, history, english, philosophy, and chemistry) who have worked hard to develop a broad historical perspective on science/technology/society issues. Within the context provided by the resurgence of teacher education programs, the successful math/science programs, and the strong interest of some faculty in STS issues, three events occurred last year which have served to catalyze what promises to be an active STS science education program. These were: 1) the addition of a Science/Technology/Society requirement to the New York middle school science syllabus; 2) the announcement of a statewide 9th grade science test which would include approximately 15% STS questions; and 3) a five year $850,000 National Science Foundation award to Potsdam for the development and implementation of a model curriculum for the preparation of middle school science and mathematics teachers. Those events made clear the substantial need for a coherent STS program to educate both future and current teachers. Building such a program requires a good deal of hard thought (and good will) as people with professional backgrounds in the liberal arts and in education struggle to learn each others language and point of view. Substantial effort is also required to build an effective administrative framework to facilitate cooperation within the college and with local and state educational agencies.

Curriculum Development:

Overview

In the early phase of developing our program (science, math, humanities/social science, and pedagogy) for future science and mathematics teachers, significant differences of perspective concerning the nature of STS became evident. For example:

A: The science educator's first objective was to prepare teachers who understand STS issues from the perspective of a competent user of science and technology. This concern translated into the need for a college science curriculum which would enable future teachers to develop a sense of their control over science and technology. The science laboratory is particularly well suited to developing that sense by providing students with the opportunity to assume responsibility to plan and carry out lab activities. Technological devices may be readily incorporated into the lab in the form of microcomputers, analytical instruments, and other devices. Such a laboratory helps provide students with a functional understanding of science and technology as well as a sense of control over both - - thus addressing objective number one. The science educator's second objective was to insure that future teachers develop an integrated view of science which linked mathematics and the several science disciplines together and which dealt with subject matter related to daily experiences. Such a view of science is best developed in courses where such a view is constantly modeled and this requires the creation of new integrated science courses. Realization of both objectives in the college program is necessary to enable future teachers to design classroom environments which prepare their students to thrive in an increasingly technological society.

B. The perspective of the scientists and mathematicians emphasized development of competency in science and mathematics. A firm grounding in each of the sciences and in mathematics, they argued, must be established within a context which models strategies of interdisciplinary teaching and thinking. Students then may be brought to a point where they can be expected to continuously renew their familiarity with new scientific developments and to sustain a high degree of intellectual sharpness at testing scientific propositions. Individuals having those competencies will be prepared to address STS issues adequately.

C. The humanities/social science faculty perspective emphasized development of an understanding of the historical influence of science and technology in shaping current social conditions, development of critical analytic skills with which to assess the impact of specific scientific and technological developments on society, and development of a sensitivity to the role science and technology can play in resolving/aggravating local, regional, national, and world wide social issues.

D. The State Education Department perspective included many of the concerns described above, but tempered by the need to suggest the manner in which STS could be integrated into an existing elementary through junior high science syllabus without inhibiting the creativeness of teachers in the design of their own science programs. In addition, the State Education Department must consider the issue of assessment of programs and students. Those dual responsibilities demand great flexibility on the one hand, and some degree of specificity on the other. Meeting such diverse demands is no simple task.

It was apparent that STS is a complex set of interrelated issues, and a coherent program must provide for a variety of perspectives. A composite program is being developed to address these complexities. Four arenas have been specified as focal points for attention. First, the science team is pursuing the objectives of developing competency in science, intimate familiarity with computers and technical equipment as tools of inquiry and tools of managing information, and an understanding of the interrelatedness of the sciences and mathematics and the technological tools of those disciplines. Furthermore, the new science courses are intended to demonstrate the fun and excitement of science, and the relationships linking science to everyday life. Second, several humanities/social science STS courses have been designed to develop a historical understanding of STS issues, a philosophically informed analytic ability to assess STS issues, and a sensitivity to the ways in which STS issues affect our modern society. These courses satisfy a variety of Potsdam College general education requirements and students in the NSF model program may elect to take one, two, or three of these courses prior to their senior year. Third, a senior year Interdisciplinary Seminar (required in all Potsdam College B.A. programs) for science and math education students will include STS as one of several themes. Fourth, the seminar coincides with math and science methods courses taken in model classroom settings, and co-taught by master middle school/junior high teachers and college faculty. The interdisciplinary seminar will help students to simultaneously grapple with the complexities of STS and the demands of classroom instruction. Taken together, these four arenas (Science, Humanities STS, Interdisciplinary Seminar, Methods) provide the multiple perspectives which will enable students to develop an understanding of the relations between Science, Technology, and Society. As the program matures, we expect to be able to build into our courses numerous points of contact linking the four major arenas.

Science Courses

The Interdisciplinary Science Major consists of 36 semester credit hours of course work designed with several basic criteria in mind. First, courses progress in sophistication and depth in a manner common to traditional science major course sequences, but each course (in the first 24 credit hour set of four courses) is interdisciplinary both in lecture and in lab. At the completion of the 24 hour sequence, students have knowledge and skills equivalent to science major students completing the freshman year in each of the sciences (except Physics). Second, the introductory courses include two 3 hour labs per week, emphasizing student management of the laboratory (within the bounds of reason), a focus upon concrete lab activities wherever possible, and the use of the computer as a common tool. Third, field work is common in the introductory courses. Fourth, topics of current interest and subject to debate are introduced regularly. Concurrent with the science courses, students observe middle school/junior high students in model science classrooms. That experience is expected to nurture an understanding of professional science teaching, which attends to needs of the individual learner while educating the individual in science. In turn, this increased sensitivity to the need to explain science to children in terms which they can understand will prod the college student to reexamine their own understanding of science concepts, and thus enhance their learning.

Humanities/Social Science

Parallel to the Interdisciplinary Science Major are three courses taught from the perspective of the humanities/social science and intended to build bridges between material discussed in the introductory science courses and the STS science education literature. Two of the courses, offered at the freshman level, are titled "Science and the Making of the Modern World" (I, II). Drawing upon the history of science and technology, these courses consider the broad social and cultural context of the 17th century scientific revolution, the industrial revolution of the 18th and 19th centuries, and the current science based technological revolution. The sequence concludes with comparative studies of science and technology policy in Russia, Japan, China and the western democracies, and includes case studies of major contemporary problems such as environmental quality, energy resources, and third world development. The third course, at the sophomore/junior level, focuses upon expert disagreement in public controversies involving science and technology. Course materials are drawn mainly from the philosophy and sociology of science. The goal of the course is to help students understand the ways in which epistemological, sociological and public policy issues interact to stimulate expert disagreement in areas such as health, environment, and arms.

Summary

The recent threefold stimulus (State Syllabus, Competency Test, NSF Grant) to provide enhanced STS education for future science teachers has brought a number of people from diverse areas together on a common task. The result has been expansion of each person's understanding of STS, development of new courses to address specific aspects of STS, and expansion of program objectives to include a variety of STS related activities. The principal focus of our current work is continued development of courses associated with the NSF Model Science and Mathematics Teacher Preparation Program at Potsdam College. Graduates of this model program (beginning with the class of 1991) will be especially well prepared to create model middle school/junior high STS classroom environments because of their strengths in Interdisciplinary Science, Mathematics, and Humanities STS studies. But much work remains to be done. Along with the tasks involved with the development and implementation of new courses in a new curriculum we need to continue working to lower the disciplinary barriers which separate faculty members educated in the humanities, the sciences and mathematics, and in education. Discussions of scientific method, scientific process, scientific change, the nature of technology and technological change, and the relationships linking science, technology and society all contain numerous intellectual mine fields which need to be charted and dealt with en route to an effectively integrated and successfully functioning science and STS undergraduate program.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 243-247, 1987. Printed in the USA.

MODEL PROGRAM FOR THE PREPARATION OF MDDLE SCHOOL SCIENCE TEACHERS

Dianne Robinson

Rationale

Hampton University, under a grant from the National Science Foundation, is developing a curriculum to improve the training of middle school science teachers. This paper summarizes the need for this program, its goals, its present implementation, and explanation of its future development. The goal that all learners acquire the ability to function effectively as individual workers and citizens in a world increasingly permeated by science and technology is no longer a lofty educational challenge, but rather a present day necessity. Concern over the "rising tide of mediocrity, (A Nation at Risk, 1983), in science education has focused on the need to continue to produce high quality scientists and mathematicians, as well as scientifically literate individuals who understand and are able to use scientific knowledge in their everyday decision making (Educating Americans for the 21st Century, 1983). Such literacy is incomplete unless the individual possesses the ability to formulate questions about nature, and the ability and interest to seek answers to those questions through observation, exploration, and analysis of natural and man-made phenomena.

The foundations on which this goal will be met lie in the experiences our schools provide during the elementary and middle school years, where interest in science and technology is either sparked or extinguished, and the desire to pursue future scientific careers is kindled. The fact that many science career choices are made, and that the childhood perspectives begin to evolve into adult values, make the early adolescent years a critical time period. It is most appropriate then, that middle school science classes be taught by teachers adequately versed in the knowledge of science, cognizant of the educational and psychological needs of students of this age, and able to teach science as a dynamic interrelationship between man and his world. Students must learn to be sensitive to the impact and relevance of science and technology on their everyday lives.

A National survey report that 85% of children find science to be uninteresting and irrelevant by the time they reach the eighth grade, thus suggesting that the goal of a scientifically interested and literate public is far from being reached. A number of factors have been advanced as contributing to our nation's present and future problems in science education. Among these are: inadequate training of teachers in math and science; inappopriate methods of instruction on the part of science teachers; and insufficient numbers of students entering the teaching profession, especially minority students.

Inadequate training of teachers in math and science is exemplified by the lack of certification of a large percentage of our science teachers. Even when certification requirements are met, many science educators question the adequacy of those requirements. Virginia, typical of many states, requires only fifteen semester hours of science courses for a middle school science major. In contrast, the National Science Teachers Association recommends thirty-six hours (NSTA standards, 1983). In addition, the pre-service teacher often has insufficient preparation in mathematics to deal effectively with the science curriculum. The science courses they do take are often designed by college faculty to meet general university requirements, or are merely foundation courses for majors in that discipline. They do not address the needs of the middle school science teacher. Furthermore, these course are often taught as abstract disciplines, with little apparent relevance to everyday living, and without the perspective of the impact of science and technology on our lives in an increasingly complex society. What is needed is a substantive science curriculum, taught by scientist working with educators, that incorporates social and technological relevance. Statistics report that the percentage of college bound students entering the teaching field each year has dropped drastically. At the present time, four percent of college bound students declare teaching as a major. This problem is magnified in the black community where an even smaller percentage of blacks are choosing to go into science teaching because of an expanded range of opportunities available to them. Nationally, the figures for minorities in math and science education are appalling. We have seen a decline in the late seventies and early eighties in the numbers of blacks entering the university, due in part to the poor economy and rising costs of education. This trend is especially true of the sciences, thus reducing the already small number of models that attract the black student into either the sciences or the teaching of science. If this trend continues, we will see fewer and fewer black minorities represented in the ranks of science, while the percentages of blacks in the total population continues to increase.

Program Goals

The goals for the science education program at Hampton are:

1. To provide an atmosphere of excellence for the middle-school pre-service teacher through interdisciplinary activities which relate appropriate course content to socially and technologically relevant issues.
2. To provide teaching models and training to optimize the teacher's ability to develop student interest, and an understanding of, science concepts.
3. To develop a national model program that will specifically be oriented to identify, motivate and attract pre-college black and other minority students into science teaching.

The first of these goals has been addressed during the first year of the program. A select group of science professors working with educators has participated in a series of workshops, conferences, and seminars focusing on the relationship between science, technology, and society. As a result of this interdisciplinary faculty development, a core of science courses are being designed for the science education major. Course content of the required science courses is being developed around societal and technological issues. These courses include: biology, physical science, chemistry, physics, geology, earth science, and environmental science. Three of these courses, biology, physical science, and geology, will be taught for the first time in the Fall of 1987.

The development of these courses will evolve through continued discourse and evaluation with colleagues and outside consultants during the second and third year of the project.

Another interdisciplinary course, a one semester hour S-T-S seminar, will become part of the general studies requirements for education majors in the Fall of 1987. This seminar will be required of education majors each semester of their sophomore and junior years. Faculty from the School of Education and School of Pure and Applied Sciences will team teach the course. The focus of the seminars will be on students solving problems arising from the impact of society.

Already, as an outgrowth of this interdisciplinary collaboration, science faculty are considering the incorporation of S-T-S perspectives into all the courses required of science majors, as well as graduate courses. General biology and genetics have been revised.

The second goal, to provide appropriate teaching models, is being met by the science faculty at Hampton University. The science courses will be taught to the pre-service teacher in the same manner that middle school teachers should teach their students. The courses will be student centered and activity oriented. The focus is on doing, rather than passively receiving. College instructors are viewed as important models for the pre-service teacher, who is likely to emulate them when he/she goes into the classroom.

To further reinforce this critical dimension of teacher training, cliniical professorships are being established for teachers in the public schools who will serve as mentors for the pre-service teacher. These teachers will be selected based on recommendations of their science supervisors, and on the teacher's own expressed interest in the program. The target group will spend two weeks during the summer at Hampton University, and will return to campus one Saturday each month for the academic year. During this time they will be exposed to the S-T-S philosophy, the importance of a student centered activity oriented classroon, and the role of the classroom teacher in helping the pre-service teacher to develop his/her ability to teach and motivate the middle school child in the study of science.

The pre-service teacher will be placed in the classroom with the teacher-mentor each semester for twenty hours beginning in the sophomore year and culminating with the student teaching experience. The pre-service teacher will work in different classrooms with different mentor-teachers each semester to gain a broader base of experience.

The third goal is to develop a model program to identify and attract minority students into science teaching. Hampton seeks to address this problem by developing a permanent network for identifying and subsequently training black science teachers who can address the above described issues for the middle school student. Hampton, a historically black university with sixty percent of the student body drawn from out of state, is in a unique position to provide a national model for training middle school science teachers.

An essential element of this model will be identifying and attracting qualified minority students into this field. The model will seek students from two sources, the pre-college sector and the transfer student from pure science.

The first source of students, the pre-college student, will be identified through a network consisting of science supervisors, counselors, teachers and university faculty. A permanent network will be established similar in scope to the National Action Council for Minorities in Engineering, Inc. (NACME). Twenty school districts, supplying the greatest number of students to Hampton, will identify potential high school candidates for a science education program in each of the sophomore, junior, and senior years.

The next step in network development is a workshop at Hampton to begin in the summer of 1988 for these key school personnel. This workshop will train them in identifying minority students that have potential as science teachers. External consultants will help the project director plan and implement this workshop.

By the third summer of the program, twenty students will be selected from each of the three grade levels and be brought to the Hampton campus for a two week summer enrichment program consisting of both science content and observation/participation with middle school children who attend summer programs at the university. This program is intended to allow early exposure to both working with science and experiencing teaching roles.

The second source of students are transfer students from the pure science areas. Many universities are experiencing large numbers of students enrolling in freshman science courses, declaring pre-medicine of a related science field as their goal. Statistics show that only a small percentage of these freshman will receive a terminal science or medical degree, a situation magnified with minorities, where opportunities have previously been denied. Transferring to a science education program is a viable alternative career goal for the student who has demonstrated both competence and interest in the sciences. This can provide both internal student transfers from the pure science and external transfers into the program from other universities.

The successful recruitment of minority students to the university is dependent on the coordinated effort of not only the public schools and the university, but also the community. It is here, the child's community, that the child experiences frustrations, but also where he finds reinforcemnt and support systems.

To bring together this triad of community, school and university, Hampton has established an Advisory Board. The Board is composed of superintendents of schools, principals, science supervisors, middle school science teachers, the program director, the Dean of the School of Education, and the Dean of Pure and Applied Sciences. This group meets periodically to give feedback on program developments and make additional suggestions. This cross section of professional educators giving continual feedback on program effectiveness is the keystone of a teacher training program designed to prepare teachers to be effective catalysts for stimulating scientific learning and curiostiy in students.

In summary, Hampton's science education program is a visible, broadly based community program that helps minorities redefine roles they might occupy in society. It affords them a chance to interact actively with technoloigies that impact their everyday lives, with an ultimate goal of reversing the dismal decline of minority involvement in the sciences.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 248-252, 1987. Printed in the USA.
0720-4676/87

THE CURRENT STATE OF RESEARCH IN PRECOLLEGE STS EDUCATION: A POSITION PAPER

Peter A. Rubba

In this position paper I examine the current status of research in precollege STS education and the implications it has for the stability and survival of STS education as part of the precollege curriculum. On any matter involving judgement, such as this one, one's perspective is influenced by the complicated interaction of a number of factors. Among these would appear to be one's philosophical perspective regarding education as a whole and STS education in particular, one's educational background and professional experience, one's level of scientific and technological literacy, and one's research interests and previous research experience. I will preface these remarks with three propositions in which are reflected many of the factors which have influenced my perspectives on this topic.

> <u>Proposition #1:</u> STS education is not a curricular or instructional frill at the pre-college level, but a necessity given the unique nature of the interdependence which exist today among science, technology and society, and the responsibilities associated with citizenship in a democratic society.

The plethora of blue-ribbon reports on the state of education in the U.S., particularly science education (Aaronlan and Brinckerhoff, 1980; Harms and Yager, 1981; NSTA, 1982; NSB, 1983; among others), which appeared during the first half of this decade, emphasized the need for precollege science education (curriculum and instruction) to address the scientific and technological literacy needs of the general population via the infusion of STS.

Everyday citizens face issues which arise out of the interactions of science, technology and society, in such areas as environmental quality, health and medicine, national security, waste management, world population. The authors of these reports found alarming the inability of citizens, and in many cases the unwillingness of citizens, to deal in a responsible manner with the science and technology-related societal issues which touch our everyday lives. Dogmatic decision making and avoidance behaviors are common responses to STS issues among the general public.

> <u>Proposition #2.</u> Because STS issues have foundational components rooted in the natural and social sciences, science and social studies courses are logical points from which to initiate STS education at the precollege level.

This does not preclude the infusion of STS into other areas of the school curriculum, particularly the arts and humanities. In fact, STS may be an appropriate theme around which to integrate the entire school curriculum. Nonetheless, natural and social science courses would appear to be inherent curricular foot-holds for STS. A working understanding of certain concepts from the natural sciences (e.g., anthropology, economics, psychology, sociology), as well as an understanding of the characteristic interrelationships among science, technology and society, are needed if one is to work towards the resolution of an STS issue (Rubba and Wiesenmayer, 1985). In recognition of this, a number of states (foremost among them Florida, Illinois, Indiana, Maryland, Michigan, New York, Pennsylvania, Washington and Wisconsin) have undertaken STS education initiatives within one or both of these curricular areas (Rubba, Barchi and Wambaugh, 1987a), though science courses typically have been the focai point for the infusion of STS education into the precollege curriculum (NSTA, 1982).

Proposition #3: The ultimate goal of STS education at the precollege level is to assist students in the development of the knowledge, skills and affective qualities needed to make decisions and take action on STS issues in a responsible manner, now and in the future.

For the most part it appears the STS instruction students presently receive in school (science courses) centers on a limited number of STS issues, one or two of the most popular issues per course, with these issues dealt with minimally at an awareness level via teacher led lecture-discussions (Rubba, 1986). Awareness of the domain of STS issues currently facing mankind is an important outcome of prcollege STS education. But, it should not be the terminal outcome.

STS education must go beyond issue awareness; behond helping students develop the abilities to explore an STS issue, to suggest means by which an issue might be resolved, or even, to note consequences associated with the various means which could compose the resolution process. STS issue resolution will occur only if citizens are willing, able and do take action. Helping students develop these capabilities must be the terminal goal of precollege STS education (Rubba and Wisenmayer, 1985).

The literature is clear on the connection between instruction, and student development and retention of the ability, the desire and the taking of actions on issues. Precollege students who receive instruction on issue action strategies and have an opportunity to apply the strategies in the resolution of an issue are more likely to take action on issues immediately followng instruction and over an extended period of time (Rubba and Wiesenmayer, 1985). Because the STS issues facing mankind are sure to change over time, development of the knowledge, ability and desire to take action on STS issues is an enduring goal for precollege STS education, especially when compared to awareness of any particular set of STS issues.

These three propositions encapsulate my perspective on precollege STS education. A fourth proposition, presented below, expresses my view of the relationship between precollege STS education and the current research agenda in the area.

Proposition #4: Precollege STS educational practice -- curriculum development and implementation, instruction, evaluation, and teacher education/staff development -- must be research based if STS education is to help a significant number of future citizens meet the ultimate goal of STS education.

The merits of drawing upon a scientific base of information in educational decision making, versus the use of experience, authority, or logical reasoning, are clear. The body of scientific knowledge about the educational process which has been accumulated over the past half century provides a reliable base upon which relevant curricular and instructional decisions can be made.

Educational practice has not always been influenced by the results of careful and systematic investigation. In fact, decisions are still being made in some educational circles on other bases. Fortunately though, the number is decreasing as teachers and administrators gain an understanding of and appreciation for the systematic inquiry processes which compose modern education research methodology, and educational research findings are translated into usable strategies and materials for practitioners.

In the rush to implement STS education at the precollege level, in direct response to the reports of the various blue-ribbon panels and the ensuing bandwagon effect, STS educational practice has proceeded independent of a research base. There is, in fact, little or no research upon which extant precollege STS educational practice could be directly based. A small amount of relevant research exists in other areas of education, mainly in STS education's sister area of environmental education, but this in no way compensates for the dearth in precollege STS education itself. There is, of course, a body of position papers which sing the praises of precollege STS education, but these do not provide an objectively tested knowledge base upon which to make STS educational decisions (Rubba and Wiesenmayer, 1985). This leaves precollege STS education in a very vulnerable position, both conceptually and curricularly.

Nonetheless, the prevalence of non-scientific modes of decision making are not only to be tolerated in the infancy of an educational area, but in many ways are necessary tc facilitate the initial growth spurt which will sustain the area until and during its maturational transition to a scientific mode of operation. It was to be expected that precollege STS educational practice would be guided by logic, authority and experience during its emerging years. Still, there will come a point in time when precollege STS education will be judged by the standards of a mature, scientific discipline, by individuals operating within the area, but especially by individuals from other areas of education (e.g., science education, social studies education) wherein knowledge is built and decisions are made using scientific standards of evidence. If precollege STS education is not able to stand along side of the other science-based educational disciplines, it may be cast aside.

That point may soon be upon us. Already, STS educators are being asked by practitioners for "proof" that STS education will empower students with certain knowledge, skills, and/or affective qualities. Every subsequent request reinforces the need for a scientifically built knowledge base upon which precollege STS educational practice can be grounded.

Beyond providing a foundation for educational decision making, what other contributions would be made to precollege STS education by the development of a research base? First, a scientific knowledge base would demarcate the domain of STS education by defining a range of practices in terms of their outcomes. Quality precollege STS education would consist of those instructional methods and curricular components which have been shown to contribute to achievement of the goals of STS education.

Secondly, a scientific knowledge base would help to protect precollege STS education from falling prey to the whims of its practitioners and to undesired intrusions by other elements of our educational system. In an environment in which scientific verification is the accepted method of establishing effectiveness, new practices and materials would find widespread acceptance only after evidence was available from objective testing procedures.

Thirdly, a scientific knowledge base would provide a platform from which STS education can continue to develop via further research. As it does in other areas, the scientific knowledge base of precollege STS education will reflect the questions for which answers, at least tentative answers, have been found. Simultaneously, it will help to expose those problems for which answers still are to be sought.

An Analogy

It would be unthinkable, as well as impractical, to suggest that a freeze be placed upon precollege STS education while a robust research foundation is established. But neither can the present, unsecured state of affairs continue for very long. To paraphrase a biblical statement, a house built upon sand will not survive.

When building contractors are faced with the task of erecting a structure on beach-front property or in other sand areas, special construction techniques are used to anchor the building. A relatively secure structure can be built on sand by placing it upon piers driven down through the sand towards bedrock. Later, further structural integrity can be added by building bulkheads between the piers. A parallel method might be used in bulding a research base for precollege STS education.

"Piers of research," strategically placed under STS education would provide the needed measure of initial stability. One could argue over the number and placement of the piers -- I suggest at least three regions for their placement: STS curriculum, instruction and teacher education -- but that is not crucial to the major point. Pier-like research columns would not only provide some immediate research support for precollege STS educational practice, but they also will be the structures to which will be fastened the bulkheads of research findings to be amassed as the major research agendas of precollege STS education develop.

The pier-like research supports will have to be solid timbers if they are to bear the weight of precollege STS educational practice, plus the strain eventually to be placed upon them by hefty bulkheads of research-based information. Hence, the significance of the problems to be focused upon, the quality of the studies themselves and the complimentary nature of the studies which compose the pier-like research supports will be important factors for STS education researchers to consider.

Unfortunately, the construction and placement of these peers will not be a simple matter. As noted earlier, we will not be able to prefabricate them from existing research findings. Pieces of extant, relevant research will be used in their construction, but mostly new research materials will have to be provided. Neither will we be able to simply set them into place under STS education. The research piers will have to be driven, figuratively, deep into the sand by the force of the studies which compose them. Of course, time is of the essence. STS education presently is receiving widespread acceptance at the precollege level. However, if we do not begin now to build a secure research foundation under precollege STS education, it is doomed to be swept away in the next tide of political and/or educational reform.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 253-259, 1987. Printed in the USA.
0270-4676/87

WOMEN AND TECHNOLOGY: CONTEXTUALIZING THE ISSUES

Pamela E. Kramer and Sheila Lehman

Introduction

As computers increasingly predominate in many educational and workplace settings, a small group of feminist researchers has become concerned about the personal and economic consequences for women of an apparent gender gap in computer access, learning, and skills. In previous research, we critically examined a tendency in much of the literature on women and computing to attribute this gender gap to factors similar to those initially identified as causes of women's avoidance of mathematics including lower aptitude and inadequate education and experience (Kramer, P., & Lehman, S., 1986). By so doing, we hoped to encourage a more feminist approach in which women were no longer viewed as passively responding to innate or culturally determined factors, but instead were viewed as making active choices reflecting positive values and preferences.

Part of our argument reflected the obvious (but seemingly often-ignored fact that new technologies are introduced into existing social, educational, and economic contexts. Therefore, although the new technologies may be value free, or gender-neutral, the educational and workplace settings into which these technologies are introduced are certainly not. Women and girls accurately perceive that whether in school or on the job, computer access and skills fit into a complex hierarchy where level of proficiency is not necessarily reflected status or pay where the inherent "boringness" of much computer-related work takes on different importance depending upon who is doing the work; and where the most interesting aspects of either computer-related learning or work may not depend upon the computer at all.

In future research on sex and gender equity in computing, we therefore feel that it is important to distinguish between the many varied computer skills, applications, and careers; the many different settings in which these skills or careers are pursued; and most importantly, between the various institutional and cultural contexts in which computer-related education and experiences are introduced to various groups of individuals. It is this contextualized analysis which, we feel, has proved most effective in understanding and countering sex and gender differences in mathematics aptitude and abilities. We believe that a similar approach to studying sex, race, and gender differences in computing will not only prove fruitful, but will reveal that women's responses to computing depend upon factors other than those which have already identified as causes of mathematics avoidance for women and girls (Kiesler, S., Sproull, L., & Eccles, J.,1986; Sanders, J., & Stone, A., 1986; Shiengold, K., Hawkins, J., & Char, C., 1984).

In the remainder of this paper, we offer specific criticisms of preliminary research on womens' presumed avoidance of computers. We also present some of our own research as an illustration of these criticisms and as a demonstration of the effectiveness of a contextualized analysis of the impacts of the sociocultural and institutional contexts of computing in its many forms, levels, and applications within and across different environmental settings.

Previous Research on Women and Computers

Previous studies of lower rates of participation for women in computer-related learning and work have tended to attribute women's avoidance of computers to various causal factors including attitudes towards computers and technology, personality factors, computer "aptitude", and lack of computer-related experience (Dambrot et. al., 1985; Konvalina et. al.,1983; Lockheed, M., 1984; Vredenburg et. al., 1984). These attributions are typically based upon intercorrelations of computer-related learning or performance with the causal factors listed above. However, in addition to the problem of inferring causality from correlational data, many of the factors which are being promoted as hypothetical causes of women's avoidance of computers and technology can be shown to reflect previous mathematics experience or learning. "Computer aptitude", for example, is frequently measured in such a way as to become virtually synonymous with mathematics achievement or course taking--which we know is often less for girls than for boys after the second year of high school. In such research, the presumed finding of lower "aptitude" for girls, and the use of "aptitude" as a causal explanation for girls' unwillingness to take computer courses or poorer performance in such courses, becomes invalid. In fact, and as would be expected, a measure of computer aptitude (CALIP) designed to be independent of previous mathematics experience also does not yield significant sex differences (Poplin, M., Drew, D., & Gable, R., 1984).

In addition," aptitude" may not necessarily predict either liking or learning for computing, or the ability to succeed in a computerized classroom or workplace (Clements, D., 1985; Lepper, M., 1985). However, the prevalence of reported findings of linkages between "aptitude", mathematics achievement and experience, and computer-related learning or performance reinforces and extends an existing negative stereotype: women don't like and aren't good at mathematics; therefore, they ar n't going to like or be good at computing either. All of this threatens to become self-fulfilling prophecy.

Difficulties of Basing Predictions of Success in Computing and Technology on Previous Mathematics or Computer Experience

A study of factors predictive of success in college precalculus, calculus, and computer programming illustrates many of the difficulties described in the preceding section (Kramer, P., 1984; Kramer, P., & Lehman, S., 1986). The subjects were adult women reentering higher education at a technological university which requires at least one year of college level mathematics (calculus) and computer programming for the degree. Fifty-six (56) of these women were two-year college graduates enrolled in a combined Bachelor's and Master's degree program in Social Sciences and Management. An additional 34 women were four year liberal arts graduates retraining in Transportation Engineering. Women in both groups were typically employed in "traditional" jobs for women; were 34 years of age with children living at home; and had completed two years of High School mathematics.

All of the women participated in a non-credit but intensive review of high school mathematics designed to teach necessary skills for college calculus, and 'coping' skills in terms of dealing with mathematics anxiety. Following this review, previous experience in mathematics, and other demographic and personality variables did not predict grades in either trigonometry or calculus. The only exception was age: women over 40 experienced considerably more difficulty in college level mathematics courses (1).

In contrast, attitudes about mathematics, including self-perceived ability to learn mathematics, perceived ability in comparison with others, willingness to take mathematics courses, perceived ability to succeed in a math-related field, and mathematics anxiety as measured by the Math Anxiety Rating Scale (MARS) were all individually

1. Correlations between age and mathematics grades were -.38 for the two year college graduates, and -.30 for women liberal arts students enrolled in Transportation Engineering. These correlations are significant at the .001 and .01 levels. Other demographic variables including marital status, number of children living at home, and number of years of High School mathematics did not significantly predict college mathematics grades for either group.

strong predictors of grades in Introductory College Calculus (2).

In addition, while performance in the noncredit mathematics "review" course predicted subsequent grades in college-level mathematics, and while all mathematics grades reflected the womens' overall cumulative average to a modest extent, none of these measures predicted performance in college computer courses (3). Most women experienced considerably more difficulty in computer courses than in mathematics courses: for example, while only two women failed to complete college mathematics requirements (trigonometry and calculus), of all of the women who took a college-level introductory programming course, two-thirds either dropped out or failed. We believe that this high failure rate was due to the way in which computer courses are conducted in an engineering environment; and specifically to problems created by an "alien culture" which may be unique to college-level programming courses (Sproull, L.S., Kiesler, S., and Zubrow, E., 1984).

In summary, women who are highly motivated and who receive appropriate supports can succeed in fields which they have previously avoided, which they have disliked or even feared, and where they have not been adequately prepared. However, if measures of "aptitude" which in fact reflect differential experience and/or socially mediated attitudes are used to limit access of women and minorities to these fields, the opportunities for such successes will never occur.

The Need for a Contextual Approach Across Different Institutional Settings

Contextualized analyses of women's under-representation in computer-related fields has focused upon early socialization and attitudes, previous learning, existing educational structures, instructional strategies, and curriculum contents (Campbell, P., 1985; Linn, M., 1985; Lockheed, M., & Frakt, D., 1984; Shuchat-Sanders, J., & Stone, A., 1987), Few if any investigations have examined

2. The overall regression coefficient for various attitudinal factors with mathematics grades for both groups of women combined was an astonishing +.94. While this coefficient reflects the strong individual correlations of the various attitudinal variables which were measured with mathematics performance, it must also be viewed with caution due to the small size of the sample.

3. Correlations between the high school mathematics review course and percalculus grades were +.61 for the two year college graduates, and +.35 for women in Transportation Engineering. These correlations are significant at the .001 and .01 levels respectively. The correlation of mathematics grades with overall cumulative index was .43 (significant at the .01 level).

women's responses to the introduction of computer technologies into the workplace. With over 75% of all working women employed in "traditional" jobs which appear highly likely to be affected by new technologies, questions need to be raised concerning women's access to new and better career opportunities, and changes in the quality of the work experience which are likely to result.

Some feminist researchers have suggested that many of the changes resulting from new technologies in the traditional workplace will be negative for working women. We believe that questions need to be raised in regards to at least the following areas of concern:

1. Impact of existing organizational structure(s) on womens' job roles.
2. Changes in job characteristics and demands.
3. Interaction of attitudes concerning womens' occupational roles with new roles and demands.
4. Formal and informal retraining efforts designed to integrate women and men into the new workplace.
5. Changes in formal and informal acknowledgements and rewards following technolgical change. This might include possible job enhancements such as an opportunity to participate more in decision making.
6. Impact of new technologies on quality and quantity of communication between employees, or employees and supervisors; cooperation between employees and/or supvisors; employee selfesteem, perceived locus of controll, and job satisfaction.
7. Changes in workplace environment, including workstation design, adequacy of software and hardware, possible worker isolation, and environmental stress.

We have presently been examining responses of 50 women sales representatives at a nationwide telemarketing center in terms of the issues listed above (See Kramer, P., Lehman, S., & Wener, R., 1987). Preliminary data from a 218 item questionnaire administered to all of the women sales representatives at the center was followed by fact to face interviews with many of the sales representatives (who are all female), and their supervisors (who are male). A videotaped analysis of the physical environment of the facility accompanied the face-to-face interviews.

The women sales representatives who responded to the survey were all of the workers employed in this position at the center. These women are highly trained, skilled personnel who earn substantially more than the typical women worker (over $30,000/year) and who must use computerized database systems, programs, and telecommunications equipment to perform their jobs. There is very high job dissatisfaction, and a disproportionately high turnover rate (approximately 70% of the women leave each year) among the women workers at this center. In turn, job dissatisfaction can be related to perceived problems in all of the areas of concern listed above. These problems are not determined by the technology itself, but must be understood within the total job context which we have only begun to touch upon here.

Conclusion

A major objective of this paper was to critically examine an increasing tendency in much of the research literature on sex and gender issues and technology to factors similar or identical to those initially identified as causes of women's mathematics avoidance. However, this conceptualization of the "problem" of women and computers incorporates several fallacies, and will not take us far in terms of understanding the complex interactions of experiential, social, cultural, and technological issues which underlie women and minorities' underrepresentation in computer-related fields.

A contextualized perspective allows for the possibility that women's and men's choices relative to computers are motivated not by lower (or higher) interest or ability, but more often by positive choices and alternative values. Such an approach also admits that choices of whether or not to engage in computer-related learning and work often reflect problems inherent in the specific and localized ways in which computers are introduced and used in various institutional settings. One important result of such a contextualized approach should be a better understanding of how computers might best be used in educational and other settings for the benefit of all children and adults.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 260-272, 1987. Printed in the USA.
0270-4676/87

TECHNICAL CAREERS FOR WOMEN: A PERSPECTIVE FROM RURAL APPALACHIA

Michael N. Bishara

Abstract

The onset of the electronics-based information revolution will augur changes in the sociological perceptions c^ 'suitable careers' for women. This phenomenon is particularly evident in rural Appalachia.

A planned, systematic delivery system was designed, developed, and implemented by Southwest Virginia Community College to introduce women to the challenges and possibilities of technical careers. This was accomplished through a gradualized phase-in to Technological Literacy, followed by in-depth involvement, culminating in an industrial internship experience. A special curriculum was designed to ease the transition of the women, most of whom were homemakers, into the fast-paced mainstream of the academic environment.

Duration of the introductory segment was one academic quarter. All project participants were clustered in a peer group, led by the project director, a trained counselor. In addition to a central course on Career Directions for Women, the program design emphasized Industrial Dynamics, the variety of uses possible with "user-friendly" microcomputers, Computer-Assisted Drafting, Electronics Instrumentation, Mathematics and Communications. Field experiences and visits to area industries were integrated into the program plan, as were visits from women who had achieved success in technical careers. Particular efforts were made to arrange for visits by the limited number of women alumni from the college's technical programs. Students were then mainstreamed into a regular program in Electronics or Computer Aided Drafting in the intermediate segment. Students are given a closer look at the industrial sector in the final segment.

An examination of the social structure in Appalachian Virginia is presented, together with an albeit tentative prediction of the implications for female wage earners in this highly traditional region, so dependent heretofore on coal mining. Finally, the concept of whether this effort will lead to evolution, rather than revolution, is discussed.

While covering a somewhat homogeneous and unique population cluster, the action blueprint outlined can be applied to other population groups in the U.S. and abroad.

Introduction

This paper describes an effort undertaken to meet the growing needs of women in southern Appalachia to qualify for, and acquire, a new breed of challenging job. These jobs are principally within technical fields and, heretofore, have been in the domain of the male wage-earner. The project's ultimate objective is to make it possible for female wage earners to enter this new technical world that is inexorably tied to virtually every community's future.

The Backdrops: Southern Applalachia

Southwest Virginia Community College is a state-supported institution of higher education located in the southern Appalachian highlands, virtually equidistant from East Tennessee, West Virginia, Eastern Kentucky and North Carolina. As a service-oriented college, it reflects, serves and seeks to advance the values and well-being of the unique communities that it serves, while preserving and nurturing the legitimate and valuable culture of the area.

Southern Appalachia is often perceived simply as a distinct part of some states. To some, it conjures images of beautiful and serene surroundings, a wooded paradise inhabited by a quaint, and impoverished people who are out of touch with mainstream American life. But these are but images, frequently fraught with inaccuracies, biases and distortions designed to make good political or journalistic copy. But to comprehend the legimate culture of the people, one mus' accept that southern Appalachia is, in itself, a state of mind and that the people represent a legitimately ethnic group.

A number of scholars have lived and reported on this fascinating part of America. Emma Bell Miles preceded Jack Weller, Loyal Jones, and others in identifying the characteristics of the people. If one were to dare generalize, it can be said that the ethnic roots of the people are Scotch-Irish while the cultural roots are American Indian. Put somewhat differently, the frontier that was tamed by the American Indian later tamed the Scotch-Irish immigrant who settled in the land. It is interesting to note that in his "Study of History", Arnold Toynbee[1] identifies a relationship between Scotland, Ulster and Appalachia, pointing out that:

'...the twice transplanted offspring of these "Scotch-Irish" emigrants to the New World survive, far away from their kinsmen in Ireland and their kinsmen in Scotland, in the fastness of the Appalachian Mountains: a highland zone which runs through half a dozen states of the North American Union from Pennsylvania to Georgia.'

More recently, McCrum, Cran and MacNeil[2] linked the language roots of the Appalachian dialect with the migration of Scots through Ulster and, eventually, to Appalachia. Since the language and cultural roots are certainly intertwined, the implications for the existence of a distinct character for the Appalachian people are real.

Frederick Turner[3] asserted that the strength of the wilderness culture overwhelmed the emigrant:

'The wilderness masters the colonist. It finds him European in dress, industries, tools, modes of travel, and thought. It takes him from the railroad car and puts him in the birch canoe. It strips off the garments of civilization and arrays him in the hunting shirt and the moccasin. It puts him in the log cabin of the Cherokee and Iroquois and runs an Indian palisade around him. Before long he has gone to planting Indian corn and plowing with a sharp stick...In short at the frontier the environment is at first too strong for the man.'

Emma Bell Miles[4] observed:

'The bearing of the mountaineer, for instance, dignified rather than stolid, distinct from the homely shrewdness of the New Englander, the picturesque freedom of the man from the new West and the elaborate courtesy of the South proper! Does it not bring to mind the vision of moccasined feet and the grave, laconic speech of chiefs met together for a high pow-wow?'

The Apppalachian Woman: Past

Women in Appalachia had a well-defined role in a society that fused the values of the Scotch-Irish, as well as the frontier societies. These values stressed strong family ties, a distinct separation of roles for the husband (as the protector and provider of material resources), the wife (as the confessor and provider of moral and spiritual support), and the children (as the principal recipients of the fruits of the parents' efforts.) Emma Bell Miles[5] writes of the relationship:

'Men do not live in the house. They commonly come in to eat and sleep, but their life is outdoors, footloose in the new forest or on the farm that renews itself crop by crop. His is the high daring and merciless recklessness of youth and the characteristic grim humor of the American, these though he live to be a hundred. Heartily, then, he conquers his chosen bit of wilderness, and heartily begets and rules his tribe... Let the woman's part be to preserve tradition. His are the adventures upon which future ballads will be sung... For him it is the excitement of fighting and journeying, trading, drinking and hunting, of wild rides and nights of danger. To the woman, in place of these, are long nights of anxious watching by the sick, or of waiting in dreary discomfort...

Thus a rift is set between the sexes at babyhood that widens with the passing of the years, a rift that is never closed, even by the interdependence of a poor man's partnership with his wife. Rarely is the separation of a married couple in the mountains; the bond of perfect sympathy is rarer.'

But today's times have crept up on 'yesterday's people.' Once able to provide a good living for his family from the area's coal-based economy, the Appalachian man and his family have fallen upon hard times. Foreign competition has severely damaged that industry's posture as a steady-state employer. Mechanization has become the viable solution to the problem of competition. And, as a result, coal mining has evolved into a capital-intensive industry, as opposed to a labor-intensive one. Complicated mining machines are controlled by sophisticated electronic brains, rather than by human (male) ones. The technological marvels behind the machine are now electronic, rather than mechanical. The production hero is now the machine and the individuals who are technically skilled to keep it productively functional for as many hours of the day as possible. Thus, modern times have brought about drastic changes in the Appalachian man's image: unless they are able to cope with the changes thrust upon them, Appalachian men are no longer valuable in their area's principal industry. Typically, most of them are excellent auto mechanics and electricians; they can dismantle and assemble virtually any car designed from the 1920's through the 1970's; they can wire a house or a coal mine. These skills have stood them in good stead. But a preponderance of them are sadly outdated today. Today's automobile functions thanks to one of 7-8 on-board microcomputers. And coal mining equipment electrical circuits are also controlled by microprocessors. To yesterday's electrician, the hardware is as foreign as can be. This has made a number of them unemployable. This, coupled with the tendency of the Appalachian male to drop out of school in 4-6th grade to make a living mining coal, have frequently placed severe strains upon his employability and, sometimes, upon his self-esteem.

The Appalachian Woman: Present

The Appalachian woman has coexisted with this turmoil. Yet even though the society has evolved, today's Appalachian woman still lives with the vestiges of past preconceptions about 'man's work' and 'woman's work.' But, through the years, it has become increasingly obvious to her that an expansion of her role as a secondary provider of material resources is necessary. And many wives have assumed this role of 'secondary provider' with alacrity, securing jobs that were a simple extension of their 'man's helper' roles at home. They got jobs nursing the sick, cooking and serving meals, helping men handle money and business, and teaching children. Thus sexual stereotyping has unwittingly became her constant companion, as she assumes her 'new role' in nursing, food services, in bank teller, secretarial and teaching occupations.

But, intrinsic in this arrangement is the concept that her earnings are secondary. Table I shows employment and earnings data extracted from a recent study by the Tayloe Murphy Institute[6] at the University of Virginia. The data represent selected occupations clustered at the high and low ends of the salary scales. It becomes obvious that 'helper occupations' simply do not pay. Because they do not require specialized training, and because of the large workforce available, earnings for the jobs of licensed practical nurse, food services employee, teller, secretary and teacher aide average just over $11,000 per year. This should be contrasted with occupations that require technical knowledge and a 2-year technical/community college background. And though employment potential for secretaries, bookeepers, typists, nursing and cashiering is high, salary potential is low. Though one is tempted to empirically deduce that salary potential varies inversely with supply, such is not necessarily the case with the middle-income occupations listed in Table II. The data for these occupations (that generally require specialized technical training or college education) show that technical training counts. For example, average annual salaries for Electricians and Personnel Specialists are nearly the same ($23,700), even though there are more Electricians employed than Personnel Specialists. Table III shows the same data ranked according to average earnings. And the data show the difference. For example, earnings for telephone installers/repairers, electrical power installers, computer repair technicians, stationary engineers and electricians average almost $26,000 per year, significantly better than secondary school teachers, who average $22,800. The situation is integrated graphically in Chart I. There are over 5,000,000 secretaries employed nationwide, but their salaries will average only 65% of those of an electronics technician. Furthermore, electronic devices are burgeoning in today's office, causing a slowdown in the number of job openings in the secretarial pool, and creating more job potential for the electronics repair business, an occupation still in the stages of relative infancy. The situation is quantified in more detail by Cetron[7] who predicts fast growth for electronics technicians and secretaries in the '90's; however, mid-career salaries for the former (at $24,000/year) exceed the $12,000 salaries for the latter by 100%.

So the status quo, while acceptable to some, can be quite repressive to others. Widowed and divorced women frequently find themselves as 'de-facto' heads of households, yet can not function under the restrictive, quasi-static financial constraints imposed by the system. And, since they are in no position to qualify for the better-paying jobs, they find themselves under extreme financial duress. Many of them have sought answers in a variety of training programs. But in too many cases, they were psychologically self-constrained from moving from the very same, sexually-stereotyped world which they were seeking to escape.

The Problem in Search of a Program

The problem, as perceived by the project developers, was to break the logjam of job stereotyping and usher the women into a world in which they could exercise better control over their destiny and their financial well-being. What was needed was a multi-faceted program to overcome this sexual stereotyping and to 'de-program' the participants from the notion that there was such a thing as a 'woman's job.'

Program Goals

Specific goals were established at the outset. The principal goal was to motivate the participants to seek technological literacy. This goal was to be attained by providing the

Table I

	SALARY WORKERS EMPLOYED FULL-TIME & MEDIAN WEEKLY EARNINGS			
		RANKED BY WEEKLY EARNINGS (UNITED STATES)		
JOB TITLE	1000'S EMPLOYED	WEEKLY EARNINGS	EMPLOYMENT POTENTIAL	SALARY POTENTIAL
Pilots	55	$738		
Chemical Engineers	57	$723		
Lawyers	317	$719		
Aerospace Engineers	87	$691		
Mechanical Engineers	257	$665		
Electronics/Electrical Engineers	520	$664		
Civil Engineers	201	$629		
Economists	82	$624		
Physicians	209	$607		
Computer Scientists/Analysts	317	$602		
Industrial Engineers	174	$598		
Payroll/Time Clerks	161	$302		
LPN's	277	$294		
Secretaries	3251	$279		
Data Entry Operators	307	$277		
Bookeepers	1311	$272		
General Office Clerks	489	$267		
Typists	646	$259		
Library Clerks	53	$246		
File Clerks	197	$234		
Health Aides (except Nursing)	247	$233		
Receptionists	434	$225		
Dental Assistants	107	$224		
Tellers	357	$219		
Nursing Aides	866	$202		
Hairdressers/Cosmetologists	277	$201		
Pressing Machine Operators	117	$198		
Teacher Aides	165	$196		
Maids/Housemen	361	$188		
Cashiers	878	$178		
Waiters/Waitresses	542	$170		
Kitchen/Food Preparation	66	$169		
Food Preparation Occupations	244	$166		
Waiter/Waitress Assistants	102	$155		
Food Counter Related Occupations	71	$147		
Child Care Workers	142	$88		
	AVERAGE $:	$352		

DATA EXTRACTED FROM: Virginia Occupational Demand, Supply and Wage Information
Virginia Occupational Information Coordinating Committee
Virginia Employment Commission, November, 1986

1985 Data

Source: Tayloe Murphy Institute, University of Virginia

Table II

MIDDLE-INCOME OCCUPATIONS FULL-TIME EMPLOYMENT & MEDIAN WEEKLY EARNINGS (RANKED BY TOTAL U.S. EMPLOYMENT)			
JOB TITLE	1000'S EMPLOYED	WEEKLY EARNINGS	RELATIVE EARNINGS
Elementary School Teachers	1204	$412	
Secondary School Teachers	1074	$439	
Accounting	1064	$458	
RN's	1010	$434	
Underwriters & Financial Officers	561	$468	
Electricians	547	$456	
Industrial Machinery Repairers	524	$404	
Computer Programmers	500	$502	
Machinists	479	$409	
Administrators	424	$561	
Law Enforcement	416	$452	
Financial Managers	372	$581	
Insurance Sales	365	$415	
Plumber, Pipefitters, etc.	361	$431	
Personnel/Labor Relations Specialists	316	$454	
Designers	302	$477	
Electronic/Electrical Technicians	286	$426	
Real Estate Sales	282	$406	
Telephone Installers & Repairers	227	$530	
Securities/Financial Sales	200	$593	
Purchasing Agents & Buyers	198	$445	
Firefighters	190	$437	
Heavy Equipment Mechanics	160	$459	
Inspectors (non-construction)	157	$459	
Buyers, Wholesale & Retail	157	$416	
Counselors	146	$488	
Tool & Die Makers	134	$491	
Advertising/Sales	126	$422	
Pharmacists	120	$566	
Public Relations Specialists	116	$460	
Computer Repair Technicians	115	$500	
Sheet Metal Workers	111	$415	
Personnel/Labor Relations Managers	105	$540	
Chemists	104	$588	
Electrical Power Installers	102	$510	
Stationary Engineers	99	$495	
Chemical Technicians	89	$412	
Aircraft Engine Mechanics	86	$491	
Psychologists	86	$472	
Millwrights	85	$497	
Police/Detective Supervisors	70	$534	
Telephone Line Installers & Repairers	68	$523	
Structural Metal Workers	58	$494	
DATA EXTRACTED FROM: Virginia Occupational Demand, Supply and Wage Information; Virginia Occupational Information Coordinating Committee; Virginia Employment Commission, November, 1986			

1985 Data

Source: Tayloe Murphy Institute, University of Virginia

Table III

MIDDLE-INCOME OCCUPATIONS FULL-TIME EMPLOYMENT & MEDIAN WEEKLY EARNINGS
(RANKED BY MEDIAN WEEKLY SALARY)

JOB TITLE	1000'S EMPLOYED	WEEKLY EARNINGS	EMPLOYMENT POTENTIAL	SALARY POTENTIAL
Securities/Financial Sales	200	$593		
Chemists	104	$588		
Financial Managers	372	$581		
Pharmacists	120	$566		
Administrators	424	$561		
Personnel/Labor Relations Managers	105	$540		
Police/Detective Supervisors	70	$534		
Telephone Installers & Repairers	227	$530		
Telephone Line Installers & Repairers	68	$523		
Electrical Power Installers	102	$510		
Computer Programmers	500	$502		
Computer Repair Technicians	115	$500		
Millwrights	85	$497		
Stationary Engineers	99	$495		
Structural Metal Workers	58	$494		
Tool & Die Makers	134	$491		
Aircraft Engine Mechanics	86	$491		
Counselors	146	$488		
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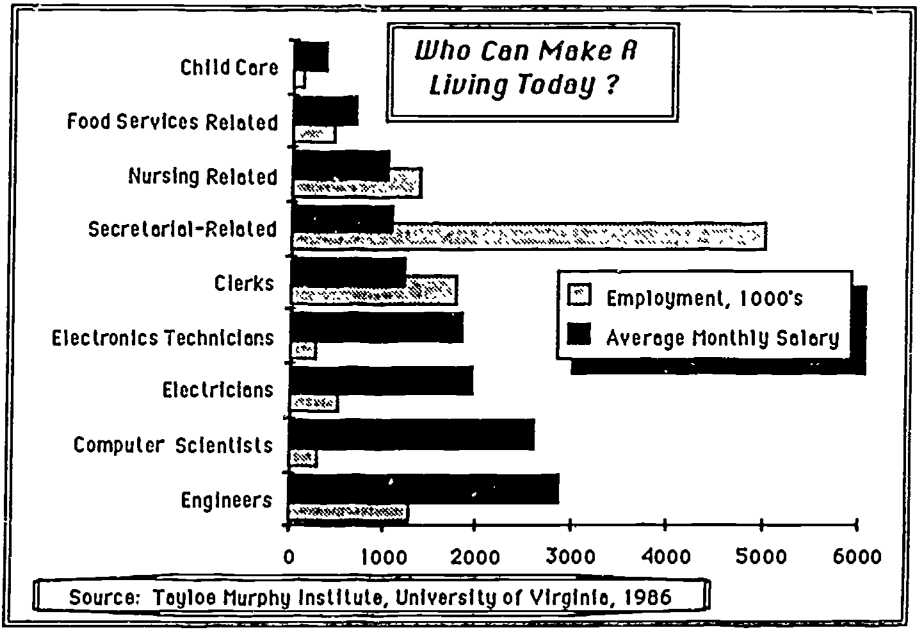
Inspectors (non-construction)	157	$459		
Accounting	1064	$458		
Electricians	547	$456		
Personnel/Labor Relations Specialists	316	$454		
Law Enforcement	416	$452		
Purchasing Agents & Buyers	198	$445		
Secondary School Teachers	1074	$439		
Firefighters	190	$437		
RN's	1010	$434		
Plumber, Pipefitters, etc.	361	$431		
Electronic/Electrical Technicians	286	$426		
Advertising/Sales	126	$422		
Buyers, Wholesale & Retail	157	$416		
Insurance Sales	365	$415		
Sheet Metal Workers	111	$415		
Elementary School Teachers	1204	$412		
Chemical Technicians	89	$412		
Machinists	479	$409		
Real Estate Sales	282	$406		
Industrial Machinery Repairers	524	$404		

DATA EXTRACTED FROM: Virginia Occupational Demand, Supply and Wage Information
Virginia Occupational Information Coordinating Committee
Virginia Employment Commission, November, 1986

1985 Data

Source: Tayloe Murphy Institute, University of Virginia

Chart I



participants with meaningful information on careers as technicians and skilled workers in new and emerging technical fields. In addition, participants interests were to undergo constant 'honing' through the provision of a planned variety of participative and 'hands-on' activities. It was also considered an imperative to provide them with an understanding of the use and relevance of mathematics and sciences to the world of technical careers.

Participant retention during the experience was vital. This was to be accomplished by reduction, if not elimination, of factors that could inhibit the students persistence in the program.

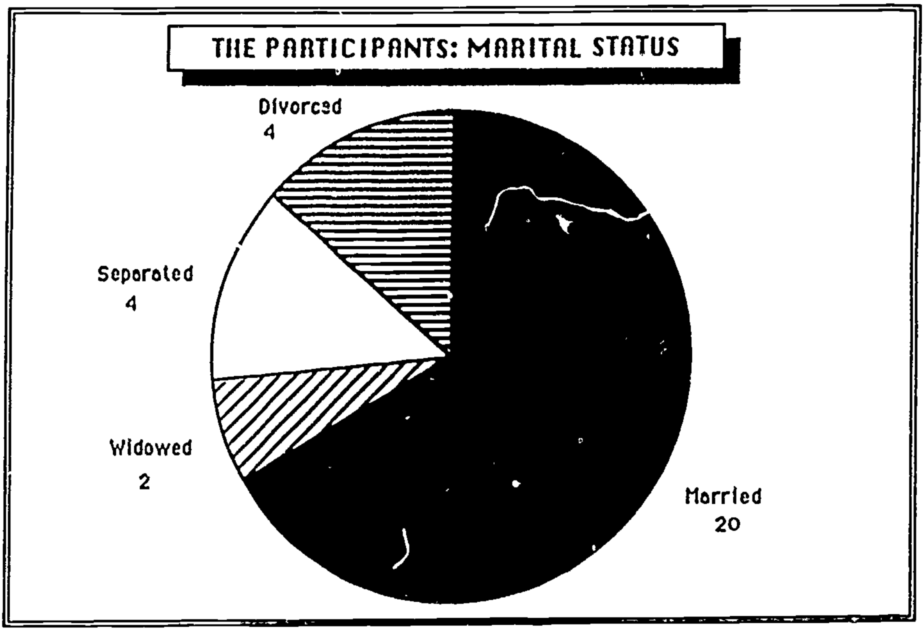
As part of the mainstreaming process, the program was to provide for experiences at area industries to enhance the students understanding of the 'real world.'

A number of 'a-priori' assumptions were made concerning the participants. These were vital factors in the design of the educational delivery system.

The first assumption was that the women were likely to be first-time enrollees at the college level. Some of them were likely to be full-time home-makers and mothers of growing children. Furthermore, if married, they were likely to have better 'book learning' than their spouses. It was also likely that some of the women were to be heads of household, either widowed or divorcees.

As a result of persistent role stereotyping from childhood, the women were likely to see themselves as 'unfit' for technical careers but, at the same time, they could not explain why they are 'unfit.' Finally, while the women would possibly be initially intimidated by the objectives of the project, they would probably be more intimidated at the outset by the presence of male mainstream participants in technical programs.

Chart II



The Students: A Thumbnail Sketch

Data gathered during the first year are shown in Chart II. Twenty of the thirty were married; two were widowed; four were separated, and four were divorced. It should be noted that the average age of the participants during this phase was just over 2[illegible] years. More than 50% of the participants were in need of child care funds to participate in the program. Fifty-nine children (56 of them under 18 years of age) were dependent upon the participants. Their educational background is illustrated in Chart III. As was expected, the participants had, in the main, completed high school or the General Education Diploma.

The Delivery System

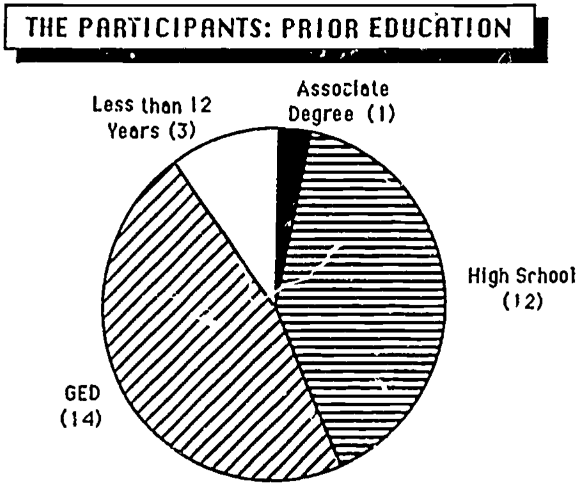
This was built upon a 3-Phase Program.

The Introductory, 3-month long phase ushered the participants into the program. Several provisions were made to ensure their success.

Participants were homogeneously grouped in all courses to ensure a strong peer support group. A specially-designed course, titled "New Directions for Women", was designed and developed by the Project Director. It was taught by a woman, and included a variety of activities designed to enhance the students' self-concept as a potential technician. Activities were kept simple, with an emphasis upon piecemeal success. Exposure to the simplest, user-friendly microcomputer provided an excellent springboard to the more sophisticated Computer-Aided Drafting (CAD) activities encountered later on.

Mathematics and technical courses were taught by instructors with a strong industrial background, as well as a strong orientation to students. Emphasis was placed upon relating industry realities to program and course objectives, while providing a humanistic 'you can succeed' learning atmosphere.

Chart III



It was considered imperative that factors inhibiting the participants persistence in the program be addressed and overcome. Therefore, provisions were made for payment of tuition, books, child care and supplies for all project participants. In addition, free bus service was provided as part of the college's overall service system. Finally, student schedules were tailored to a 4-day week during this phase.

The following courses and activities were incorporated:

New Directions for Women

This was a cornerstone course. The Project Director played the pivotal role in leading the students through 10 weeks of peer-supported self-examination. Myths and realities were explored, as were career choices (past, present and future.) In addition, Assertiveness Training as well as Time Management Training were built into the course.

The World of Electronics

This centered around exploration of 'easy-to-build' electronic devices, using a popular Radio Shack Electronics hobby kit. THe principal strength behind this course (which was described by some as a 'fun' experience) was the reassurance and easygoing manner of a very competent instuuctor, who could simplify the complexities of simple electronics circuits through the initial use of viable analogies.

Indusirial Dynamics

This course was designed to project to the participants the nature and impact of the many variables in the industrial balance equation. Again, the driving force behind the course was a highly credible., industry-experienced instructor, who could be challenging and reassuring at the same time. An important part of the course was a examination of individual values and motivations, and how these vary with time.

Computers and Drafting

The participants were introduced to the microcomputer via a powerful, yet 'nonintimidating' machine: the Apple Macintosh. THe variety of software and the excellent graphics resolution allowed the students to 'cut their teeth' on simple graphic arts, progressing gradually to computer drafting. THe course concluded with an exposure to a more complicated IBM-PC based Computer Assisted Drafting system. It was gratifying to see no significant traces of cyberphobia in the participants.

Advanced Reading Skills

This well-rated activity took the form of diagnostic tests followed by the establishment of a joint learning strategy by the participants and their instructor.

Mathematics for Electronics Applications

This special activity was designed to allay fears and create an inner motivation for the student to learn mathematics because of it's use in the technical world. THe critical factor in this activity was the presence of an instructor who could relate mathematical concepts to technical (especially electronics) applications.

Field Trips to Area Industries

These included companies involved in Communications and Biomedical Electronics, as well as in Computer Drafting, Particular care was exercised to arrange visits to companies that had hired the small number of women technical graduates from the college. In addition, the Project Director was able to arrange for visits and speeches by women established in technical careers. One of the electronics-oriented companies was headed at the local level by a woman manager, who constituted an invaluable human and inspirational resource.

The second, Intermediate, phase 'mainstreamed' the participants into one of two technical programs of their choice, ushering in an increased depth of academic study.

The students were permitted to select one of two technical career areas: Electronics Technology, and Drafting and Design (with emphasis of CAD.) Arrangements were made to provide for 'open entry' into these programs.

All persisters were monitored closely for signs of tutorial, counseling, financial and academic advising needs. Once discerned, these needs were met, inasmuch as was possible within operational guidelines, through provision of special tutoring, personal counseling, financial aid and academic/career planning. In all cases, the Project Director worked in concert with the student's academic advisor.

The Third (Final) phase is presently in the startup stage and comprises monitored internship experiences at area industries.

Results

The project was a success and, most certainly, added value to the lives of the participants. How else can one explain comments such as "..doors opened for me that I thought were closed forever"? One student wrote that ".. the desert cactus may feel [the way I do] after it has waited so long for the rain." The overwhelming majority stated that the project should be continued, whether or not funds are available. In particular, the project ushered the students into developing a positive self-concept, removing limitations on the nature of their future job satisfaction and contributing to the enhancement of their future earning potential. Furthermore, it demonstrated that barriers of age, sex and background tumble when faced with individual determination, coupled with concern-based instruction. Most of all, it provided the participants with a valuable realization: that they can learn. Finally, as more students were successfully mainstreamed into demanding programs such as electronics, they provided a definite example to potential enrollees that they, too, can succeed. Indeed, two electronics students from the first mainstreamed group have already achieved exceptional academic scores and were recently nominated to the Phi Theta Kappa honorary organization for Junior/Community College scholars.

Future Plans

Plans call for continuing the activity, with added emphasis on the industrial interface. It is felt that placement, through the medium of Cooperative Education or Industrial Internships, will provide an exceptional stimulus to potential enrollees. This, however, requires the cultivation of industry contacts, involvement and associated linkage mechanisms. These, and other, possibilities are presently being explored.

Questions

In the final analysis, are we being driven, through Science and Technology, to interfere with this society?

Are we causing the demise of a way of life?

Will we cause uncertain feelings to surface in the minds of male heads of households?

The qualified answer to the first question is yes. We are interfering with the future course of a society that is surrounded by change, yet is unable to avail itself of the fruits of the change agents. That women were seeking full-time work is undeniable. The charge was to make that work more lucrative and more conducive to a better overall quality of life without sacrificing the bond of love and respect that unites a family.

Furthermore, we are causing the demise of one undesirable aspect of a generally desirable way of life. The project did not, by itself, change rural America's social values and perceptions of what makes a man and what makes a woman. The satellite dish did that. The medium has been the message for years. And the medium has shown women as detectives, law enforcement officers, astronauts and in all images except that of a Roman Catholic Pope. And after the medium showed it, individuals made it happen. Nonetheless, other invaluable segments of the Appalachian way of life shall remain, but will move along an evolutionary track. Spouses have already developed relationships based upon the 'First Among Equals' principle, as opposed to the 'Padre, Padrone' mind-set adhered to in the past. These changes were latent, have already surfaced, and are comfortably ensconced in the minds of spouses and children.

Finally, one has to wrestle with the question of whether a male head of household has the respect of his family if he cannot cope with the inexorable changes that face him daily. When asked whether her spouse would resent her receiving her Associate degree in Electronics, one young mother commented that her spouse now sees her as an example to their children. Her seeking learning at the same time in which her children are going to school is proof that "Mom and Dad believe in Education." Children no longer will do as parents say; they will do as parents do. And parents in Appalachia are eager to do a lot of learning nowadays. That is why this particular rural community college has the highest market penetration among it's peers in the state.

So a new 'family togetherness' now binds the strong family. And, to those families that had a strong relationship to start with, the bond lies in their ability to collectively and confidently face challenges, conquer uncertainties, and successfully adjust to an exciting, dynamic, world.

Acknowledgements

The author would like to thank Ms. Linnea Olson, the project's capable director and co-developer, who succeeded in making the fledgling effort take wing. Her commitment to excellence and her drive to innovate made this project, in the opinion of the external evaluator, "..among the very best [that he had evaluated over the past decade."] Ms. Olson was assisted by a part-time peer counselor, Mrs. Wllie Monk. Mrs. Monk was most capable, energetic and empathetic to the needs of the participants. Ms. Tammie Beavers provided efficient clerical support and was a mainstay in the extensive record-keeping system. Thanks are also due Ms. Elizabeth Hawa of the Virginia Department of Education, whose solid support kept that department's sponsorship operating smoothly under the Vocational Sex Equity Program. The Southwest Virginia Community College faculty and staff were instruments of excellence. In particular Professors Nancy Cyphers, James Gibson and Devi Mitra showed initiative and innovativeness in their courses. Their dedication to the students and to the project cannot be overstated. Finally, sincere

appreciation is extended to the remarkable women who gave meaning, cause, and professional reward to all of us who were privileged to touch their lives.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 273-278, 1987. Printed in the USA.
0270-4676/87

EQUITY IN COMPUTER-BASED INSTRUCTION

Gene L. Roth

A flurry of national and state reports have expounded the need for educational reform. Findings, conclusions and recommendations of these reports direct educators toward the pursuit of excellence in education. Unfortunately, some of these reports have omitted a crucial element of excellence in education. That element is equity. It is an unfortunate omission because excellence in education cannot be achieved without fair and equal treatment of students in schools (Roth, 1986). This article addresses the importance of gender equity in computer based instruction. Several strategies are outlined in this article for creating equal computing opportunities for students.

The 1980's has been a decade of growth for computer-based instruction. Whereas there were fewer than 30,000 microcomputers in American schools in 1981, that number is in excess of 1 million units in schools in 1986 (cited in "Survey Maps," 1986, January). Teachers, school administrators, and parents have struggled and battled to get microcomputers into schools. For many, the procurement battle was enough, but for some the battle is just beginning. For although approximately 98% of elementary and secondary schools in America have microcomputers ("Uses of Computers," 1985), students do not have equal access to those machines (Stone, 1987).

The growth of computer-based instruction in schools has not increased computer technology opportunities for female students. According to Andrew Molnar, computer education specialist at the National Science Foundation, gender inequities appear to be increasing. Molnar's assessment is that power is not evenly distributed now and computers are broadening the gap (cited in Sturdivant, 1984). These inequities must be stemmed in infancy before they rob young women of opportunities to pursue computer oriented careers.

Usage of Computers by Boys and Girls

Boys and girls in primary grades use computers for the same periods of time and for similar purposes. At the outset of puberty their interests in computer technology begins to vary (Alvarado, 1984). It appears that significant alterations in the attitudes of both boys and girls occur during the relatively brief three-to-six year period after elementary school (Swadener & Hannafin, 1987). In many instances, at this stage in their lives girls begin to show less interest in courses such as science, mathematics, and computer science.

As students enter high school, two trends often emerge. First, boys join together in both formal and informal organizations related to their interest in computers. Second, boys take the types of computer courses that may lead them to leadership positions in industry (Smith, 1985). These trends play a major role in the inequities that are found in computer-related occupations. The higher the status and/or pay of the computer-related job, the more likely the job is held by a white male. Thus, engineers in computer scientist positions are 95% male while data entry operators near the bottom of the high tech status heap are 71% white women (cited in Smith, 1985). This issue is magnified in light of the projection that women will make up 60% of the workforce by 1995 (Gallagan, 1985). If progress of women in computer-related occupations is going to improve, educators will have to do something to encourage young women to develop higher levels of computer competence.

Currently, the gender gap is clear in educational computing. Three out of four computer camp students are boys. Four out of five computer magazines subscribers are men. Among the members of the freshman class at the University of California at Berkeley, twice as many men as women have computers at home or have written computer programs. In light of this social context, it should come as no surprise that twice as many males compared to females enroll in elective computer literacy classes (Luehrmann, 1985). Collis (1985) found that sex differences were clearly established with respect to attitudes towards computers by the eighth grade. Male students were more interested in computers than female students and they were less likely to be negative toward the impact of computers on society.

Faddis (1985) examined computer equity from three dimensions: access, participation and benefits. Access pertains to the number of microcomputers available for student use. Equity issues arise when the access to computers is limited for students because of the school they attend or its geographic location. Other restrictions to access may occur if students are not enrolled in specific courses such as advanced science or math. Participation is the amount of computer time allotted for student use. Inequities might crop up if free-time usage is dominated by boys in a way that excludes girls or if high achieving students are allotted more time to use computers than lower achieving students. Benefits are the kinds of rewards that may be accrued by students who use computers. Students will gain more benefits by using computers for activities that engage higher order thinking skills as opposed to drill and practice activities.

The quality and quantity of student interactions with computers at home, school and play may determine the degree to which they develop interests in computer technology. Interests that students develop early in their lives with computers often prove to be significant factors regarding whether they will enroll in computer courses later in life. Career interests for students follow along socially defined sex stereotyped occupations. Educators need to foster interests among female students for gaining proficiency with computers. If this does not occur, we may be perpetuating traditional work roles for men and women.

Planning for Equity

Why are microcomputers emerging as male machines in schools? Do educators, parents, teachers, and administrators believe microcomputers to be of much greater value to boys than girls? Teachers can play a vital role in eliminating stereotypes associated with computers. Educators may plan strategies to create an awareness for students that microcomputers are general purpose, gender neuter tools which can benefit all students in their educational and career plans (Lockhead & Frakt, 1984).

Strategies have been used to recruit females into other types of male dominated careers and educational programs may be used to attract female students to educational computing. The following tactics may help females realize potential benefits of computers in their educational programs (Roth, 1986):

1. A classroom file may be created that contains information about skills needed for the information age. Students would be expected to contribute articles to that classroom file.

2. Labor/work trend projections and employment bulletins may contain data regarding information processing skills. This type of information should be shared with classes. Guest speakers can also contribute to these topics.

3. Instructors should procure and display promotional literature and posters that convey the importance of computer skills in a variety of occupations.

4. Business leaders, especially women, should be sought out to speak to classes about microcomputers and their applications in business and industry.

These are starting points for establishing an awareness level for young women regarding the importance of computer literacy in their futures. However, beyond these initial planning steps, a well orchestrated effort should be undertaken by teachers, administrators, parents and students to ensure that all students realize the benefits of educational computing. The followir ideas gleaned from the work of Marrapodi (1984), Edwards (1984), Neil' (1984), and Sanders (1985) may help educators devise fair and equitable educational computing opportunities in their schools.

1. Considerable promotion should be undertaken so that students, parents, and teachers understand that equity is a high priority in all programs in the school.

2. Model programs based on fairness and equity in educational computing should be identified on a local, regional and state basis. Correspondence should be initiated with teachers of these programs and site visits should be arranged.

3. Educational software and its documentation should be examined for sex bias. Software evaluation forms should be used by teachers that address the items of sex, race, age, disability, or cultural biases (Rose, 1984).

4. Equity in educational computing should be the topic for an inservice education meeting so that all teachers can work together to reduce or eliminate this problem.

5. Female students should be encouraged to join or initiate a computer club at their schools so they can learn more about computers.

6. Educators should monitor the free time use of computers in schools to assess the degree to which males and females are using microcomputers.

7. Teachers should be encouraged to play active roles in the computer committee at school. Computer committees play important roles in creating staff development for educational computing, procuring hardware and software, and integrating computers into curriculum and instruction. A high priority should be established for this committee to set computer equity as a goal for all educational computing programs.

An excellent resource for educators striving to build fairness into educational computing is the kit Programming Equity into Computer Education.

The kit, available from the Project on Equal Education Rights, National Center for Computer Equity, provides information that can help teachers ensure equity in computer-based instruction ("Kit Available," 1985):

1. Sample interview questions to elicit data about school policies, practices, and allocation of resources regarding the use of microcomputers in the schools.

2. Sample questions that can help teachers collect data regarding the perceptions of teachers, students and administrators regarding students' access to computer technology.

3. Sample forms and instructions for analyzing student enrollment, patterns in computer courses, and extracurricular activities.

4. An annotated listing of resources that includes books, articles, organizations, and projects that relate to computer equity.

Teachers Must Take the Lead Role

Teachers will be the keystone to achieving computer equity in educational programs. They have the potential to establish learning environments that offer equal opportunities for all students regardless of age, sex, race, or handicapping condition. All students should be provided opportunities to discover that educational computing can be fun and enjoyable in school. Once female students enjoy successful experiences in educational computing, they can begin to set literacy goals for themselves that can provide benefits for their educational and career futures. With a workforce that is increasingly dependent on computers to help workers perform jobs, the educational computing skills that females master in school may help them identify a full slate of educational and career options.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 279-281, 1987. Printed in the USA.
0270-4676/87

TELEVISION AND TECHNICAL LITERACY

Charles B. Crawford

When it comes to science and technology in America, I think it's probably fair to say never have so many known so little about so much. There is growing evidence that along with some of the most remarkable scientific advances in the history of civilization, there is an increasing lack of understanding of existing and emerging technology. And perhaps of even greater concern are indications of a growing apathy among both children and adults, when it comes to acquiring simply a basic understanding of how things work.

In a recent survey, more than 7 out of every 10 adults were unable to explain how a telephone works. Another survey reports by the end of the third grade one-half of the students don't want to study more science and by the 10th grade two-thirds of the youngsters are not confident of their ability to learn <u>new</u> science.

Responsibility for this dismal picture doesn't belong to the schools alone; it must be shared among educators, parents and the electronic media, the last being the one with which the most time is spent. Children in this country spend an average of 25 hours a week watching television. That's as much time as they spend in five days of classroom activities. And for the most part the little bit of science and technology news reported on radio and television leaves a great deal to be desired. At the network level "Nova" and "The National Geographic" are among the very few regular shining lights in what otherwise is a sea of darkness for science and technology reporting. And there are some very fundamentals reasons for the paucity of such programming, the most important being ratings and revenue. The commercial networks are--number one--in the business to make money and to make money you have to have ratings. Walter Cronkite's Universe lasted only two seasons--not because it was poorly done but because it was scheduled as a summer replacement program and then pushed around to various time slots where even those of us who worked on the broadcast had a tough time finding out if and when the next episode would air. In addition all too often network programs, including the evening news with Dan Rather are run by committee where a small group of people will sit around and try to decide how this study will play in Peoria or Hoboken. If you don't think the ratings influence which stories do or do not make the evening news I invite you to pay close attention the next time you watch Rather, Brokaw or Jennings. In addition to the inevitable Washington, DC, coverage, invariably you'll see a story from New York, Chicago and/or Los Angeles. Not because those stories were more important than a scientific paper published in Columbus, Ohio, but because the New York, Chicago and Los Angeles TV markets collectively amount to more than half the people watching television in the entire country.

Unfortunately, television news both at the commercial and local level often suffer two serious problems--hype and a negative approach. I'm reminded of the producer at CBS News whose response to a story proposal when I was the health and science correspondent was "Is it the cure for cancer and can you tell it in 45 seconds?" And an executive producer who once told me quite candidly "I have no place for 'news you can use' and if the story doesn't have controversy I'm probably not interested."

At the local level poor science reporting is more likely to be the result of benign neglect. Budgets rarely allow hiring a qualified science reporter. The result is a general assignment reporter, usually armed with only the sketchiest background and little or no knowledge of the specific scientific discipline involved, sent out to do a story for tonight's six o'clock news. And given that result, it's no wonder many members of the scientific community are reluctant to deal with electronic journalists.

And local stations aren't alone when it comes to a lack of general knowledge.

But misleading and at times inaccurate reporting is not all an internal problem. Increasingly, journalists are finding themselves victim to a slick public relations or advertising firm that is looking to get a client's face or product before the public in the guise of a news report. Media manipulation has become an art form, mastered by Madison Avenue and a growing number of others in our society. This includes university P.R. offices and individual scientists, who agree to do a television story on their research at coincidentally the same time funding for the project has or is about to run out.

Having dwelled at some length on the weaknesses and inadequacies of science and technology reporting on television, I would like to focus on some of the more positive attributes of electronic journalism. In a nation where more than 60 percent of its citizens use television not only as their primary but also their sole source of information there is an enormous potential for reducing the widespread functional illiteracy regarding matters of science and technology. And there are some encouraging signs that the potential is beginning to be exploited, specifically by cable television.

With the recent debut of the discovery channel viewers have an opportunity to gain insight on a wide variety of science and technology research and development. To the delight of many the Nickelodeon channel has brought back Don Herbert as Mr. Wizzard. And even though Mr. Wizzard rarely gets into anything particularly complex he has had an enormous impact. It's reported that when students applying for Ph.D. work at Rockefeller University were asked how they became interested in science one-half said they first became interested after watching Mr. Wizzard.

For years I tried unsuccessfully to convince the decision makers at CBS News that science and technology reporting was an important journalistic endeavor that also could attract a large audience. I was told in effect to stick to medical reports where the audience is able to say I've had that disease or I know someone else who's had it. In other words play it safe. Why we had some executives at CBS who were so narrow-minded that they used scratch pads only one-inch wide.

At CNN it's quite different. Not because the network is particularly any more courageous but because many of the news reports on CNN are backed by sponsorship For the last two years AT&T has sponsored Science and Technology Today. Five different reports aired Monday through Friday in at least 15 different time slots during the week. In addition, we produce Science and Technology Week, a sponsored 20-minute broadcast shown on Saturday morning and repeated Sunday afternoon. Consistently, Science and Technology Week is among the highest rated broadcasts on CNN with a weekend audience approaching one and one-half million viewers. I mention this not to boast about CNN's success but to underscore the fact that science and technology reporting is not only an admirable journalistic endeavor but that if presented well using state-of-the-art graphics and animation there is an almost insatiable appetite by the audience to learn more.

As for the future, I don't see anything that would suggest a marked increase in science and technology programming at ABC, NBC and CBS. ABC reportedly did have plans to air a 30-minute science broadcast on Saturdays but those plans apparently have been dropped or put on the back burner. Thirty-minute or longer programs are expensive to produce and at a time when fewer people are watching television the ability to earn the huge profits of the past is becoming increasingly difficult.

Science and technology reporting can probably only be expanded by local television stations. Technology itself with portable direct up and down satellite links is making local stations less and less dependent on the networks for news, be it in the local area or from a spot half way round the globe. With the new capability comes new revenue-producing possibilities for local station operators who are willing to try new programming at a fraction of the cost incurred by the networks.

Science is a flickering light in our darkness, it is but the only one we have and woe to him who would put it out.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 282-295, 1987. Printed in the USA.
0270-4676/87

PRIDE AND PREJUDICE IN THE COMPUTER INDUSTRY: THE MULTICULTURAL SOLUTION

P.S. di Virgilio

American English and the Computer Industry

What constitutes literacy in an electronic age? Marshall McLuhan predicted that the West's advantages would be transformed into disadvantages in such an age [1]:

> It is this very situation which today puts the Western world at such a disadvantage, as against the "backward" countries. It is our enormous backlog of literate and mechanistic technology that renders us so helpless and inept in the handling of the new electric technology. The new physics is an auditory domain and long-literate society is not at home in the new physics, nor will it ever be.

However, this fatal prophecy has proven only partially true. A symbiosis has developed between a canonical culture and the developing nations: its frontier is a sociolect [2] of American English, "computerese." The third world, the poor, and recent immigrants to the West do not share in this revolution because of a barrier overlooked by McLuhan, language. The language of computing is English even if the technology is foreign.

For many years, computers and printers could not generate the characters necessary for the most elementary computer applications in a foreign language. Consequently, "computerese" is to this day an English jargon restricting the spread of the new electronic technology in even the advanced European block nations. Restricted access to the electronic revolution both hinders national aspirations and frustrates free will. In fact, the computer industry constitutes the new "determinism." In the midst of quantum leaps towards freedom of thought, the humanist finds himself confronted with a new definition of free will.

Random access to computer technology may be limited, but random access to its canonical language is not. As a result American English is subject to random shifts in extension which tend to undermine the intentional value of both its colloquial usage and its efficacy as a technical language. No one technological revolution is responsible for the current collapse of precise intentional meaning in American English. Historically, only Medieval Latin rivals American Engligh as an international source language for all signifieds. A "fuzziness" of intentional meaning resulting from accumulated partial similarities is the product of such unbridled extension.

Throughout the industrial revolution the ability to readily assimilate partial meanings made American English an ideal vehicle for a rapidly expanding technology. However, the advantages were not without their disadvantages: American English's identity as metaphor, as a veritable crossroads for meaning became the norm in the linguistic community baffling educators and dismaying linguists. Why is every word the source of a simile for American youth?

Deformation in French Generating Rules

Transformation of Deep Linguistic Structures in Target Language During the Manipulation of Complex Virtual Concepts Such as Computer Terminology

Content: A Simple Unified Term =S1
[Total Coincidence of Surface and Deep Structure]
(ex. science fiction)

Polysemically Distributed Term in Translation= S1
science fiction (Foreign Referent Node)
Distribution: science S2 (Node 1)
fiction S3 (Noeud 2)
charniere d'etrangete - S4 (Noeud 3)
(ex.science-fiction)

Form: A Simple Unified Signifier

Coincidence of Surface and Deep Structure = Stable Generating Rule R1
(ex. barre-code)
(English Referent) (Noun/Noun)

Ambiguity in the Reference Function Generated by the Computational Contextre porte-caracteres/barre-code)

Stable French Generating Rule R1
porte-caracteres (Verbal Form/Noun)

Unstable French Generating Rule= R2
(ex. barre-code) (Noun/Noun)
Index for Alienation=) R3
Complex Alienating Generating Rule R3:
R3=[(R1 = R2) Computational Node].

Other nations have not profited from American English's canonical nature with impunity in the computer industry. As a matter of fact AmericanEnglish assumes such a major role in current French scientific thought that no effort is made in French universities to teach French technical writing. To the contrary the faculties of Medicine at the Universities of Paris offer courses in English terminology as an integral part of their program in Medical computer applications. The computer industry specifies modern technology's cutting edge where today is always yesterday as one technological generation succeeds the other with lightening swiftness.

The accelerated pace of computer technology combined with its economic threat to national sovereignty set the stage for the French language to experience a shift in its generating rules that is to say its deep structures. In computer terminology, the logically foreign rule mutates into two generating rules: one stable, and one completely unstable. The result is a "fuzziness" at the intersection between the paradigmatic and syntagmatic axes. What restricts the exploitation of French's diverse repertory of syntactic devices in generating computer terminology? In effect lexicographers have generated just such glossaries but a written lexicon does not make a spoken language. Consequently, many French expressions for computer terms are simply too complex for high frequency usage. Although French prepositions create cohesive semantic bonds, a surfeit of prepositions generates syntactical ambiguities suggesting many possible combinations. Because of American English's linguistic intrusion upon French cultural sovereignty, various Francophone communities must generate vocabulary in an ambiguous context where the only referent, both semantically and pragmatically, is English. As can be seen in these lists, the resulting cultural disintegration emerges aslinguistic discontinuity. This discontinuity in computer terminology fragments the linguistic community.

La terminologie de l'informatique à trait d'union

La Terminologie du Québec (3)	La Terminologie anglaise	La Terminologie française (4)
action approche-précision 621	coarse-fine action	
adapteur canal-à-canal 548	channel-to-channel adapter	
barre-code 251	bar code	codes à barres
bibliothèque image mémoire 858		
bibliothèque-langage d'origine 3314	source statement library	bibliothèque de programmes d'origine
calculateur-interpolateur 1133	director	
calculatrice-perforatrice 428	calculating punch	perforatrice calculatrice
carte paramètre 813, 1866	control record card	carte paramètres carte-paramètre 813
conversion décimal-binaire 1017	decimal to binary conversion	conversion décimal en binaire
état-moniteur 2257	monitor state	état de contrôle
feuille-document 985	data sheet	fiche technique
hors-code 3220	shift-out	caractère de code spécial
imprimante/laser 1916	laser printer	imprimante à laser
langage-machine 2047	machine language	langage orienté machine
programmeur système 3498	system programmer	programmeur d'étude

Les chiffres correspondent au numérotage des articles dans <u>Terminologie de l'informatique</u>.
M= la même expression.

This governing rule redefines the geolect of languages like French according to national boundaries and proximity to the source culture, the United States.

The phenomenon is not limited to European cultures, more distant linguistic and cultural groups are also effected. The Chinese face similar problems. As you are possibly aware the popular concept of the Chinese ideogram is a construct of the Western imagination: in practice, the ideogram is a fully independent pictograph, imparting both meaning and instruction. The pictograph provides five modes for representing Chinese words based upon both notional and sound systems. The latter allows the Chinese to easily transliterate computer terms but not without posing a fundamental threat to the generating rules for Chinese in future generations. If a term dependent upon a morphological object [5] such as the ending "er" is transliterated into Chinese consistently using the same pictograph a foreign morphological rule will also be assimilated into the fundamental generating rules for Chinese. The gift of computer technology will only makes these morphological objects easier to discover and categorize as formal grammatical rules.

Of course, this potentially dangerous situation has not gone unnoticed by those involved in the process of generating modern terminology. As a result, China favors notional procedures for representing the new terms whereas Taiwan favors transliteration. The French have perceived the problem and are acting upon it: article in popular periodicals like <u>Micro-Systemes</u> describe the seizure of English software, arrests and fines in accordance with a law forbidding employers to force the French to work in a foreign language [6]. At this precarious moment in the evolution of computer technology, trade barriers based upon national pride would be disastrous.

<u>Multiculturalism's Contribution to Technology</u>

As a result of the North American computer industry's symbiotic relationship with the world, foreign concepts also renew the North American market. In the European context, French systems such as <u>Inalf</u> generate new application concepts. The concept of the data base as a national monument is no longer a novelty but a reality for most European nations: France has <u>Inalf</u>; Italy is developing the Pisa Lexicon and England concentrates its research in the Exeter Lexicon project and the Oxford English Dictionary while the University of Chicago directs the ever-expanding <u>Artfl</u> system. Many innovations in on-line processing have issued directly from such projects justifying their expenditures by highlighting the issues of national heritage and pride.

Often, the contact between cultures poses irresoluble enigmas which necessitate new and different conceptual frames. However, currently, contact between Japanese robotics and North American artificial intelligence provides notional solutions in the quest for the universal parameters crucial in creating computer languages. The Japanese notion of controlled unoccupied space is particularly pertinent in the development of a visually oriented generating system for the hypercube and cube-connected cycle architectures of a new generation of computers. In effect, contact with foreign cultures serves both to create and dissipate "fuzziness" in our thinking and our languages: when we think critically and comparatively about foreign concepts, our canonical "fuzziness" can be dissipated by means of contrastive rules. However, stereotypical and co-optative thinking about foreign cultures only adds metaphors to already fuzzy paradigms.

Multiculturalism Within the Canon

North America is a continent of immigrants: our great monuments remind us that immigration is a fundamental tenet of both democracy and our mythic identity. Consequently, North America is a fertile microcosm reflecting the interaction between various world cultures. What does it mean to belong to this microcosm? Universally, membership in the North American microcosm is synonymous with well-being and success. Sadly, from within the microcosm, educators know that well-being is currently being threatened by a lack of success. Thus, my original question, What is literacy in an electronic age? is synonymous with the question, Who can speak "computerese?" in the multicultural community? What is "computerese?" Paradoxically, "computerese" is not merely a jargon: it is the American chronolect and sociolect currently synonymous with success in a world view of America's mythic destiny.

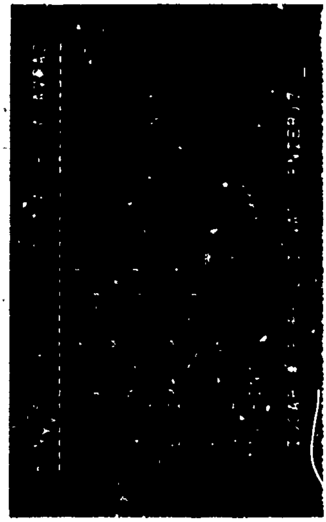
So strong is the attraction of this language which is a privileged subset of American English, that it is difficult to stimulate other cultures to think of computing in their own language. At this perilous moment in history for both American English and its culture, new foreign ideas must be bred within the sociolect, "computerese" to prevent any further rarefaction of American English. Instead of yielding English to more partial assimilation and deformation through foreign technological applications, let us seize the opportunity of cultivating a hybrid "computerese" in our multicultural community.

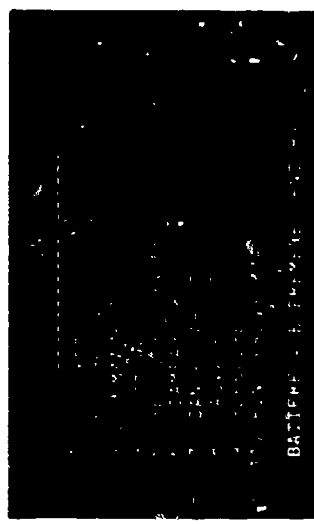
The Educator, Acculturation and the Computer

With these facts in mind, I embarked upon the establishing of a French Program in Micro-computing in the context of Continuing Studies. As a result all of the problems of multiculturalism became immediately clear. First we encountered cultural resistance from those who equated the use of English with the success of the computer industry. Consequently, English appears as the key not only to computer literacy but also to success. Secondly, the current state of French terminology does not facilitate the acquisition of a spoken "computerese." Moreover, students in commerce, computing and other business concerns are reluctant to enroll because either the linguistic requirements seem too high or they suffered from "computerphobia." As a result, our normal advertising proved inadequate. Thus, we were forced to engage the francophone community on the level of pop culture advertising.

In order to orient the program toward the immediate problem of computer literacy in our second official language, computer literacy is linked to a common set of concerns for all computer users, word processing and data base management. Such applications facilitate acculturation because of the coincidence of their needs with those of business, thus assuring the availability of commercially developed software. Consequently, these courses combine business French with the exploitation of French versions of Word Perfect and Lotus 1-2-3. The object of the courses is only superficially the teaching of these two commercial programs: behind the pretense of learning these office skills, is concealed the important task of engaging native French speakers in the use of French "computerese."

Because these courses create an immediacy in the teaching environment by means of the students interaction with the computer and a diversion from the task of learning vocabulary they are ideal vehicles for encouraging the passive assimilation of a French jargon in the work place. Moreover, artificiality is avoided in the classroom environment. Our environment is comprised of a large classroom equipped with sixteen IBM XTs arranged on tables not in booths. Ideally, this French "computerese" will facilitate the discovery of the authentic French applications of computer technology which might well be greatly removed from the original applications learned in class. The concern for multicultural computing is reflected in a variety of software providing students with on screen commands in their native language. The importance of providing on-screen commands in the student's native language cannot be over-emphasized in the multicultural environment. Students from other cultural environments come to the class with the presupposition that computing is an environment alien to their culture. A screen that speaks the foreign language tends to reinforce this presupposition causing a general decline in the student's willingness to use the target language, French, as a vehicle for the newly acquired computer literacy. With the French model in mind you can easily see the possibilities for Arabic, Chinese, German, Italian, and Spanish. The cure for a new crisis in literacy ten years from now is to provide the ounce of prevention today. If we are not to be faced with a new generation of computer "illiterates" we must model foreign computer jargon which will keep both America and the "backward" nations on the crest of the new wave, well out of the reach of the undertow of computer ignorance.





Canonical Thinking--Artificial Intelligence and Education

The current slowing in the spread of the computer revolution throughout North America reflects the failure to surpass several elementary computer applications: word processing, data base management and the computer's identity as gadget. Consistently, the computer industry has failed to see itself as an educator because of a fundamental misunderstanding about its own procedural languages. Languages like Pascal are logical tools, mathematical representations of critical thinking. Therefore, learning to compute as you would learn to type neither integrates your knowledge into the new chronolect nor exploits the computer's full capacity. Thus, Thomas Osborne of Hewlett-Packard could still assert today [6]:

> Apparently the majority of the public is computationally illiterate today--at least if one considers anything past the most primitive operators. Most people simply do not comprehend problems requiring anything more complex than those problems which are easily solved by +, -, x, .

There is a clear distinction in the chronolect, "computerese," between theexpression, "to think about computers," and the expression, "to think with computers." This fragmentation results from a frequently documented conflictrecorded in a survey of educational computing by Robert J. Seidel [7]: those who think about computers are researchers, whereas those who think with computers have to date been users who only had partial access to the computer's capacities. How do we bridge the gap between researchers and teachers? Is computing to be limited to the sciences as technology for its own sake? Currently, most educators remain in the user category making little or no demand on the computer as a machine that thinks. In fact as many computer experts like Marvin Minsky, Joseph Lipson [8], John Morton and John Rockart [9] have indicated that most programs and educational software to date have been poor, encouraging teachers to treat computers like a poorly fitted prosthesis. Some of these inadequacies stem from our theory of learning. More of the problems stem from the fact that computer processing is mainly declarative or procedural knowledge whereas real experience tends to be a blend of these fundamental experiences with a third, called common sense [10]. The knowledge we recognize as declarative or expository and procedural is in fact, as Piaget indicates the product of the third factor, a common sense organization of perception [11]. Only by understanding Understanding could Piaget's sense of invention function as an effective mode for knowledge acquisition [12]: "invention is a spontaneous reorganization of earlier schemata which are accommodated by themselves to the new situations through reciprocal assimilation."

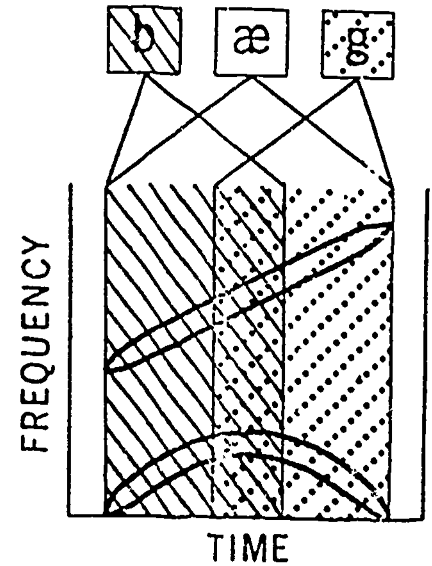
However, if we examine the programs we use currently we discover that they do not respond to these cultural imperatives. The next revolution in the computer industry, will require educators' input concerning understanding, if it is to be successful. Educational techniques and cognitive theory will be important in the current computational revolution because the focus of its data and programs is relational. Thus, educational and technological needs are precipitating a new union, artificial intelligence. In this union the artificial aspect at long last assigns a positive role to the machine in our culture while intelligence is justly reserved for the human dimension. A new generation of programs with an historical perspective promises to unify a fragmented view of knowledge within "computerese's" cultural canon.

Critical Thinking and Continuity: Knowledge as Vision

Artificial intelligence deals with the same universals described by Aristotle, Plato, and the Stoics. As Marvin Minsky asserts, artificial intelligence responds to the question, What is understanding? not by means of procedures and expository data but by means of a repertory of transformations with a genealogy facilitating the separation of various logical steps and categories. Most artificial intelligence programs allow us to think concretely, often geometrically about abstract concepts. The computer became a typewriter, a graphics display board and a quantitative laboratory in response to Western man's long literate past. Marvin Minsky perceives the revolutionary aspect of Artificial Intelligence in its ability to reply to questions completely removed from this frame of reference. Thus, culturally, Artificial Intelligence responds to many current social problems by answering questions like: What do you do if you don't know something? What do you do if what the teacher told you doesn't work? What do you do if the computer-assisted machine says something stupid? and What do you do if you get into a fight with a friend and didn't want to? Succinctly, artificial intelligence teaches us to handle "fuzziness" rather than concealing it behind artificially constructed solutions for equally artificial situations. "Fuzziness" is a sign of cultural aging and complexity. Our complex society creates complex tasks with multi-leveled focuses. Such demands tend to disorient our graduates by causing them to lose their focus on the precise goal in a multi-facetted procedure.

Seeing Patterns: Instantiating Solutions

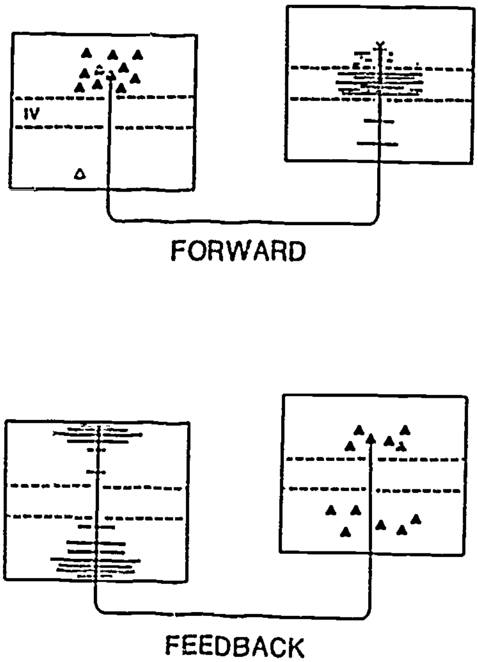
Most real problems are maze-like with either virtual or actual visual solutions such as memorizing landmarks or finding security.[13] Visual processing precedes our linearly logical speech patterns during childhood becoming a fundamental governing and binding rule for judging the truth factor in language. Cerebrally, "fuzzy" input is organized as linearly conclusive and logically tenable solutions. As Piaget and the genetic epistemologists suggest, most sensorial input is "fuzzy" overlapping with other perceptions, or perhaps even fragmentary. Let us take as an example of "fuzzy input perception" the word, BAG [14]. We hear bag because our brain is computationally capable of separating and mapping knowledge linearly not because the original input was linear. The computer simulation of the processing of such words reveals the complexity of sorting inherent in the most elementary act of cognition. When the following picture is presented upside down a slight confusion is felt regarding the features. This



A schematic spectrogram for the syllable bag, indicating the overlap of the information specifying the different phonemes. (From "The Grammars of Speech and Language" by A.M. Liberman, 1970, Cognitive Psychology 1, 309. Copyright 1970 by Academic Press, Inc. Reprinted by permission.)

slight disorientation masks the massive disorder in the picture perceived when the picture is viewed right side up. This, tco, is inherently a function of the brain's ability to organize information as you can see as the image is again inverted and even though you are conscious of the deformation you cannot perceive the massive disorder because of your's brain cognitive organization. Seeing words and understanding how the brain sees images is part of artificial intelligence's visual geometry, a visual representation of knowledge. The slight disorientation when viewed as language mirrors the "fuzzy" image commonly called metaphor.

Tilting this image and other similar images of varying colors and luminance defines a pattern of vectors and frontiers for critical thinking beyond the range of semantics. Like mazes, ambiguous images represent many different cognitive events in similar terms. Unfortunately, in the pursuit of homogeneity our psychological models consider all human thought to be relatively similar whereas neurologically all evidence points to a specialization of processing which is as important as the specialization of specific lobes of the brain. As a result of this specialization, feedback involves different lamina in a typical layer of brain tissue than feedforward with the result that phenomena that are psychologically similar are neurologically very different [15]. An increased consciousness of this phenomenon in Artificial Intelligence allows us to organize knowledge for maximum absorption by exploiting the mind's ability to process "fuzzy" images of reality. Such knowledge allows us to create programs and classroom environments that respond to urgent problems such as dyslexia.



A schematic diagram of the characteristic laminar distributions of cell bodies and terminals in forward and feedback cortico-cortical pathways. Forward pathways arise mainly from the upper layer and terminate mainly in the middle layer. Feedback pathways arise from both upper and lower layers and terminate mainly outside the middle layer. Triangles represent cell bodies, and axons are represented by thin lines. (From "The Connections of the Middle Temporal Visual Area and Their Relation to a Cortical Hierarchy in the Macaque Monkey" by J.H.R. Maunsell and D.C. Van Essen, 1983, Journal of Neuroscience 3, 2579. Copyright 1983 by The Society for Neuroscience. Reprinted by permission.)

In the new mosaic culture emerging as developments in Artificial Intelligence, maintaining a precise goal while focusing on the continuity of a multi-leveled problem is the hallmark of success. A recognition of "fuzziness" in our thinking affords us opportunities for critical thinking across cultural barriers replying to the very real need to see authentic patterns in foreign cultures instead of reflections of our own desires. Often the clarity of a pattern expressed as a cognitive plane instantiates a wide range of solutions to intercultural conflicts transforming the "fuzziness" of partially shared concepts into sets of precise differences and similarities which can be resolved.

Thirty years ago Marshall McLuhan revealed a multiculturalism spawned upon opaque printed pages. Today, computing and Artificial Intelligence are breeding a new

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Bull. Sci. Tech. Soc., Vol. 7, pp. 296-299, 1987. Printed in the USA.

WORD PROCESSING: WHY THE RELUCTANCE TO USE IT IN TEACHING READING AND WRITING

James R. Squire

The potential contribution that the word processor can make to the teaching of composition and comprehension has been well documented in research and development.[1] As a "tool for the mind," it can focus the individual learner on the construction and reconstruction of ideas and, particularly, on conveying those ideas to others or receiving them from others. Installed in the regular English or language arts classroom, it can transform the daily communication atmosphere into a socially and linguistically interactive setting -- a goal toward which intelligent English teachers have been striving for generations. Further (when associated with visual projection devices), it provides an instrument for modelling excellence in reading and writing, for focusing the attention of writers on audience, the attention of readers to complete texts, for proofing, revising, reviewing and even publishing after writing. Given current "process-oriented" approaches to teaching composing and comprehending which focus on a succession of stages in the complete cognitive event of reading and writing -- what happens before reading and writing; how does one activate prior knowledge; what happens during or after reading or writing; how does one relate parts to the whole -- it is difficult to imagine a tool more supportive of sound approaches to teaching. Hillocks, after a review of the research of the past twenty years, recently declared such process approaches were twice as effective as traditional grammar-based or word-based approaches.[2] Indeed, the word processor is a tool whose very essence is process -the continually redefinable transmission of ideas.

Given, then, all of these well-established factors in research and, more importantly, demonstrated in practice, why has the word processor thus far had so little effect on teaching reading and writing? Three years ago I felt we were on the verge of a powerful redirection of our educational effort. Today, save for an occasional brave teacher or experimental project here or there, one can find little but disappointment as one reviews school efforts.

At least five factors seem to explain our current condition:

1. <u>Cost</u>

Word processing equipment is expensive - not in terms of its ultimate contribution to children's learning, but in relation to today's rigid views of fixed installation and probable recurring costs. One school district estimates $5,000 for every terminal - or a cost of $25,000 to equip a single English classroom with five terminals, the minimum number I would recommend for a classroom of 30 pupils.

The nation's schools have made substantial gains in financing the qualitative dimensions of education during the four years since the academic reform movement was initiated by publication of A Nation at Risk. Teachers' salaries have increased by around 33%, and expenditures for instructional materials are up as much as 40 percent. But still we are spending annually only around $32 per pupil - on an average - on textbooks and little more on library books - less than one percent of the school budget. We are under enormous pressure - and rightly so - to increase the access of children to books (they read only 4-7 minutes each day), and this means increasing book supply. Children who don't read books are not likely to learn to read word processors with any degree of facility. To talk under these circumstances of a one-time cost of perhaps $750 per pupil to install word processors in the classroom seems on the surface to be a form of educational madness.

What really seems to be needed is a comprehensive restructuring of educational finance to relate more directly our budgetary allocations to decisions which have major consequences in learning. It seems likely to me that the payoff in installation and intelligent use of word processors at every elementary-level classroom through grade 8 could be an average increase of two or three years in the reading and writing competence of 75% of our students. Surely reconsideration of traditional budgetary allocations is a small price for a major breakthrough.

2. Teachers of reading and writing and specialists in technology have confused the potential contribution of the word processor to improved thinking, composing, and comprehending with uses of computers in managing instruction or providing independent drill and practice.

The idea processing/word processing that should be the focus of a classroom concerned with improved higher order thought processes is a world apart from the routine testing or drill function too often seen as a critical aspect of English teaching. Idea processing strengthens the central effort in our classroom; far different from uses which extend the drill activity that occupies far too much attention today. (The National Academy on Education notes that 75% of all time for reading instruction is committed to drill and practice.[3] Certainly we don't need more.) Another study reports that economically deprived children, less likely than others even to use a computer, are four times as likely to spend whatever computer time is available on routine drill activity. One clear clue that the nation's teachers and media specialists fail to see word processing as central is the continuing national concern about the adequacy of software - not a greatly significant problem if the only software really required is an adequate word processing system. Our focus needs to be on facilitating communication of ideas, not on more tightly managing or checking what is taught.

3. We need to assert the centrality of idea processing at the heart of a required installation of 4 or 5 terminals in every classroom where writing, reading, and thinking is to be taught, not in some distant media center where machines are locked away from the continuing focus of classroom instruction. Installation of banks of terminals in special centers, however well-intentioned, works against intelligent use in reading and writing.

Let us not relive the mistake of the past when film-showing became a "special" event in "special" rooms, and children (and sometimes teachers) became set for entertainment whenever taken to the special film centers.

Further, most of today's special computer rooms that I have seen consist of 25 or 30 terminals all in a row -- useful for drill activity with "each one on one," but hardly for the desired interactive communication that occurs when five or six children share a processor. Like the carrels of the older, rejected, individualized instruction, such banks of computers are alien to the interactive linguistic atmosphere needed for growth to occur in language.

4. Failure of Schools to Embrace "Process" Approaches.

Fundamental, of course, to limited progress in using computers in the classroom is the slowness of schools to adopt modern "process approaches" in teaching reading and writing. Despite the avalanche of well-publicized "process" research of recent years -- the work of Emig, Graves, Pearson, Applebee, Langer, Fowler, Bereiter, Scardamalia, and others - I could go on and on - and despite the efforts of the National Writing Projects and the Centers for the Study of Reading and Writing to publicize the potential of new approaches, classroom studies continually demonstrate that, in this area, our reach exceeds our grasp. NAEP, for example, reports no more composing in our classroom in 1984 than in 1974.[4] Dolores Durkin finds teachers studiously avoiding instruction in the processes of comprehension even when help is available in the teachers manual.[5]

Recent years have seen a disappointing reception to five new process-oriented textbook programs, at the same time that schools appear to be reembracing traditional grammar-based language arts textbooks. Word processors are not likely to find many adherents except among those who recognize the cruciality of teaching higher order thinking process in language. And at the moment, such advocates seem in short supply in our schools.

Why such a condition? The widespread current use of assessment instruments which emphasize acquisition of specific skills rather than basic linguistic processes appears to be one culprit. Indeed, 90% of all currently used texts are found to be incompatible with contemporary views of language and learning.[6]

5. Teacher Education

All of these problems could be overcome if teachers of reading and writing were clearly informed about the nature of composing, comprehending, and word processing. But few in-service teacher education programs and even fewer pre-service efforts have come to grips with these problems.[7] The National Writing Projects, almost alone in current staff development efforts, focus on process approaches, and thus far they claim to have reeducated only 65,000 of the nation's two million teachers. At a time when one generation of teachers is yielding to another (will our schools not be transformed by a new generation of teachers by 1995?), we must direct major attention to such concerns.

A Final Word

These then seem to me the five major roadblocks to be addressed if we are to make real progress in using the word processor in the classroom. The task will not be easy, but our perception can be clear. Unlike so many problems in education, the agenda before us is manifest. If specialists in reading, writing, and technology will join together in common purpose, we can ensure that tomorrow's teaching will be far more effective than today's.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 300-305, 1987. Printed in the USA.

SELFCONTROLLED INTERACTIVE LEARNING SYSTEMS: AN APPLICATION OF COMMUNICATIONS THEORY

D.R. Steg and I. Lazar

Adaptive versus Adapting Behavior

Adaptive

Automatic activity of man, animal or machine is an adaptive control system, by its very nature. It is safe to assume that, as with the laws of physics, the laws governing control systems apply equally to animal, man or machine. In the language of the system engineer, this is a closed-loop control system. The control system pattern consists of

1) an input signal that triggers some action,

2) a feedback signal of the result of this action to compare with the input signal,

3) a closing of the loop and a summation of the two signals, and

4) effective action to counteract any resulting signal.

A persistent residuary signal can be made to affect memory which results in "learning." In a control system, work is triggered as a result of an actual error input.* The error is essential to the activity of any control system. These mechanical patterns apply equally to automatic machinery, animal behavior, and man's everyday automatic activity.

Adapting

An important deviation from the automatic pattern occurs when the automaticity of a system is eliminated. Non-automatic activity will not necessarily be subjected to the adaptive nature of the control system and trigger its energy to cancel the disturbance.

With the automaticity eliminated, the response to a disturbance is chosen after the disturbance has been analyzed as to its source, the energy involved in the disturbance, the possible response and resulting consequences, including analysis and assessment of energy sources and energy balances. In other words, understanding is replacing automatic response. In this case the system exhibits adapting behavior.

Generally, in people one can observe a mixture of adaptive and adapting behavior. To date, clear-cut adapting behavior has been observed only in people.

This human ability of adapting an environment extends human reach in a specific fashion, including in the process, the use of tool, machines, psychological, socio-political, economic, educational, and other instruments. Specifically, the human mechanism directs

* The term "error input" is an e. .ineering term commonly accepted to mean a disturbance.

the signal-triggered action with a view to the adaptation of the environment to eliminate the differential between the feedback signal resulting from the modified environment and the original input signal. The mechanism involved in this system of disturbance is subject to the "filter" of intelligence, thus creating an "art image"
of the environment to serve as a blue-print for the adapting process. The system involved in specifically human activity is operable only when an action is triggered to adapt the existing, "given," "objective" environment to an "art" or "dream image."

As defined by Dewey, art is "to select what is significant and to reject by the very same impulse what is irrelevant and thereby compressing and intensifying the "significant" (p. 208). We should add to the statement that both the "significant" and the "irrelevant" are dynamic concepts that continuously change position. Because machines have only automatic, adaptive responses, and thus have built-in qualitative aspects, or "significant aspects," "creativity" is impossible.

Education, formal or informal, is the phenomenon which initiates a control activity, triggered by the element of relation, association or construction that appears, for example, when an artist produces an image unlike the one achieved by a camera. It also appears in all scientific discovery, as a change from the accepted previous concept. In other words, education centers on the "art" created image and its involvement in control system activity.

Adapting behavior depends on education and not training alone. Training involves learning some specified patterns of behavior, be it prestidigitation or tightrope walking, while education is new concept formation. The result of education is creativity while the result of training is peformance involving skill.

If the adapting control process "filters" disturbances, or input signals, in the closed-loop servo-system which control human action, education is then taking place.

The servo-mechanism of the human control system continuously develops and grows as thinking develops and grows. Inquiry and correlation of experience are tools used in this process of eduction. They are elements which trigger the controls. As for experience itself, we can no more know what a particular "experience" will do to education than what a "pencil" will write. Experience, of course, is a prerequisite, just as one needs a pencil or something to write with.

Any realization of something being wrong or different than expected, is a discovery. It contradicts the previously assumed satisfactory order. Anything that has been "logical" up to this point becomes "illogical," becomes "wrong," becomes an "error," and will make room for the elimination of error - for a new logic - for the "ought" instead of the "is." This realization that something is wrong or different (which initiates the process) is a prerequisite required for new concept formation. There is a difference between man and animal or man and machine which is made to simulate man's behavior. The computer essentially accomplishes its function by operating on multitude of types of problems with techniques for solving them. Thus, a problem fed into the computer in a sense triggers the answer that was originally built into it. But, to reiterate, human problem-solving is a matter of education and growth. It creates or formulates problems and at times their solutions.

While one can decide which behavior one wishes to enhance, adapting or adaptive, it is well to realize that the trend is fairly clear in education, in learning, in the acquisition of skills, for instance in reading, typing, comprehension, language and other areas of cognitive and affective development.

While conceivably these behaviors are unique in education (2), it is certainly not likely. They have been generalized to social (3), political (4), as well as ethical (5), psychological (6, 7) and economic (8, 9, 10, 11) behavior.

If adapting behavior is aimed for, then the following are critical:

- ways of handling variety (6) (1, p. 252)
- access to information, or selectivity of information (6, p. 252)

Beyond deviation-counteracting feedback or negative feedback, there is also a deviation-amplifying component, or positive feedback (12, 13).

We have, thus, a model of thinking which contains quality as an essential element and operates pragmatically as a closed self-organizing loop. It accounts in a new way for teleological processes like problem-solving, "planning" and mechanistic behavior and allows for an infinite variety of perceptual feedback systems.

Adapting Behavior in Early Childhood Education

Let us now consider some aspects of the theoretical and programmatic background to the concept of "Self Controlled Interactive Learning Systems: SCILS" and its relation to learning.

Transformation of Control and Some Empirical Substantiation in Education

A. Feedback vs. Reinforcement

Dynamic sensory feedback provides an intrinsic means of regulating motion in relation to the environment while knowledge of results, given after a response, is a static after-effect which may give information about accuracy, but does not give dynamic regulation information. Dynamic feedback indication of "error" or selection of what is "taken from the environment" would thus be expected to be more effective in peformance and learning than static knowledge of results. Dynamic feedback is not the same phenomenon as reinforcement, although feedback often does also serve to support the desire to continue an activity. (3)

Furthermore, the efficacy of reinforcement assumes an active need or drive state while feedback theory assumes that the organism is built as an active system and thus energizes itself. Hence, body needs are satisfied by behavior that is structured primarily according to preceptual organizational mechanism and require programs that communicate. (14, 15, 16, 17, 18, 19, 20, 21)

Reinforcement theories assume an essentially mechanical connection between the reinforcement and the response. There need be no rational or structural connection between them other than their spacio-temporal relationship. We propose, by way of an alternative, the notion that learning and understanding require that meaningful feedback inform the behaving individual, and for this to take place the content of the feedback must be intrinsically related to the behavior and its outcome. Purpose can then be seen as an outgrowth of the activity.

B. The SCILS Program

The SCILS program involves the use of a "talking typewriter," a "talking page," and "voice mirror." Children teach themselves to communicate and to become authors.

Its premise is that learning involves both the acquisition of skills (training) and the formation of new concepts (education). The proper use of instructional technology is to enable the learner to acquire skills which can be utilized in new concept formation, in growth and in development. The teacher's role shifts from concentration on training to involvement in education. However, if instructional technology is to be effective, it should incorporate control by the learner and instantaneous feedback to the learner which allows for self-regulation and self-correction.

It should be clearly noted that SCILS did not have specific competencies or goals stated "a priori" such as learning the alphabet or reading or arithmetic. What was primary was the design of an environment that would have as features ways for the learner to act adaptingly not adaptively. This was carried out as the methodology throughout the entire SCILS's program. (13) What was secondary was subject matter.

The designs of the hardware, courseware and software components of SCILS embodies educational principles which are encapsulated in its name, Self-Controlled Interactive Learning Systems. Specifically, learning in the SCILS program involved the following features enhancing adapting behavior.

- Learner control of the environment,
- Multi-sensory engagement of the learner,
- Actions of the learner triggering continuous dynamic feedback by the equipment,
- Instantaneous feedback allowing the learner to evaluate his actions in relation to his goals,
- Variety of courseware to allow individualized content.

C. Summary of Results

- Achievement of children in the areas of reading and arithmetic correlates significantly with the time on equipment (SCILS Time),

- Achievement of low SES (Socio-Economic-Status) children in the areas of reading and arithmetic correlates significantly with attendance at the Early Childhood Center. After the second grade, SCILS time was the most significant factor,

- For Get-Set* children Pre-mean IQ 71.8 (with two children untestable),

- For these same Get-Set children Post-mean IQ 94.6 (with the two previously untestable children now included),

- No significant correlation between IQ and achievement,

- No significant correlation between change in IQ and change in achievement,

- All children with a minimum of thirty hours of instructional time in SCILS, regardless of pre-IQ level, are achieving at or above grade level in reading and reading comprehension,

- Long term goals appear to be sustained 11 years after the children have left the Center, i.e., remain at or above grade level in reading and comprehension,

- Regardless of initial achievement levels, all SCILS children show significant improvement as compared to 2 other control groups. This has implications for gifted children as well,

- The longterm gains are incremental, that is, increase year by year.

* Children from low-income families

Conclusion

We ha e found a pattern of "adapting" behavior where the environment is changed to suit the requirements of the system, as opposed to the system changing to suit the requirements of the environmen.. This is a true cybernetic activity. Exhibited adapting behavior in SCILS enhances taking choices, relating to information selectively and most criticaliy controlling one's learning.

A technologically based cybernetic learning environment based on this theory demonstrates continued incremental longterm gains in reading and reading comprehension. Over the last eight years, progress has also been made with learning disabled adults enrolled in similarly structured programs.

These studies suggest the conditions under which to arrange the optimal use of technology for applications to information and learning tasks by people. Cybernetic principles point to ways to improve the opportunities for learning and describe a sensible relationship between students and computers.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 306-309, 1987. Printed in the USA.
0270-4676/87

COMPUTER LITERACY AND THE CYBERNETIC DREAM

Ivan Illich

Technological Literacy has been placed on the agenda for a second year at this meeting of educators, engineers and scientists. This year, the theme is technology and the imagination. Imagination works day and night. I want to speak about the imagination in daytime when people are immersed in neon light. Only indirectly I will refer to that mini-competence on keyboards at switches and in face of graphs which makes everyone feel a little bit of a hacker. As useful as it might be, I look at this kind of pseudo-literacy mainly as a condition to keep your sense of humor in a world that has been programmed. I will deal with the machine and its cybemetic logic only insofar as these induce a vaguely dream-like mental state. I am concemed about how to keep awake in the computer age.

It is helpful to distinguish three ways in which a technique affects the human condition. Technical means can be tools in the hand of the engineer. The engineer is faced with a task and for it selects, improves and applies a tool. In a second way, tools have a way of affecting social relations. A telephone-society engenders something new, still called "trust"--towards people whom you address but cannot face. Finally, all tools tend to be themselves powerful metaphors which affect the mind. This is as true for the clock as it is for the motor or the engine; it is as true for the letter covered with the alphabet as it is for a string of binary bits. The first two effects of tools, namely the technical use and its fallout on social structure I want to bracket for today. I want to focus on cybernetics as a dominant metaphor, speak of the computer as a potentially mind-boggling device.

However, before I get to this subject, I want to clarify one more point: I am not speaking about this ominous power of the computer in a general, world-wide way. I am not saying what the computer as a metaphor does to Japanese children who have studied cangi-ideograms for three hours daily for 11 years. I want to orient our discussion on the fit between the cybemetic metaphor and a particular mental state: the characteristically European, western mental space which over a thousand years has been shaped by the alphabet and the alphabet text as a dominant metaphor. I suggest this restriction for three reasons: first, because what I know about is mainly history; second, because with several friends in the Penn State STS Program, which organizes this meeting, I am studying the function alphabetic notations have, insofar as they can be considered as generators of post-medieval, typically European unexamined axioms; and, thirdly, because I want to invite you to discuss with me the impact of the computer-as-a-metaphor not as a sociological but as a literary and historical phenomenon.

Classical science has been created by people who recorded the sound of words by which they discussed nature. It was not created by Chinamen who for millennia have graphically expressed unsounding abstractions. Increasingly westem science has become quantitative, abstract, symbolic, mathematical, but even so, until quite recently those who shaped it were highly literate men. Modem science therefore is an outgrowth of the literate mind, in the sense in which this term has been used by Milman Parry or Walter Ong. Turing's universal machine appears as a singularity within this mental space during that fateful year 1932/3. I propose that we explore how the cybemetic metaphor proposed by

Norbert Wiener has affected the mental topology of the alphabetic mind. I want to describe the disembodied mode of perception which corresponds to the computer-boggled mindstate, if in contrast to the perception characteristic for the literate mind.

For this mode of conceiving and communicating of people who are high on the cybernetic metaphor Maurice Berman has coined an excellent term. He calls this state "the cybernetic dream." Many of you will know Berman from his "Reenchantment of the World" published in 1981. He is now working on a new book, on the Body of History. An article published in the journal of Humanistic Psychology gives an attractive foretaste of what is to come.

Berman too is concerned with the evidence that the dimming of those certainties on which the classical, scientist mode of perception had been predicated, makes many thinkers search for a new fundamental paradigm. Many, in this connection, speak of a holistic or new-age mode of perception: and most of them, according to Berman, have one thing in common: they encourage their followers to abandon themselves to the cybernetic dream.

Berman, in this article, comes to this conclusion by examining a set of North American authors who have recently been influential in the general public and tend to pose as disenchanted scientists. He recognizes the enormous difference in language, logic and style between Douglas Hostadter, Frank Capra and Ken Wilber, and Jeremy Rifkin or Rupert Sheldrake. Deftly he sketches their respective pet-terms: holographic paradigms, morphogenetic fields, real time, implicate order. And convincingly he argues that all of them rush into the same trap into which even Bateson ended when he reduced the body--towards the end of his life--into part of a monistic, mental process.

All of these authors, at one point, claim to offer an epistemological approach to reality that would be alternative to the mechanistic, empiricist, value-free consciousness which each one of these authors ascribes to "current science" or "the scientific establishment." In fact, however, according to Berman, these authors do nothing of this kind. Each of them, albeit in different words, interconnects another set of concepts that are related to information theory, and thus creates a purely formal, abstract, disembodied system of reference, which he identifies with what is going on in his own mind. This state of mind, for Berman, is best called the "cybernetic dream." It puts the mind into a state which can be accommodated to any situation at all. For Berman, the cybernetic dream brings the logic of 300 years of mechanistic science to its full fruition. I would rather say: it represents a "singularity"--in the sense in which a black hole is a singularity in time-space.

Berman tells the story of a friend, called Susan. It has so impressed me that I cannot but elaborate on it. Susan teaches high school in northern Florida. Many of her students have home computers. When Susan assigns a paper to these students, they run off to their machines. They feed it Susan's key words, have it retrieve materials from data banks, string these together and present them to the teacher as their homework. One afternoon Frank, one of these students, stayed on with Susan after class. The paper that week had been on drought and hunger south of the Sahara. Frank wanted to show her more of his printouts, and at one point Susan interrupted him. She said, "Frank, tell me: what do you feel about this?" Frank started at her for a moment and then replied: "I don't know what you mean." At this moment the abyss between Susan and Frank comes into view. Michel Foucauld would have spoken about an epistemological chasm. Let me sketch her mind and his.

For Susan, a statement is an utterance; behind each utterance there is somebody who means what she says. And, further, Susan cannot mean anything without feeling how this meaning is embodied. When she spells out "hopeless hunger" she senses something, which she does not when she operates on "3+3." Therefore, for Susan, the words that make up a sentence are like the planks of a bridge to the feelings of another.

For Frank, words are units of information that he strings together into a message. Their objective consistency and denotational precision, not their subjective connotates, counts. He operates upon abstract notions, and he programs the use of data. His perception is locked into his head. He controls redundancies and noise. Feelings and meanings would arouse anxiety and terror and surges of affection and he keeps them low, keeps his cool. The text-composer is the model which imprints his mode of perception. He conceives of his senses as "preceptors" and of his ego as proprioception.

Susan (now taken as an ideal type) is a perceptually embodied self. Her utterances surge from the mass of flesh and blood, from the forest of feelings and meanings which engulf again everything she has said. She is a teacher, because she has disciplined meanings and feelings without downgrading them. With great pains she has trained her inner Descartes and her inner Pascal to watch each other: to balance mind and body, Spirit and flesh, logic and feeling.

Frank is, at this moment, for me the emblem of the opposite perceptual state. He has detached himself from the morass of feelings. He has learned how to take off, to leave the dense atmosphere behind and operate in free space, without gr. .y He has hooked on to the computer and he has been caught into the dragnet of operational thinking. Turing's formula has induced for him the cybernetic dream. He can coast above the Sahel and its parched Earth, the last dying camel, and analyze growing despair and hostility. His mind is a camera which does not distort those sig ls it does let in. He wants Susan to grade the takes that he has composed into a "text."

Susan and Frank are both persons. They are responsible for the mental state in which they are. Susan can steer her way between romantic sentimentality and critical lucidity, between sloppy and sensitive choice of connotates, choose the traditional lineage of authors in which she wants her metaphors to fit. When she speaks she is using words that have been written, and thinking for her is a way of silently spelling things out. This constant reference to the alphabet makes her different from the preliterate, but also in a very different way, from what Frank does. Frank, too, is responsible for what he does. He can use the cybernetic metaphor for what he does when he speaks as an analytic tool which misses more than it models. He can use it as a joke; like Fromm when he speaks of psychic plumbing, Frank can refer to shit-in, shit-out. But he can also become sloppy and let this one metaphor swallow all others, and finally move into the state Berman calls cybernetic dream.

As the two mind-sets confront each other, both can harden into ideologies. I know several Susans for whom literacy has become an anticybernetic ideology. They react to every reference to computers as fundamentalists react to communism. For these anti-computer fundamentalists a trip through computerland, and some fun with controls is a necessary ingredient for sanity in this age. Those of you who study computer literacy sometimes forget its importance as a means of exorcism against the paralyzing spell the computer can cast. But I know many Franks who, under this spell, have turned into zombies, a danger Maurice Merleau-Ponty clearly foresaw almost thirty years ago. He then said--and I quote--that "Cyberneticism has become an ideology. In this ideology human creations are derived from natural information processes, which in turn have been conceived on the model of man-as-a-computer." In this mind-state, science dreams up and "constructs man, and history on the basis of a few abstract indices" and for those who engage in this dreaming "man in reality becomes that manipulandum which he takes himself to be."

When I earlier described Susan and Frank standing opposite to each other separated by an epistemological chasm, I both avoided to say that they "face" each other, or that they "interfa :." Merleau Ponty already speaks of that which--as a cypher--I call 'Susan's body' "as the soil of the sensible which emerges" on the face "in every word and act," and of the absolutely faceless artifice of the possible body, my "Frank" as "the information machine." I have great difficulties in speaking about the encounter between these two entities, both the "body" of living persons, yet bodies that are "lived" in such extremely different ways.

I do not dare say that Frank "faces" Susan; when I think of the glazing which the screen brings out in the eyes of its user, my entrails rebel when somebody says that screen and eye are "facing" each other. A verb for what happens there had not been coined when Merleau Ponty wrote in 1959. The verb was created ten years later by McLuhan, and within a year "to interface" was current in psychology, engineering, photography and linguistics. But I feel that I would demean Susan, if I say that she "interfaces with Frank" across a great distance. All I can say is that Susan sees her vocation in seeking Frank's face.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 310-319, 1987. Printed in the USA.
0270-4676/87

RESISTING THE INFORMATION MACHINE: AN EXISTENTIAL VIEW

Maxine Greene

I want to begin with selections from two poems that, in a haunting way, represent the two poles of my concern. One is by Galway Kinnell, called "The Fundamental Project of Technology" and suggested by a comment by a survivor of Hiroshima--"A flash! A white flash sparkled!" The other is by Anne Sexton, called "Riding an Elevator into the Sky." The Kinnell poem begins:

> Under glass: glass dishes which changed
> in color; pieces of transformed beer bottles;
> a household iron; bundles of wire become solid
> lumps of iron; a pair of pliers; a ring of skull-
> bone fused to the inside of a helmet; a pair of eyeglasses
> taken off the eyes of an eyewitness, without glass,
> which vanished, when a white flash sparkled.
>
> An old man, possibly a soldier back then,
> now reduced down to one who soon will die,
> sucks at the cigarette dangling from his lip, peers
> at the uniform, scorched, of some tiniest schoolboy,
> signs out bluish mists of his own ashes over
> a pressed tin lunch box well crushed back then when
> the word future first learned, in a white flash, to jerk tears.

He describes the school children caught by the flash on a bridge; and he says the "fundamental project of technology" is "to de-animalize human mentality, to purge it of evolutionary characteristics, in particular of death, which foreknowledge terrorizes the contents of skulls with . . . " The consciousness of mortality is gone, he means, in the suddenness of that flash; and some day there may come a time when a "day flashes and no one lives to look back and say, a flash, a white flash sparkled." A loss of awareness of mortality, memory--and with that (the reader feels) all human possibility.

Anne Sexton's poem begins with a warning by a fireman about booking a room over the fifth floor in any New York hotel, a comment on ladders, a comment that elevators seek out the floor of the fire and automatically open and will not shut. Very factual, very technical; and, yes, good common-sense advice. And then:

> Many times I've gone past
> the fifth floor,
> cranking toward,
> but only once
> have I gone all the way up.
> Sixtieth floor:
> small plants and swans bending
> into their grave.
> Floor two hundred:

mountains with the patience of a cat,
Silence wearing its sneakers.

Floor five hundred:
messages and letters centuries old,
birds to drink,
a kitchen of clouds.
Floor six thousand:
the stars,
skeletons on fire,
their arms singing.
And a key,
a very large key,
that opens something--
some useful door--
somewhere--
up there.

The metaphor has focally to do with possibility, with moving beyond established boundaries, with discovering new ideas of what it is to be of use. "Some useful door--," Sexton writes, "Somewhere--up there." Unpredictable doors opening in experience; new perspectives opening; new modalities being tapped. The poem has to do with imagination and contingency, with surprise. The contingent is the existentialist's word for chance, in contrast to the necessary--believing that the characteristic of lived reality is its uncertainty, the individual irregularity, what Kierkegaard called "the leap." I do not need to tell you that the technologist must master the contingent. In the interests of predictability and control, the technologist (unlike the scientist, I would say) must reduce the chances of surprise.

I said that the two poems suggest the poles of my concern. Obviously, I mean the connection of technology with nuclearism on the one side -and the connection of doors "somewhere" and keys opening "something" with the human vocation in all its openness, contingency, and ambiguity. And that human vocation entails for me ongoing quests for meaning, freedom, and what it signifies in human lives. Let me say immediately that I want to focus my attention between the poles in lived spaces where there can be resistance, yes, but not a mindless Luddite smashing of the screens. I want to talk about combatting what Ellul called "technological anaesthesia" and, along with that, a kind of moral blankness with regard to the uses of machines. I need, as educator and as existentialist, to challenge the technical rationality that governs so much of what is happening, along with the blandness and wishful optimism that accompanies it, the links being forged (as Jeff Smith writes in the Bulletin of the Atomic Scientists) with certain selected visions of the past when there was no real "badness" associated with American gadgets or machines. (He speaks, for instance, about the numbers who chose to attribute the Challenger disaster to sabotage rather than admit we could manufacture faulty seals.) President Reagan, he says, unveils Star Wars with misty comments about the "strengths in technology that spawned our great industrial base and that have given us the quality of life we enjoy today." That notion of "spawning" is a kind of touchstone for popular belief in our benevolence, our destiny to be "number one in the world," Japan or no, deficits or no, "rising tide of mediocrity" or no. And it is all connected to our technical wizardry. No, I am not associating the rows of computers in classrooms or the delighted young afficionados of programs and spreadsheet fabrication with the playing of war games, at least not directly. But I do think we ought to hold in mind the degree to which computers (at home and in schools) are connected to a great expanding system that is altering patterns and expectations of work and labor, revamping notions of educational reform, changing the meanings of knowledge and truth, affecting our concepts of representation and thought, altering the ways we speak--transforming our very metaphors.

To speak of "resisting" information technology is not to speak of battling against it, attempting to win a victory that will made it recede. I have in mind the existential notion that freedom can only be achieved in a resistant world, that we can only open spaces for action and for choice when we name certain things--fences, if you like, barriers, conventions, pressures, mechanisms--as obstacles to our becoming. It is a matter of engaging dialectically with what is presented as "given," objectively and unchangeably there. I am preoccupied, not solely with the tendency to confuse information with knowledge in these times, but with the equally disturbing tendency to take in information (or, as is frequently said today, to "process" information) with scarcely a question about its source, its validity, its contingency. We have had multiple reminders in recent times of the frequent lack of "fit" between what we accept as information and what we mutually constitute as our lived reality. Who can forget the monitoring of the Challenger, the information about its continuing flight even as it plunged towards the sea? Lately, we have heard about the computerized messages--the "information"--that (because of the powers of the computer) made economic projections and extrapolations that set the so-called "Dow" averages soaring and almost caused rioting on the floor of the Exchange. Indeed, the very concept of "disinformation" highlights the current habit of viewing information as bits and pieces of objective "fact." I cannot but summon up a passage in Don DeLillo's novel White Noise to expand on what I mean. Some of you may know that the novel deals with a "noxious cloud" (later called--what with the technologizing of language--"an air-borne toxic event")--that escapes from a railroad car in a midwestern college town and leads to the evacuation of people who cannot believe that they (who are not third-world people or poverty-stricken peasants) have to be evacuated. In any case, the narrator, who has had to stop for two minutes on the road to fill his gas pump, finally arrives with his family at the camp to which they have been assigned--to find Mylex-suited men, pylons, and groups that were the "sources of information and rumor. One person worked in a chemical plant, another had overheard a remark, a third was related to a clerk in a state agency." All the remarks, he says, "existed in a state of permanent flotation. No one thing was either more or less plausible than any other thing. As people jolted out of reality, we were released from the need to distinguish." The climactic moment here comes when a man at a computer punches out data having to do with the narrator's exposure when he was pumping the gas. He says they have a "situation." Then, no, "I didn't say it. The computer did. The whole system says it. It's what we call a massive data-base tally . . . I punch in the name, the substance, the exposure time, and then I tap into your computer history. Your genetics, your personals, your medicals, your psychologicals, your police-and hospitals. It comes back pulsing stars. This doesn't mean anything is going to happen to you as such, at least not today or tomorrow. It just means you are the sum total of your data. No man escapes that."

When I say "resisting the information machine," I have in mind the experience anyone would have when hearing information like that. Yes, there are data, probably unarguable data; but there are also the questions that arise, the rebellion against the very possibility that existence can be equated with the sum-total of data. There is the fundamental question, then, the question that informs significant resistance: about what it signifies to be human, to exist in a hostile or uncaring or inscrutable world. (I have just been teaching King Lear, and some of you may recall the horror and the wonder of that question in the play. Remember Lear on the heath confronting the naked Edgar in the storm. "Is man no more than this? . . . Thou art the thing itself; unaccommodated man is no more but such a poor, bare forked animal.") The only way you can bear such a statement, I think, is by summoning up what Kierkegaard called the "courage to be"--even in the tempest, even on the heath. That means reaching out to choose yourself within your lived situation as somehow "more," connected with others, awake to the world. It means, as well, realizing that you--like all other human beings--are "condemned to meaning" (as Maurice Merleau-Ponty put it), to transcending despair by discovering patterns, creating orders within your experience, finding openings and alternatives, looking at things as if they could be otherwise.

As in King Lear and many other great works of literature (Don Quixote, say, The Brothers Karamasov, Moby Dick, "Heart of Darkness," To The Lighthouse, One Hundred Years of Solitude, Invisible Man, The Plague, The Unbearable Lightness of Being) the questions having to do with what it is to be human bring with them questions about understanding and knowing, about meaning and truth. More often than not, something must be done to break through the "white noise," or what Melville calls the "whiteness," Conrad, the "darkness," Camus, the indifference, Jundera, the "kitsch," if the questions are to come clear. I ponder this with respect to the machine--the information machine, the other machines of our time. It is evident enough that our interests, our concerns, our personal preoccupations tend to organize our experience in such a way as to become so much part of the taken-for-granted we cannot make explicit what they are. For the philosopher, Heidegger, that is what happens to the objects or the things of the world which we know only as they become what he called "equipment." We encounter equipment in terms of contexts or arrangements--computers, for instance, belonging to certain kinds of rooms, tables, printers, seating arrangements, spareness of decoration, hard surfaces, disks, a context of "task-to-be-done here." We know the equipment in the light of "in-order-to," the end it is intended to serve; but the particular, the computer itself, call it object or thing or tool, is not noticeable in and of itself or what Heidegger called "conspicuous," unless there is a kind of disruption of what is ordinarily a static order. If the computer does not strike us as "user-friendly," if something unexpected and unwanted appears on the screen, if it does not seem to be submitting to us properly, we will notice it. We may even attend to it and wonder about it. It is like suddenly realizing you do not have the strength you though you have if you find yourself unable to pick up a rock or a child, suddenly attending to the color and shape of a pen when it gets lost. What I am suggesting is that, if the computer remains submerged in equipmentality, if we take for granted the enframing order it imposes, say, or the binary codes it brings with it, or the idea of nature laid out before it is to be registered or diagrammed on the screen--we will never ask the kinds of questions that will enable us to examine its value under various circumstances--to justify our use of it--to choose or not to choose. Once again I think of Heidegger speaking of thoughtlessness, or what he called "flight from thinking," a flight we ordinarily will neither see nor admit. The human being will say, "quite rightly, that there were at no time such far-reaching plans, so many inquiries in so many areas, research carried on as passionately as today. And this display of ingenuity and deliberation has its own great usefulness . . . But . . . it is thinking of a special kind. Its pecularity consists in the fact that whenever we plan research, and organize, we always reckon with conditions that are given. We take them into account with the calculated intention of their serving specific purposes. Thus we can count on definite results. This calculation is the mark of all thinking that plans and investigates. Such thinking remains calculation even if it neither works with numbers nor uses an adding machine or computer. Calculative thinking computes. It computes ever new, ever more promising and at the same time more economical possibilities. Calculative thinking races from one prospect to the next . . . never stops, never collects itself. Calculative thinking is not meditative thinking, not thinking which contemplates the meaning which reigns in everything that is."

Resistance, I am suggesting, demands naming, a bringing to visibility, a posing of questions about the given, and--always and always--new modes of thoughtfulness. For me, teachers, students, children, all those involved with the new technologies must somehow be provoked to think about thinking, about what it signifies to move towards the undisclosed, to discover, to interpret, to make connections from their own lived vantage points in the world. Resistance means self-reflective cognitive action--authentic and intentional, certainly if we are not to find ourselves in bad faith, dazzled by false and misty promises, caught in reductionism or unfamiliar either/ors. We need to be attentive to the contexts of our choices and their consequences, attentive to the nature of our practice and the ways in which it relates to other events, other phenomena in our endangered common world. As seldom before, we are obligated to ponder the ways of human knowing and sense-making and symbolizing, the modes of construction and representation available to us, the connections between knowing and thinking, between thinking and imagination and dialogue. Of course, rationality must be attended to, the kind of rationality enacted by our programs; but I believe a rational passion also ought to infuse the efforts any of us make to enable others to inquire, to learn to learn, to experience mastery and engagement, to make use of problem-solving tools, to thematize, to tell stories, to understand.

I am in no way underestimating the nurture of technological literacy or the gaining of skills, certainly not if we take proactive rather than reactive approaches to technology and keep asking what it is for and how it can serve the needs of humankind. And I am not underestimating the importance of encouraging craft, not only in programming and the handling of tools, but in making, saying, inscribing, ordering the multiple materials of lived life. There ought to be (as part of a quest for technological literacy) a continuing nurture of active, intentional mindfulness with respect to experienced situations--care, as John Dewey once said, solicitude in attending to the events of the intersubjective world. It is only as that world--that variegated, always incomplete world--is actively perceived and named that it becomes visible and audible to those who inhabit it. Only then, as I suggested above, does it become stuff, material for mind and imagination to play upon, interrogate, shape, reorder. Only then can computer literacy and the analytical skills, the "higher order skills" to which it may lead, feed into life-long quests for meaning. Only then are they likely to play a part in empowering the young in their being together--to become different as they develop wider and more informed perspectives on their shared realities.

Reading what I can, speaking to those who are becoming expert in the latest technologies, I want to keep speaking of contexts and raising the question of purposes. I want to move you to ask, along with me, "What is it for? What is it really for?" It is obvious enough that the proponents of the new technologies want to extend the reach and competence of children and adults. I know that some are concerned about social interaction and (perhaps prematurely) welcome the news that little children at computers seem more likely to work together at problem-solving (at least in twos) than under traditional circumstances. Some say this is especially so when the young are involved with programming. Some point to the ways in which children talk things over when they share computers, wonder together, shape hypotheses. It appears that mathematical achievement may increase, along with understanding of mathematical processes, that word processing may feed into the development of reading skills, that the capacity to make and rearrange objects on a computer or to play with images in space may make for enriched visual experiences. In many cases, computers, when consistently used, seem to encourage active learning, often self-motivated learning. Some young people, we are told, are moved to ask themselves or each other surprising questions about structures and sequences and about what problem-solving and correctness really mean. And no one can deny that children enjoy working with computers (at least when they first come in contact with them), that there can be little comparison between passive listening, or copying, or memorizing and the taking of even minor initiatives before a screen. And at another stage of the lifelong learning process, we cannot deny the opportunities opening when it comes to the storage of scholarly information and commentary, the retrieval of relevant material, the enhancement and amplification of heuristic reasoning, the application of various logics, the extension of measurable productivity. Granted, this--along with talk of networking and exchanging and new modes of communicating--is the best case. Granted, also, these achievements and the moods that accompany them and often make them attainable--are contingent on the environments created, on the accessibility of materials and machines and disks and relevant software, on attitudes towards equity and excellence and gender differences, on teachers' beliefs and understandings and attentiveness to what is going on.

No, I am neither technophobe nor paranoid; but I am resistant enough to want to keep sounding cautionary words about technicism, objectivism, organization, systematicity, and power used to "subject" people--to make them normal and docile and accepting. And I want to warn as well against a resurgent unease in the face of ambiguities, redundancies, contradictions, relativism, perspectivism, and what is sometimes called "soft cognition." I am not trying to refute all the arguments about the benefits of the new technologies by saying these things; nor am I privately predicting a future of tripods and Frankenstein monsters. Nor am I suggesting that our schools and universities will necessarily become subject to a new totalization, to a systematized, militarized order of things, if things go on as they are. I cannot help it if I see shadows, if I feel contradictions few Americans seem to want to take into account. For some reason, I am reminded of the beginning of Herman Melville's "Benito Cereno," that tale of a righteous New England ship captain of limited perception who is unable to see the turmoil occurring on a derelict slave ship he tries to help. At the start, Melville describes the grey silence of the morning, the way in which the sea seemed "sleeked at the surface like waved lead that has cooled and set in the smelter's mould." He speaks of the heavy sky, the grey fowl mixed with grey vapors skimming over the water, and then of "Shadows present, foreshadowing deeper shadows to come." The shadows I see are the shadows due--not to lack of technical expertise--but to bureaucracies and lack of care. I see the shadows of dislocated farmers, of dislocated factory workers, of homeless families, of hungry children, of young men with AIDS, of adolescents on crack. And these are among the shadows to come--along with Star Wars and war in Central America and eroded countrysides. And, yes, the shadows of limousines with darkened windows, million-dollar apartments, Mike and Adidas running shoes, images of the "rich and famous"--and, on the other side, the burnt-out buildings, the warehoused buildings, the mentally ill. And I keep wondering whether technologies can sweep away those shadows or remedy the silences in what ought to be a public space, the silence of incomprehension, of credulity, of hopelessness. Over the silence, like those fowls hovering over the sea, are the amplified voices saying things in cost-benefit language or in evangelical language or in ideological language or in punk-rock language. Can technological literacy, no matter how imaginative, halt the flight from thinking--if that is what is happening? Can it repair the burnt-out buildings, stop the wars, outlaw the bomb tests, stop the terror?

No, these things are not due to the machines directly; but, as we can tell by turning back in time, even to a few works in American literature, there have been cautionary words over the years with regard to the development of machines and technologies in a country dominated by pecuniary concerns, by business, by what used to be called "trade." Recurrently, there have been romantic celebrations, of course, of manufacturing power and the building of railroads, associated with the towering figures of inventors and explorers and conquerors; but there has also been an underlying uncertainty about what the industrial expansion would mean for individual persons and for the values associated with the face-to-face community in which the democratic tradition began. I am always haunted, for example, by the images of Nathaniel Hawthorne's over-reachers--his scientists and magicians and highly developed intellects who found the "counterpose" between their minds and hearts repeatedly disturbed--and lost hold of the ties that bound them to those Hawthorne called their "brother-men."

I think often of Thoreau's ambivalence, his description of the locomotive, the "travelling demigod, this cloud-compeller . . ." followed by "If all were as it seems, and men made the elements their servants for noble ends! If the cloud that hangs over the engine were the perspiration of heroic deeds, or as beneficient as that which floats over the farmer's fields, then the elements and Nature herself would cheerfully accompany men on their errands and be their escort." And some of you may remember his asking whether people had not become more punctual since the railroad was invented, and whether or not they talked and thought faster "in the depot than in the stage office." He concluded ironically that "we live the steadier for it," and the ground-bass of questioning went on.

There was the account of the try-works in Moby Dick, furnaces with iron mouths for boiling the blubber. Starting with scraps of wood, the fire was soon fed by the whale's own oil. "Like a plethoric burning martyr, or a self-consuming misanthrope, once ignited, the whale supplies his own fuel and burns by his own body. Would that he consumed his own smoke! For his smoke is horrible to inhale, and inhale it you must. . ." Then there was that other emblematic furnace made visible when the steamboat crashes down the river in The Adventures of Huckleberry Finn, where the drama of the advancing modern age may have been played out on a single page:

> We could hear her pounding alone, but we didn't see her good till she was close. She aimed right for us. Often they do that and try to see how close they can come without touching; sometimes the wheel bites off a sweep, and then the pilot sticks his head out and laughs, and thinks he's might smart. Well, here she comes, and we said she was going to try and shave us; but she didn't seem to be sheering off a bit. She was a big one, and she was coming in a hurry too, looking like a black cloud with rows of glow worms around it; but all of a sudden she bulged out, big and scary, with a low row of wide-open furnace doors shining like red-hot teeth, and her monstrous bows and guards hanging right over us. There was a yell at us, and a jingling of bells to stop the engines, a pow-wow of cussing, and whistling of steam--and as Jim went overboard on one side and I on the other, she come smashing straight through the raft.

We can all summon up other images: the "valley of ashes" in The Great Gatsby where the ash-gray men move dimly in the powdery air; "and occasionally a line of gray cars crawls along an invisible track, gives out a ghastly creak, and comes to rest and immediately the ash-gray men swarm up with leaden spades and stir up an impenetrable cloud, which screens their obscure operations from your sight." Over that, of course, are the eyes of Dr. T.J. Eckleburg on the billboard, eyes dimmed by paintless days, brooding over the dumping group. Or think of the humming machine in Ellison's Invisible Man: "the panel arrayed with coils and dials," and the voices saying "we're trying to get you started again. Now shut up!" Or the fantastic rocket in Gravity's Rainbow with its promise, its prophecy of escape. "So much has to be left behind now, so quickly. Pressed down-and-aft in his elastic bonds . . . Gottfried does not wish to cry out . . . he knows they can't hear him, but still he prefers not to . . . "

I summon these not to make a romantic case against progress, nor to suggest that those who use computers are complicitous with steamboat pilots or whaleship captains or Liberty Paint manufacturers. I do so only to sharpen the questions about the kind of world we can reasonably hope to shape, and how we ought to live in it and educate others to continue and renew it in time.

Yes, the seeds of calculative thinking and abstractness and indifference have been identified by numerous thinkers and writers who have tried, not to dig up the seeds, but to make the rest of us somehow aware of what was growing in the New World. Those seeds may have blossomed in ways that have affected our socio-political as well as our economic realities to such an extent that, as Daniel Yankelovich has written, public decisions are now made largely by technocratic minds according to a "money and missiles reality sense." For Yankelovich, the dominant philosophy

> makes the assumption that what really counts in this world are military power and economic realities, and all the rest is sentimental stuff. This has overly constricted the domain of what is real and transformed the large political and moral dilemmas of our time into narrow technical questions to fit their own specialized expertise. This process of technicalizing political issues renders them inaccessible to public understanding and judgment because the public exists in the very domain of reality that is excluded. To narrow issues artificially is to exclude the bulk of the citizenry from the policy-shaping processes.

Many of the educational reform reports, as some of you realize, seem to have been prepared in the constricted domain Yankelovich describes. The young are, it would appear, to be introduced to computers in a technocratically defined school reality (where all the rest is "sentimental stuff"); and this, I believe, is another reason for resistant thinking, even in a conference on technological literacy. It is a reminder that the literacy we need to achieve is as moral as it is technical--the kind of literacy that will open spaces, that will not exclude. I would remind you, as I must occasionally remind myself, that the fault is not in the technology; the deficiencies are and have been more often in the ways in which we grasp the impinging world, the way in which we interpret our lived situations, the way in which we approach (or avoid) the task of repair.

Perhaps we have to remind ourselves as well that the young (like the rest of us) must be viewed as speaking and acting subjects, first of all, in a social world, beings striving to make sense of themselves in their relationships. They are beings whose meaning-endowing activities, whose willing and choosing activities can never be fully comprehended by the methods of social or cognitive sciences that use natural science as their paradigm. I am continually struck by the ways in which empirical and statistical descriptions exclude considerations of children's efforts to construct meanings and engage in interpretive or narrative modes of knowing, as I am by the ways in which such descriptions avoid explanations of how adolescents from (say) the immigrant groups now among us mediate the novel experiences they are having, as I also am by their incompetence when it comes to understanding the behaviors of hopelessness. What with our increasingly technicist approaches to education, our preoccupation with information gathering and sorting, I am also struck by the tendency (conscious or not) to look upon children as well as adults as what Merleau-Ponty called information machines.

He used the term in an essay called "Eye and Mind," having to do with the body, the making of meanings, and the visible world. He wrote:

> Scientific thinking, a thinking which looks on from above, and thinks of the object-in-general, must return to the "there is" which underlies it; to the site, the soil of the sensible and opened world such as it is in our life and for our body--not that possible body which may legitimately think of itself as an information machine but that actual body I call mine, this sentinel standing quietly at the command of my words and acts.

He would make the same point even more emphatically with regard to technocratic thinking. In any event, there is a significant reminder here: a reminder of embodiment, of the embodied consciousness involved intersubjectively with others. For Merleau-Ponty, consciousness originates in a primordial perceived landscape that children pattern or configure from their situated vantage points as they move about touching, smelling, looking at aspects of the actual world. My resistance makes me hold that in mind, as it makes me hold in mind the idea of the young orienting themselves by means of their perceiving consciousness, ordering their imaginary worlds as well, establishing their relations by means of pre-reflective patterning to the fields opening before them and the human and social surround. All this happens, said Merleau-Ponty, beneath the relation of the knowing subject to the known object; and the perceived and imaginary landscapes remain foundational to rationality--the ground, as it were, of the meanings that sediment, that become layered as children move into the life of language and begin thematizing, symbolizing, breaking with the limits of dependency, breaking through the horizons of experiential space.

This is the existential idea of consciousness reaching beyond itself, breaking through to what lies beyond. As Merleau-Ponty saw it, our experience of perception represents "our presence at the moment when things, truths, and values are constituted for us." He went on to say that "perception is a nascent logos . . . it summons us to the tasks of knowledge and action." Obviously, we can only recapture that presentness by reflecting back, by thinking it. There is, for me, something very significant about the recognition that things, truths, and values are constituted by human beings, by children as they orient themselves to aspects of their lived worlds. The idea of the nascent logos suggests that children, perceiving incompleteness all around, imagining what it is like where the road turns, where their fathers go in the early mornings, what the indistinct voices are really saying, what the darkness holds, become conscious of what it is to make connections in experience. to find meanings for themselves, gradually to name their worlds.

Merleau-Ponty talked about recovering "the consciousness of rationality," something rather different than the "self-referential" move computer theorists identify.

I have a feeling that, if we ourselves can reach back to that original presentness, we may recapture something of where cognition begins. I am reminded of William James writing that "our own reality, that sense of our own life which we at every moment possess, is the ultimate of ultimates for our belief." He continued to stress, in Principles of Psychology, what he called "the world of living realities." He spoke of the "sensible vividness and pungency and the ways in which the conceptual world is anchored in the perceived. When thoughts operate on sensory data, he said, or on the perceived, they transform the order in which experience comes into a different order, that of the conceived world; and it may be that we, as well as those younger than ourselves, can remain conscious of this, if we are allowed to be. I find it difficult to imagine how, without an awareness of groundedness, of the body in the world, tools like computers can become the extensions of our bodies many people want them to be, or of our hands. More attention needs to be paid, I am sure, to the feel of things against our hands and bodies, to perceptions of the appearing colors and shapes in the world around, to the lived actualities in which meaningful learning has to begin, to what Polanyi called our "tacit awareness." Otherwise the keys, the disks, the screens are merely appurtenances of something separate, something "other," and it becomes difficult to view them as amplifications of our authentic thinking, our reasoning, our problem-solving and expressive capacities.

It may be that the unanswered questions in the imaginative literature I mentioned have to do with the feeling that "the machine in the garden," the intervention of the technical and the calculative in ordinary life, in some way threatened people's hold on their lived and sensed realities. In many ways it is true that steamboatmen, concerned about getting where they are going, do not care much for bare-footed raftsmen, dangling their feet in the water, with flickering lanterns in their hands. And it is true that what the computer presents as the sum total of a man's data similarly offends the sense of lived reality and leaves one with little to do (as in White Noise) but shop in supermarkets and hunt for pills to stave off the fear of death. It is as if the machine, or the technical device, asks too often (in the name of effectiveness or efficiency or "progress") for a suppression of impulse, memory, and desire. And this may, as I suggested earlier, constitute a threat to what is felt to be most distinctively human about our lived realities.

No, I do not think it has to be this way. A great deal depends upon how we--and the teacher among us--interpret the technocratic reality and make it visible, how we subject it to naming and critique. The militarist logic that structures so many parts of it has to be exposed; the bureaucracies that administer it have to be explained; the high-flown rhetoric that justifies it has to be demystified; the confusion between knowledge and information must be brought to an end. There ought to be more emphasis on contextual and interpretive understanding--to supplement and complement what we conceived to be technical mastery. And, surely, there must be more attention paid to the possibilities of creating a better and more humane social order of things.

My resistance moves me to call for the shaping of visions of what our social world and the education that continues it in time ought to be. Perhaps only if this happens will there be a likelihood of young persons coming together with their elders, acting as free moral agents, not judged against computerized analogues--but persons capable of taking initiatives, of going in search of meanings, of breaking through created structures in order to create new ones--to reach beyond. This means, for me, grounding the use of computers in what was once called experiential learning. It means creating the kinds of situations that release preferences and worthwhile questions, questions people pose for themselves and against the backgrounds of their life stories. Dewey used to warn against "bloodless reason," treated as pre-existent, overarching, a panacea. For him, reason was a human achievement won through habit continually worked over in time. I believe he would have welcomed the kind of computer learning that enables students to think about their own thinking, to estimate or approximate, to explore possible options for solving problems they themselves have defined. He might have relished the notion that the consequences of various options may be made so evident. But I am convinced he would have wanted to see all this originating in lived social situations marked by actual explorations and actual doings and undergoings, by what he sometimes called "conjoint" communication, by the awareness of a sense of agency, by an anchorage in sensed reality.

Coming to a conclusion, I want to repeat my resistance to thoughtless efforts to overwhelm images of the soil of "the sensible and opened world such as it is in our life and for our body." I do not want to see the microworld confused with the lived world. I do not want to see a disembodied vantage point replacing human vantage points--inadequate though they may be, and flawed. I do not want to see political socialization of individuals in solitary converse with machines. I do not want to see the computer ascribed responsibility for what happens rather than the one who uses that computer as a tool. I do not want to see formal totalities overcoming the incompleteness that, for me, is necessary for desire, necessary for the consciousness of possibility. And I think this may happen if we do not keep posing the questions: "What is it for? What good does it serve? What are the human uses of technology?" I began with talk of usefulness, of a "useful door opening somewhere up there." Before my ending, I want to introduce another notion of usefulness, this one from Heidegger: "Useful is the letting-lie-before-us . . . the taking to heart . . ." It has to do with thinking, with reaching towards possibility, towards what lies before, opens out, can be taken to heart.

It is this vision of usefulness that makes me argue finally for a continually renewed attention not the ethical and the aesthetic, to noticing and to caring, to overcoming passivity. I hope to see, I dream of seeing people who can notice, who can posit alternatives, who can imagine untapped possibility. There ought to be more and more opportunities for defamiliarization of what is taken for granted--the kind of defamiliarization that comes with informed engagement with the several arts as it may in dialogue with those around. I would like, in my resistant mood, to see more and more young initiates to the technocratic world drawing circles of quietness around themselves in museums and theatres--given opportunities to move inside pictorial frames, really to see Van Gogh's birds over the cornfields, to respond with their own bodies in movement to Alvin Ailey dancers, letting their energies go out, seeing what they might never have seen were it not for the patterns of movement, music, light, gesturing hands. Even as they play with words and numbers and images on the screens, even as they learn to program and think about their own logic, their own thinking, I hope we give them time for dancing. I hope they keep on speaking their own meanings, articulating their worlds. I hope, amid the clicking of computers, there will be the sound of blue guitars, the guitars that (in the Wallace Stevens poem) represent imagination. I hope, as in another Stevens poem, they are not required to stay in square rooms like the rationalists he describes--who think in "square rooms"

Looking at the floor;
Looking at the ceiling,
They confine themselves
To right-angled triangles.

If they tried rhomboids,
Cones, waving ellipses
As, for example, the ellipse of the half-moon--
Rationalists would wear sombreros.

There is a time for square rooms, yes, and right-angled triangles and algorithms. But there remains the "fundamental project" of technology; and there are the shadows still gathering. There are multiple things that "lie before us," things to resist, things to take to heart. There is a democracy to invent, to preserve. There are communities to remake. Investing our future, we need to keep the questions open--and, yes, I think, to resist.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 320-324, 1987. Printed in the USA.
0270-4676/87

TECHNOLOGICAL LITERACY AND CITIZENSHIP

Robert K. Fullinwider

One manifestation of the current national interest in educational reform is a growing concern that knowledge of science and technology must be more widely diffused than it is now. (1) Too many of us are "illiterate" in technical matters. The nation needs to make a better effort to teach more physics, chemistry, and biology in the schools.

There are many reasons to work for greater literacy, but one persistent theme is what I call "the argument from democracy": science and technological (ST) literacy are crucial to democratic citizenship. Here are some representative claims about ST literacy and citizenship. A first writer says that there is "ample evidence we are facing a 'crisis' in the practice of our democracy. Few citizens -- indeed even few leaders of our society -- feel (or are) competent to evaluate the scientific or technological aspects of public programs ... or to participate with even minimal confidence in democratic decision-making processes about these .. programs." (2)

Another writes: "Scientists and educators are increasingly concerned about what they perceive as a growing chasm between America's science 'haves' and its 'have-nots.' Citizens are routinely finding themselves facing decisions that require scientific judgements -- from national policies on nuclear power and 'Star Wars' to personal decisions about risks of sexually transmitted diseases. But there is uneasiness that many Americans are ill-equipped by their science educators to make such decisions intelligently." (3)

Yet another is quoted as saying, "Letting the experts run things is not appropriate for a democracy. American citizens have an obligation to understand things, and that means becoming scientifically literate." (4)

Such claims are common and attract broad assent, but I remain a bit puzzled and skeptical about them and especially about the conception of citizenship that lies behind them. My feeling is that they draw too heavily and unreflectively on a "civics-book" picture of citizenship. So, to sharpen debate, I want to play devil's advocate by challenging -- in a pretty heavy-handed way -- three myths embedded in these claims about ST literacy and citizenship: the myth of democracy, the myth of crisis, and the myth of science.

I. First, the myth of democracy. Why do we need technological and scientfiic literacy? The answer: so that citizens can understand issues like SDI, participate in "democratic decision-making" about them, and not defer to the experts. The underlying picture is the model of the active, or even activist, citizen; and the underlying aim is to see policy made by the people, not experts. In this picture, participation is good, deference is bad.

Now, first of all, I don't think the American people are very deferential on technical and scientific issues that arouse their concern. On the contrary. Consider the AIDS controversy. All too many people in America seem not at all reluctant in deciding how

AIDS is spread; by casual touch, by saliva, by being in the same room with, by being in the same county with -- and they aren't a bit reticent, either, in acting on their beliefs, treating AIDS victims like lepers. Here's a case where we could use a little deference to expert judgement.

But look here, you might reply, this isn't our ideal of participation and activism; people are responding out of ignorance. What we want is informed participation. This AIDS example just proves our case; what is needed is a better understanding of science by people, and that's what science and technological literacy are all about.

Better understanding in what sense? In the sense that we all become specialists in the behavior of immune systems and the transmission of bodily fluids through membranes? This hardly can be the relevant notion of understanding. Suppose, then, we just mean having a more sophisticated general appreciation -- without understanding the details -- of the challenges the scientific community faces when confronted by a disease like AIDS. Because we've studied some elementary physics and biology we have a basic conception of how natural systems work and a rudimentary appreciation of experimental method, clinical testing, and other things scientists do. If this is what we mean by better understanding, then I suggest that the upshot will be not activism but deference. The better informed I become about science generally, the more I realize how inadequately prepared I am to substitute my own judgment for that of experts in matters like AIDS. In short, the more informed, the more deferential.

How could it be otherwise? Better understanding of science is just going to impress upon me how dumb I am about certain matters. The experts are not always right but they have a better chance of being right than I have. The real payoff from my better understanding of science will be in making me more sophisticated about who to trust, about who is the expert, not in making me a better participant in the debate about how AIDS is transmited.

The myth of democracy is that more science information means more activism. However, when public policy truly does turn on some scientific or technical matter, deference is good and participation is bad. (5) The more generally knowledgeable we are the more deferential we will be.

III. The myth of crisis is that we are now less able to be informed participants and activists because of science and technological illiteracy. There is that growing chasm between the science 'haves' and 'have-nots' that I referred to earlier. The same story from which the "chasm" quote came goes on to tell of hopes to "reverse the plunge" into ST illiteracy. (6) What plunge? More people graduate from high school and from college than ever before in our history. Even if we assume science education now is not what it once was -- a dubious assumption -- we still have to be doing better now than when half our population did not go beyond the eight grade. And now, too, we have ubiquitous TV, which is a wonderful propagator of science information -- and misinformation.

Moreover, if illiteracy creates crisis, then ST illiteracy has to stand in line: the American people are also economically illiterate, historically illiterate, internationally illiterate, politically illiterate, and, in my home state of Kentucky, 20% of the adults are illiterate plain and simple. (7) If the fact that few people can participate meaningfully in decision-making about SDI means that democracy is in crisis, then I'm afraid the patient has already expired.

You might say: science and technology are special. Such a large part of contemporary life turns on scientific and technological developments, and such a large part of public policy, that better public understanding is especially crucial here. I'm not persuaded. It is certainly true that public science and technology policies affect all our lives. But I would guess that a far greater direct and material impact on our well-being comes from, say, the policies of nations' central banks in setting interest rates, the supply of money, and the exchange rates of their currencies. Yet, members of the public understand little of the arcane and complex system of national and international banking and currency regulation, whose decisions pevasively affect whether they will have work, where they will work, and how much purchasing power their work will earn. I seriously doubt that the case can be made that ST illiteracy is more damaging to democracy than economic illiteracy or other illiteracies.

The public's failure to have a sophisticated understanding of the policy choices that face modern governments may not be good for democracy, but the public is hardly worse off now than in the past. ST literacy is not more urgent than other forms of literacy, and we are not in crisis.

III. Now for the myth of science. The proposition, recall, is that everyone needs to know more science so that citizens can participate in important policy choices. Let's now ask a bit more about the nature of the science and the nature of the participation. I think it is plain enough that the science in the proposition refers to the natural sciences -- SDI is about physics, AIDS is about cell biolgy, acid rain is about chemistry, and so on. It is less plain what is encompassed by the idea of paticipation. I suggested earlier that it is hardly credible to think our aim should be to make us all specialists in membrane permeation so that we can meaningfully debate how AIDS is transmitted. Likewise, we can't all know enough high-energy physics and weapons engineering to adjudicate the debate on Star Wars. And the proponents of ST literacy admit this is not their aim.

In fact, a surprising twist emerges in the discussion of aims. The emphasis really isn't on more factual knowledge of physical laws; it's on attiudes. "Science is not a list of acts and principles to learn by rote," offers one supporter of science and technology literacy; "it is a way of looking at the world and asking questions." Another supporter echoes this point: "science is not a series of conclusions but a way of thinking about the world. 'Science is essentially a structure for asking question'." (8) On this understanding of science, more literacy means more widely diffused good habits of inquiry, such as respect for evidence, care in drawing conclusions, curiosity, appreciation of the experimental method, a healthy skepticism and lack of credulousness, and some ability to manipulate formal models.

More literacy of this sort is surely a reasonable aim, but I'm afraid that in giving it a prominment place the ST literacy argument has now self-destructed. The reason for teaching more physics, chemistry, and biology has disappeared. The good habits of inquiry can equally well be taught in other courses. History, psychology, and economics will do just fine: the reconstruction of historical events out of available evidence, the use of economic models to test predictions, and the manipulation of psychological experiments are pefectly good ways to instill the habits we want. And we can top off the curriculum with heavy doses of Sherlock Holmes.

The same problem emerges with some of the other putative aims of ST literacy. The report of the National Science Board Commission, Educating America for the Twenty First Century, wants the curriculum to emphasize the social and political problems of technology. (9). But understanding the social and political implications of, say, nuclear power plants doesn't require of us more knowledge of physics and engineering. It requires that we appreciate the political value or disvalue of centralized versus decentralized sources of energy, that we be savvy about how regulatory agencies can become captured by the firms they are supposed to regulate, and that we consider the economic costs, to us and future generations, of alternative sources of energy. This kind of science literacy is not literacy in science, but literacy about science.

The myth of science is the assumption that physics, chemistry, and biology are relevant to ST literacy -- where we understand such literacy to mean having certain habits of inquiry or understanding the social and political effects of science and technology. The argument that we need more science for informed participation has led us to a conception of informed participation that doesn't need more science.

IV. So much for the myths of democracy, crisis, and science. What follows? What follows is to think more realistically about what is reasonable for a mass democracy. It is not realistic to expect that the public can be "competent to evaluate the scientific or technological aspects of public programs." What is realistic is to assure political control of science and technology. We can't avoid reliance on experts, but we can make sure that decisions having broad social impact get made by accountable representatives, and done so through a process that pits experts against one another. The adversarial process generated by multiple centers of expert advice within government and multiple public interest lobbies outside government keeps the experts honest and forces policy choices to take account of dissenting voices. (10)

Perhaps twenty percent of the population is "science attentive," i.e. pays any attention to science and technology policy. (11) An even smaller proportion has any sophisticated understanding of science and technology. Still, this means that tens of millions of citizens have some interest in the public policy controversies involving science and technology and that hundreds of thousands can be mobilized for any vital issue. Such numbers can make a lot of noise, support many public interest lobbies, influence legislators, and stir a larger public on occasion. As long as this network of interested citizens, public interest science groups, informed legislators, and official experts remains vital, fairly effective political control of science and technology can be maintained.

Where does this leave the argument for ST literacy? I think that it leaves it looking for better support than the "argument from democracy." Democracy, of course, even the mass variety we live in today, requires a minimal, general literacy in the population, and ST literacy has a place in general educational aims. But it has no special place. Proposals to increase greatly the science content in primary and scondary schools, and to give priority to overcoming the gulf between science 'haves' and 'have-nots', would do better to apppeal to other grounds, such as the highly technical demands on the future labor force, or the sheer intellectual value of science, than to the civics-book model of the participating citizen.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 325-329, 1987. Printed in the USA.
0270-4676/87

SYMBIOTECHNOSIS: THE CHALLENGE TO TECHNOLOGICAL LITERACY

William H.A. Williams

There have been two basic cultural response to the promise or, depending on one's point of view, threat of artificial intelligence, both of which are characteristic of our failure to grasp the nature of our relationship with our technology. As usual, we simultaneously try to bend ourselves to and separate ourselves from the tools of our own creation.

From the warp and woof of the ancient weaving room through the clock-work mechanisms of the sixteenth century to the dynamos, engines and atomic reactors of our own age, we have sought the reflections of ourselves and our fate in our technology. Today, we approach the computer and AI programing in the same curious manner. In the words of Sherry Turkle, "We are insecure in our understanding of ourselves, and this insecurity breeds a new preoccupation with the question of who we are. The computer is a new mirror, the first psychological machine. Beyond its nature as an analytical engine lies its second nature as an evocative object."[1]

We are already close to defining ourselves as information processors, what J. David Bolter calls computers made of flesh -- sweet but, alas, inferior.[2] Faced with apparent competition from thinking machines, we may feel forced to take refuge in our emotions. As Sherry Turkle suggests, "We learned to see ourselves as rational animals. Now there is the possibility for a new integration, to see ourselves as emotional machines."[3]

This, however, brings us to the borders of the second type of cultural reaction we have toward new technologies. If the image we see in the latest technological mirror is one of a diminished humanity, we the retreat into a dualistic defence, radically separating man from machine. As Patrick Huyghe has suggested, "If we can give a computer the capacity for intelligent thought, let alone emotions and creativity, then clearly the era of human beings as the measure of these things has ended."[4]

It is significant that all sides in the debate about AI's supposed challenge to human intellect -- believers and doubters, aggressors and defenders -- seem agreed upon the ground rules: if the machine can think, then humankind is somehow diminished, if not actually threatened. Constructed this way, the debate must in the long run favor the champions of AI, for it provides them with a two-pronged offensive. One the one hand, they work steadily to improve the "intelligent" qualities of the computer. On the other, they redefine human intelligence, even consciousness, in terms of computer programming. Thus, even if the machine falls short of expectations, "mind" will have been remade in its image. This is not to suggest that AI theorists such as Marvin Minsky and Douglas Hofstadter are wrong in their contention that the function of the human mind may be understood in terms of computer programming. We should simply note the corollary of this assumption. If the human mind is "like" a computer, then a computer is "like" a human mind. If one can "think", then so can the other.

Many of those who are uncomfortable with the concept of the "thinking machine" fear that we humans may eventually surrender our decision-making powers to computers. AI optimists often agree, but reason that the human race can look forward to a well-earned retirement in which machines will do the "dirty work" of complex thinking. According to Edward A. Feigenbaum and Pamela McCorduck, "The essence of the computer revolution is that the burden of producing the future knowledge of the world will be transferred from human heads to machine artifacts."[5] Even looking at artificial intelligence within an evolutionary paradigm does not alter this dualistic view of the future. MIT's Edward Fredkin acknowledges that "Artificial intelligence is the next step in evolution . . . Now with AI coming along . . . if it were a slightly better human, then we'd disappear. But it's not going to be a slightly better human. It's going to be a completely, a totally different thing, which leaves us our niche".[6]

Suppose, however, that our future will be decided not in terms of the differences but in terms of the interactions between man and machine? Let us conduct a simple mental experiment. Imagine that tomorrow's newspaper carries the announcement that scientists have achieved a direct interface between the human brain and a computer chip. As a result, a person could access, through mental processes alone, a chip containing, let us say, the basic grammar and vocabulary of Russian. Under such circumstances, what would happen to the debate about AI? In an instant we would see the future, not in terms of man or machine, but in terms of man and machine.

Direct interface between the brain and the computer chip may never be possible. Nevertheless, a human being interacting with a computer fits Gregory Bateson's concept of a man/machine system -- a system that has "mind"; a system that can evolve.

A philosopher of whole systems theory, Bateson helps us see that the dynamics of life are to be found within the interactions of systems and subsystems. From the systems vantage point, it is not things apart but things interacting that count. For example, Bateson sees a person chopping down a tree is part of a man-axe-tree-axe-man system.

> We observe that the axe flies through the air and makes certain sorts of gashes in a pre-existing cut in the side of the tree. If now we want to explain this set of phenomena, we shall be concerned with differences in the cut face of the tree, differences in the retina of the man, differences in his central nervous system, differences in his efferent neural messages, differences in the behavior of his muscles, differences in how the axe flies, to the differences which the axe then makes on the face of the tree.[7]

According to Bateson, this cybernetic model with its circular feedback loops provides messages about the behavior of the whole system — the man, the tool and the tree. Moreover, this sort of interaction and the resulting generation of systemic information also constitutes the essential characteristics of what Bateson calls "mind."

> The elementary cybernetic system with its messages in circuit is, in fact, the simplest unit of mind; and the transform of a difference traveling in a circuit is the elementary idea. More complicated systems are perhaps more worthy to be called mental systems, but essentially this is what we are talking about. The unit which shows the characteristic of trial and error will be legitimately called a mental system.[8]

In Bateson's view, not only is mind synonymous with interacting systems, but it is also synonymous with what he regarded as the true "unit" of evolutionary survival — the species plus its environment. Since the relationship between the species and its environment is systemic, both must evolve; both must either survive or perish together.[9] It is Bateson's systemic concept of mind and evolution that may provide us with a non-dualistic alternative to the man-as-machine and the machine-versus-machine approaches to the question of AI and the future of humankind. Instead of asking what degree of intellectual independence machines may attain, we should try to understand the implications of intellectual interdependence and ask what will happen as we learn to think with and through our machines. Instead of dreaming about a world run by machines, we should begin contemplating a world run by man/machine systems.

Of course, this concept may be more shocking to many people than the idea that computers could replace people. Even in an AI utopia of super-smart machines, we redundant humans could remain fully human, whatever else might happen to us. Are we destined instead to become a part of our own technology? The obvious answer is that we have never been anything else! Homo sapiens won out in the competition with other humanoids to become the dominant life form on earth because we are essentially technology-creating, technology-using creatures. For the slow biological path, we substituted the fast track of cultural-technological evolution. We have used technology to give us leverage. Machines lever our bones and muscles. Our communications technologies lever our eyes and ears. And now with computers, we have an information technology that will lever our brains. And just as the steam engine represented an adjunct muscle, so the computer chip with AI programing represents an adjunct brain.

The relationship between human and computer may be described as one of symbiotechnosis. To explore this idea of a quasi-symbiotic relationship between man and technology, we must accept certain ambiguities uncongenial to our Western culture. Symbiotic relationships cannot be fully understood in simple dualistic terms. The nature of a symbiotic system does not lie in its individual component parts, nor even at their points of interconnection. It lies rather within the interaction of the parts. At the level of the whole system, things are relatively clear. At the level of symbiotic interactions, however, things start to become ambiguous.

We have already entered the age of man/machine, natural/artificial ambiguity. As bionics continue to develop, we will inevitably become a little bit machine. At the same time, the introduction into the environment of the first biogenetically manufactured life forms suggest ambiguity in another direction. As Jeremy Rifkin points out, "With computer programming of living systems, the very idea of nature being made up of discrete species of living things, each with its own inviolate identity becomes a thing of the past."[10] Scientists are even working to replace the microchip with the biochip, genetically programmed and biologically reproduced.

The most promising way for us humans to understand and appreciate ourselves is not to focus on the differences between man and machine (or man and environment), but to accept and explore the interaction between ourselves and our technology. Just as we can not be understood apart from our natural environment, so we must see ourselves within the context of our technological environment. Like it or not, human society has evolved with and through its tools.

If we continue to ignore our symbiotechnotic relationship with our technology, we will never escape from the traps we set for ourselves during the Industrial Era, one of the most dangerous of which is the insistence that technologies are "neutral". We are not technologically determined and we are morally responsible for our use of technology. Nevertheless, we must recognize that there is a bias within any system. In man/machine systems, the bias (in the West at least) is usually along the lines of the optimal short-run economic application of the technology, as perceived by the society using it.

To return to our earlier example, there could be no man-axe-tree system without an axe. And without an axe, the man's potential for cutting down trees would be severely limited. In fact, tree cutting on any large scale would not be an easy physical or economic option open to him. Thus, the man-axe-tree system carries a bias for cutting down trees that, if not limited by perceptions of the wider ecological system in which the man lives, could lead to a destruction of the forest. Because we enter into a symbiotechnotic relationships with our technology, the resulting "system" opens up some evolutionary doors while closing others. It is essential that we understand the "bias" within any man/machine relationship in which we find ourselves.

The challenge symbiotechnosis presents to the concept of technological literacy, then, goes beyond teaching people how machines work or even how machines "work" upon our society. We must learn that the impact of technology reaches beyond socio-economic manifestations to the very marrow of our culture. Our very perceptions are shaped by our symbiotechnotic relationship with technology. This means that the basic difference between a society with, let us say, automotive technology and one that without it is not to be found in the presence or absence of cars, roads and gasoline stations. The difference lies in the way the two societies look at and react to their environment.

Symbiotechnosis is a particularly difficult challenge for those of us within the humanities. We certainly have sought to maintain man as the measure of all things, sometimes forgetting that our perceptions, , no matter how aesthetic or spiritual, may have been shaped in part by our involvement with technology. Humanists have often been the first to insist on stripping man of his technology in order to get at the essence of humanity. Man removed from his technology makes no sense, however, and can make no sense of the world in which he lives. To think of ourselves in terms of our symbiotechnotic relationship with technology should not be considered as a threat to our "humanity". It should be seem as an attempt to close the circle around the very complex set of contexts within which we live and in which we must survive.

FOOTNOTES

1. Sherry Turkle, The Second Self: Computers and the Human Spirit. New York: Simon, Schuster, 1984. p. 306

2. See J. David Bolter, Turing's Men: Western Culture in the Computer Age. Chapel Hill, N.C.: University of North Carolina, 1984. pp. 213.

3. Turkle, op. cit., p. 313.

4. Patrick Huyghe, "Of Two Minds: Attempts to Build Intelligent Machines Have Caused A Revolution in Our Thinking About Thinking". Psychology Today, 17:12:34 (December, 1983).

5. Edward A. Feigenbaum and Pamela McCorduck, The Fifth Generation: Artificial Intelligence and Japan's Challenge to the World. rev. ed. New York: Signet-New American Library, 1979. p. 39.

6. Quoted in Trukle, op. cit., p. 263.

7. Gregory Bateson, "Form, Substance, and Difference". Steps to an Ecology Mind. New York: Ballantine Books, 1972. pp. 458-459.

8. Ibid., p. 459.

9. For a more complete presentation of Bateson's ideas about mind and

evolution, see his Mind and Nature: A Necessary Unity. New York: Bantam Books, 1980.

10. Jeremy Rifkin, Algeny: A New Word — A New World. New York: Penguin, 1984. p. 23.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 330-337, 1987. Printed in the USA.
0270-4676/87

LITERACY, TECHNIQUE, METAPHOR, AND THE IMAGINATION

David Lovekin

Literacy is rarely what it seems. Its object is typically an absence. When the illiterate are addressed, they are often not there, like vermin scurrying out of range of an inquiring light. Shame renders them invisible. The illiterate, themselves ashamed. remind us of our own shame. They remind us of our obscene obsessions for work and correctness and of the elusive meaning that gestures and mocks behind our print, our symbols and our own communications. If we could say what we really meant, we would never have to speak or write again. Meaning as absolute would emerge and with it would follow a respectful, stunned silence. The silence of the illiterate is not silent. It is a dissonance which reminds many of us--well placed, tenured, or chaired--that many public documents, with income tax forms as clear cases in point, strike us as barely intelligible; that application forms for many jobs and grants stupify with prying, humiliating, unclear questions; that the majority of inter or intra office memos ought to be read by no one; and that the true focus of the mass media--the goal of most literacy campaigns--is to align our sensibilities and to corral our allegiances rather than to inform and to stir inquiring minds.

Here is another kind of shame. The shame of technology itself. The goal of our technological society is to produce solid, rational citizens, able to do their work, to understand and to be informed--it is important that all must participate--and to these ends literacy is important. George McGovern, in an address before the senate on September, 1978, states these concerns of literacy most clearly: "An astounding thirty percent of Navy Recruits. . . are a danger to themselves and to costly Naval equipment because they lack basic educational skills. One illiterate recruit recently caused two hundred fifty thousand dollars in damage because he could not read a repair manual."[1] The illiterate are those who cannot efficiently function. Their presence, however, points to a further kind of shame. The technological society, with its efficient methodologies, seems unable to clearly define this populace that eludes it.

The notion of literacy varies with time and intent. In our time literacy seems clearly to refer to the ability to fill out job application forms, to read public communiqués, to do fundamental mathematical calculations, and to read the news and attend to the mass media. These meanings were determined forcefully by the famous Adult Performance Level Study (APL) done at the University of Texas and published in 1975; on their assessment, at least twenty three million adults in the United States are illiterate.[2] Jonathan Kozol, in Illiterate America, ups the figure to sixty million "marginal" illiterates.[3] One third of America, thus, is illiterate to marginally illiterate. In 1982 an English Language Proficiency Survey was taken by the Census Bureau under the auspices of the U. S. Department of Education. They concluded that there were seventeen to twenty-one million adults who cannot read and comprehend communications they might receive from public agencies.[4] What accounts, however, for the disparity of figures? If this class is so large and if its problems are so great, why cannot they be located with greater ease?

Aware of the absence of "hard statistics," PLUS (Project Literacy U. S.) in A White Paper, published in 1985 and revised in 1986, states: "The surprising fact is that the United States, which leads the world in producing a daily volume of statistics on every imaginable subject, has never established a reliable basis for measuring illiteracy in any precise terms nor any gradations within concepts of functional illiteracy and semi-literacy."[5] Here is the shame resulting from an awareness of limitation--technology's inability to come to terms with and to justify itself, to define itself and what it is not. This is the shame, alluded to above, that many of us feel, we who are degreed and licensed but unsure of the meaning of the technical system, so well framed in the bureaucrat's memo, in the government's revelations of "disinformation." What is the intent of technology and what is its relation to language?

I suggest in this paper that the concern for literacy is simply another concern of technique, a specific form of intentionality, which manifests itself in mechanical, functional literacy. This is a literacy at odds with poetic, philosophical literacy. The language of technique, I will urge, is the language of the concept, while the language of the poetic and the philosophical is the metaphor, an original language, evoking a sensus communis. The image, the key to the concept, is a mere sensory presence before consciousness, of which consciousness may be certain. The metaphor opens consciousness to another dimension, to a sense of the whole, to an awareness of being-which-surrounds.

The goal of technology is the clear and distinct, a presence which cannot be doubted. Doubt is the enemy of technique, the reason why Descartes, held to be the originator of modern philosophy, begins his Meditations with it in order to dispel it. Descartes is also the architect for technical consciousness, la conscience technique, the understanding that truth is method leading to the clear and certain and that thought must be rational and adhere to the Aristotelian principles of identity, noncontradiction, and disjuction.[6] That which is true must either be or not be, must be what it is and not not what it is. An adequate concept must not be self-contradictory, must frame and establish an identity, and must state what is or is not the case. Such a concept is sought by statistics on literacy. But, who exactly are the illiterate and what must be done about them? It is never doubted that no clear and distinct concept of literacy is possible. Mechanical literacy, our dominant literacy, is the literacy of the concept itself.

The object of reason must appear clear and evident to the senses, must be the result of analysis, of reducing the complex to its simplest elements, must be reassembled after analysis, and must be subject to continual scrutiny and reassessment. Language too must serve these ends. We should avoid fables, Descartes observes, which, " . . . make one imagine many events possible which in reality are not so."[7] The object of reason, the Cartesian method, is to produce the concept. The goal is to develop the strongest power of reasoning, to attend to propositions making them fit the facts, making them be coherent, even if these propositions have to speak, Descartes observes, the language of Lower Brittany.[8]

It is the language of Lower Brittany that is the ideal sought and measured by the revered SAT, one major path in the tracking of literacy. Consider the following typically found in the sentence completion section:

> Though he is an amateur dancer, he has the _____ of a gazelle and the ____ of a professional.
> (A) awkwardness . . . strength
> (B) cerebration . . . credulity
> (C) agility . . . prowess
> (D) delirium . . . demeanor
> (E) detriment . . . skill[9]

The correct answer is the cliché "agility . . . prowess," which would gag the pen of any good poet. These words correspond to the facts and provide a correct description. "Delirium . . . demeanor," might be better, however, forcing a more interesting understanding of both gazelles and dancers. And "cerebration. . . credulity," moves us to the level of the ironic, no friend to polite notions of literacy, mechanical literacy, but essential to poetical, philosophical literacy.

Plato is an important critic of mechanical literacy in the Phaedrus. Plato, in my view, is a genius of philosophical-poetical literacy, carried on in the tropes of irony and metaphor. Plato does not, in his greatest moments, construct concepts. He is a builder of metaphors at crucial moments when Socrates's arguments break down or when his arguments lead to a corner. The myth of the cave and the story of Er are but two well-known example. But here I am interested in his ironies and in what we may learn from them for approaching the problem of literacy.

In the Phaedrus, Plato has Socrates, who wrote nothing, discourse against the evils of writing things down. He says: "It will implant forgetfulness in their souls: they will cease to exercise memory because they rely on that which is written, calling these things to remembrance no longer from within themselves, but by means of external marks; what you have discovered is a recipe not for memory but for reminder. And it is no true wisdom that you offer your disciples, but only its semblance, for by telling them of many things without teaching them, you will make them seem to know much, while for the most part they know nothing, and as men filled, not with wisdom, but with the conceit of wisdom, they will be a burden to their fellows."[10] The true, Plato is to say much later in his famous "Seventh Letter" can never be written down.[11] He has in mind the capriciousness of evil tyrants claiming wisdom but practicing policies of greed and self-interest. The true, for Plato, is always behind the appearance; the true must be coaxed out, obtained by dialectical and dialogical insight and concern. Those claiming to know the truth are only claiming, and their claims, as particular claims, can only have the status of relative truth. Socrates's famous wise folly, his learned ignorance, is the wisdom of the provisionality of all human accounts. He has in mind, particularly, the accounts that could be written down.

As written, as an image, the true moves more to the level of the certain, to the level of belief, pistis. For the mind in its infancy, lacking philosophical rigor, the true only appears as appearance. It was Socrates's task to undress this appearance. It was Plato's task to record it, to invent it, and to reveal it as provisional, all at the same time. In the Phaedrus, Socrates says: "And once a thing is put in writing, the composition, whatever it may be drifts all over the place, getting into the hands not only of those who understand it, but equally of those who have no business with it.[12]

Plato approaches the true with the awareness that he is writing it but not writing it. The ancient controversy seeking the true Socratic position vis-a-vis the true Platonic doctrine speaks to the success of his method. The true, as is stated in "Seventh Letter," is somewhere between the reader and the page.[13] It cannot be written down, perhaps the reason Plato wrote so much. The true is said to be like a light, when Plato does speak of it. It strikes the reader, the listener. It illuminates, but it has no substance. It is not a thing. It is revealed in the metaphor, which is the union of opposition, such that the tension between the two is never lessened, never collapsed.

An essential irony in Plato's account of literacy is the move against the claim that writing stores knowledge, a claim well-known in Plato's time and rampant in our own. Think of the notion of a computer's "memory bank." Not only does writing not store knowledge but, Plato adds, it injures memory. It allows for the confusion of "memory," an active spiritual process, and "reminder," the product of that process. Writing, or any other symbolic representation of thought, may aid our memories if we do not confuse the image, the representation, with the thing-itself. The image leads us as a that-which-is-before-us, to a that-which-it-is-not, to that which explains it. Socrates's ignorance becomes divine when it is seen as an awareness of what it is not, what the limits of any knowledge claim are, a thought bound to drive the Cartesian mind mad.

In 1708 philosopher and Professor of Latin Eloquence, Giambattista Vico, in his De nostri temporis studiorum ratione, an inaugural address to the University of Naples, states that the wisdom of the ancients is in danger of being lost in light of an imposing Cartesian mentality. Ironically, this wisdom is endangered by the preservation of it in books available for the first time to individuals inexpensively and in great variety. Vico states: "I am . . . afraid that the abundance and cheapness of books may cause us to become less industrious; we may be like banqueters, who, being surfeited with gorgeous and sumptuous dinners, wave away ordinary and nourishing food and prefer to stuff themselves with elaborately prepared but less healthy repasts."[14] Vico confirms Plato's fears of words drifting haphazardly about.

In the past, Vico continues, when a serious student required a book he had to copy it and in copying it, had to be "transformed into the author's very self."[15] The words, not the student's own, are made his through the physical process of writing. The not-his becomes his, while remaining apart. To copy a word is to retain the otherness of the word. Likewise, the ideas and insights, foreign to his own, are moved inside. They become at once his and not his. He is led back and forth. In this movement of back and forth the student recreates the movement of the poetic spirits of the first humanity.

Language and society originate together, Vico explains in his master work, the Scienza Nuova. The creative act of the first poets, able to frame the immensity of the thundering sky as Jove, brings together an infinity under a specific shape, a word brought forth in bodily action, in the voice.[16] This word is no mere image. Jove is a response to an accoustical and visual phenomenon--thunder and lightning--a specific image, which is also an all-around, an all-encompassing. This master image--an imaginative universal--is conveyed in a word that refuses to be written down; it is uttered in this divine and auspicious presence. It provided the first humans, Vico says, with a sense of destiny, a notion of providence, and meaningful rituals.[17] Nations were thus able to be formed. This is a primal language, requiring a literacy for which there are no techniques. It is the language of the imagination, fantasia, and not a language of reason, ragione.

Cartesian discourse cannot speak in this fashion, taking up instead what Vico calls the intelligible universal.[18] A universal can never be a simple particular. The first word--Jove--is not the product of an abstractive method. Rather, it requires an act which makes method possible, a language making literacy possible. Homer, the blind poet, brings forth Greek literature. Method is meaningless apart from aim, and the notion of Jove--not a concept but a metaphor--is aim itself. The metaphor requires mind to move back and forth between image and representation, not resting in either one. It is, as well, an act of memory. Mind must move from its present to its place of origin in the past. The past is made present and all is transformed. The concept requires rest, a stasis of spirit. This rest, a kind of sleep, is the abstract concept, an identity with no difference. French is useful in this discourse, Vico states, understanding that Descartes' method is no accident. Vico states: "The French language is abundantly endowed with words designating abstract ideas. Now, abstraction is in itself but a dull and inert thing, and does not allow the comparative degree. This makes it impossible for the French to impart an ardently emotional tone to their ideas, inasmuch as such an effect can only be achieved by setting thought in motion, and a vehement motion at that; nor can they amplify or elevate their discourse. Nor can they invert the order of words: the conceptual abstraction being the most general category, it does not supply us with that 'middle term' where the extreme points of a metaphor are able to meet and unite."[19] The Italian language, Vico advises, is a bodily language such that abstract concepts also clearly have quite concrete references.

Vico's critique of French aside, his idea is that metaphors are not formed by an abstractive spirit seeking the clear and distinct. The true is not found but made--verum factum--by an "indefinite quality of mind," where humanity makes things from itself.[20] When in the face of what it is uncertain of, what it does not understand, the spirit takes up the object in a metaphor. Reason points; the imagination grasps. The illiterate in our age scurry about in front of the point of reason. Language is reduced to the indicative sign, to the image, to a that-which-is-before-me. What surrounds is not grasped.

Vico writes that the Cartesian attention to reason at the neglect of the imagination weakens the imagination and memory.[21] It weakens society as well. The social glue extruded from the metaphor dries up. Bestiality returns to society no longer able to form a sensus communis. This, I suggest, is the response of a society trying to reduce literacy to mechanical literacy; to corral and to lock up the metaphor, the language of the imagination.

I recommend the literacy necessary to reading Kafka's Metamorphosis. Here we recall that Gregor Samsa awakens to discover he has become an Ungeziefer, what is translated as "insect" but which is more accurately understood as "vermin."[22] To the horror of the Cartesian mind, Samsa is an insect and not an insect. He is somehow all vermin. He has become the loathesome itself. He can no longer speak, uttering instead twittering squeaks, which his horrified family cannot understand. On the first morning of his transformation, he struggles to right himself, waving his numerous legs in the air and fixes on some specific signs of his former humanity: his traveling salesman's sample case and a picture of a woman, cut from a magazine, framed and hung on the wall.[23] The reader is never given a clear reason for Gregor's metamorphosis. His mother thinks Gregor is simply not well, at first. She says: "What else would make him miss a train! The boy thinks about nothing but his work. It makes me cross the way he never goes out in the evenings; he's been here the last eight days and has stayed at home every single evening. He just sits there quietly at the table reading a newspaper or looking through railway timetables."[24]

Kafka's publisher knew that his readers had been looking through railway timetables too and urged him to allow a drawing of the Ungeziefer in the work. Kafka refused, seeing the notion of a specific vermin not in keeping with the power of his metaphor. The power of the notion of the Ungeziefer eludes the clear and the distinct. As John Updike observes, "'The Metamorphosis' stands as a narrative absolutely literary, able to exist only where language and the mind's hazy wealth of imagery intersect."[25]

Thus, with the uncertainty and doubt issued from Kafka's poetic and philosophical literacy, we discover in ourselves the real truth: that we the literate are truly illiterate, having lost an original language. The SAT and the ACT will not bring it back.

Notes

1George McGovern, "Illiteracy in America: A Time for Examination," USA Today 108 (May 1980), 28.

2Norval Northcutt, Adult Functional Competency: A Summary (Austin: University of Texas-Austin, 1975).

3Jonathan Kozol, Illiterate America (New York: Doubleday, 1985), 10.

4Robb Deigh, "Curse It, Count It, Cure It: The Arithmetic of Illiteracy," Insight (September 14, 1986), 13. This article discusses the problems of attaining an adequate measurement of illiteracy.

5(March, 1986), 11.

6For a discussion of what I call the logic of technical consciousness, see my "Jacques Ellul and the Logic of Technique," Man and World: An International Philosophical Review, 10 (1978), 251-72. Ellul is the current thinker who has most fully explored the notion of la conscience technique. Descartes' methodology is clearly, for Ellul, the essential grounding for this form of intentionality. I explore this material more fully in my forthcoming book, Technique, Discourse, and Consciousness: An Introduction to the Philosophy of Jacques Ellul (Bethlehem, PA: Lehigh University Press).

7Discourse on Method, trans. Haldane and Ross, vol. I (New York: Dove Publications, 1931), 85.

8Ibid.

9As quoted in Robert Pattison's On Literacy: The Politics of the Word From Homer to the Age of Rock (New York and Oxford: Oxford University Press, 1982), 198. A glance at the many books on how to prepare for the SAT will show that this example of sentence completion is indeed typical.

[10]Trans. R. Hackforth, Plato: Collected Dialogues, Including the Letters, eds. Edith Hamilton and Huntington Cairns (New York: Random House, 1973), 275 A.

[11]Plato: Collected Dialogues, 241-345.

[12]Ibid., 275E.

[13]Ibid., 241C.

[14]On the Study Methods of Our Time, trans. Elio Gianturco (New York: Bobbs-Merrill, 1965), 72.

[15]Ibid., 73.

[16]The New Science of Giambattista Vico, trans. Thomas Goddard Bergin and Max Harold Fisch (Ithica and London: Cornell University Press, 1968), pars. 375-384.

[17]Pars. 385-399.

[18]See my "Giambattista Vico and Jacques Ellul: The Intelligible Universal and the Technical Phenomenon," Man and World: An International Philosophical Review 15 (1982), 407-16.

[19]Study Methods, 40.

[20]New Science, par. 405.

[21]Study Methods, 13-15, 23-30.

[22]The Metamorphosis; Die Verwandlung: A Bi-Lingual Edition, trans. Willa and Edwin Muir (New York: Schocken Books, 1968), 6-7.

[23]Ibid., 7.

[24]Ibid., 23.

[25]"Reflections: Kafka's Short Stories," The New Yorker (May 9, 1983), 129.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 338-343, 1987. Printed in the USA.
0270-4676/87

IN PRAISE OF COMPUTER ILLITERACY

Richard F. Devon

Claims for computer literacy have stressed productivity, job skills and functional (cultural) literacy for the "age of information". These claims have been questioned in a number of ways, but this paper wishes to raise a new issue about the claims, viz., that the implication that computer illiteracy is a bad thing is quite wrong and it impairs our ability to think sensibly about computers. Making this argument will entail establishing distinctions between significant and trivial computer literacy and between technological literacy and technological sense. However, the idea that computer illiteracy is good is so counter-intuitive that I will begin with some comments on the question of what we do and do not think about.

It frequently happens that a given ideal becomes valued by a society to the point that valuing the opposite notion becomes unthinkable (cf. Marcuse, 1968). When this happens, the valued idea operates as an unquestioned "good". Strategic weapons "superiority" is such an idea in our society. Strategic inferiority is thought of only as something to be feared and avoided. It is considered by our foreign policy makers as unthinkable. Yet the rest of the world, including some of the present great powers, Britain, France, etc., have learned to live with it and do not view its consequences as necessarily devastating. Some countries, such as Switzerland, Japan and West Germany, thrive on it. But even where undesired, it is, at least, thinkable everywhere else. And our inability to think about it means the arms race is limited only by our capacity to pay for it.

Another such idea which has recently been thrust upon our society is "computer literacy". The hype on behalf of computers and the negation of computer illiteracy may be viewed as having the same ideological roots in the military industrial state (Roszak, 1986; Noble, 1984). Computers are widely expected to dominate our society and pervade most aspects of our lives. Computing in the form of artificial intelligence is claimed to be the new "wealth of nations" (Feigenbaum and McCorduck, 1984). Computer literacy is the new wealth of people (Gore, 1983). Typically, these claims for the importance of computers rest on prophecy rather than on analysis of the present.

However, in retrospect, predictions for computers have not proven accurate. The early prophecies for the decade or two before the mid-1950s greatly underestimated the future of computing (Ceruzzi, 1986). The later prophecies erred in the other direction (Caporeal, 1986), except for the case of artificial intelligence which had a period of low expectations in the late 1960s (Winston, 1985). There is reason to doubt that current claims will prove any more accurate, and charges of "hype" are not hard to find (Oettinger, 1969; Roszak, 1986).

However, the aim of this paper is not to question the validity of the claims on behalf of computers. It is, rather, aimed at the contention that computer illiteracy is a bad thing. I will argue that computer illiteracy is a very good thing, and that rendering computer illiteracy unthinkable poses a more fundamental problem than computer hype itself because it erodes the base of technological sense in computing.

The Demand for Computer Literacy

If we consider other technologies such as airplanes, lasers or air-conditioning, the idea of computer literacy seems odd. Why is there so much desire for a computer literate society? It was never suggested that everyone should know how a locomotive worked when the technology was at its height. The idea was rarely suggested for mass technologies like telephones, radios and automobiles which are, and will be, used much more extensively than computers as such. It may be because the computer is in someways a meta-technology. That is, it is a technology which has become a part of a large range of other technologies. There is, too, an irrational fear of the computer (Turkle, 1984) which may be driving the desire to understand and control it. This fear is more evident in the older generation who have championed computer literacy, and recent evidence from the schools suggests that students now take computers for granted (Pulos and Fisher, 1985). More probably, the demand for computer literacy stems from the very high value placed on computers by industrialists who see high productivity and diminished labor power in automation, by the military who see the electronic battlefield as a new way to expand their power at home and in the arms race and by politicians whose careers feed on social statistics and polls (Roszak, 1986; also, see Siegel and Markoff, 1985). In a sense, the palaver about mass computer literacy may perhaps be seen as a ritual whereby the people pay their respects at the high-tech altar of the modern state.

The Need for Technological Literacy

At the 1985 conference of the American Society of Engineering Educations, one panel discussed engineers and the media (ASEE, 1985). All the panelists felt a need to apologize for having to talk to the public about developments in science and technology at all. Under questioning, they acknowledged that scientists and engineers typically do not want to explain their work to the public, rationalizing their reluctance with the argument that members of the public cannot understand what they are told. They also, no doubt, fear public condemnation. Nevertheless, the panelists, in varying degrees, recognized the need for accountability (in one case it was the opportunity for propaganda), and it is from this dilemma that the argument for technological literacy arises. Technologists must be accountable to the public, but this requires that the public must be technologically literate.

The Public's Questions and Technological Sense

The argument for technological literacy, however, may be misconceived if it does not include a recognition that scientists and engineers ask different questions of a technology than members of the public do. A technologist wants to know how a technology works, how well it compares with other technologies aimed at achieving similar outcomes and what the theoretical principles and implications are. The public wishes to know what it will do for them and what it will do to them. Will it change their profits, pleasure, free time, employment or social status? Is it likely to improve or damage their physical or mental health?

The technologists, preoccupied with their own questions, are irritated and frustrated by industrialists who tell them their idea is unprofitable, by environmentalists who express concern over the toxic waste generated by the technology or by others who ask why their energies are devoted to developing instruments of destruction. The questions posed by the technologically illiterate usually have not received a lot of thought by the developers of technology. This is not what they are rewarded for doing. Naturally, these questions - which may yield answers damning enough to halt the technology - are doubly irritating because those that ask them may have little understanding of the technology itself.

This material determinant of thought is critical. If your job is the development of a technology it is highly unlikely that you will give much consideration to questions that threaten the enterprise you are a part of and which provides your status and your income. Further, past choices and past socialization probably mean that the experts' interest is strongly focused on the technology qua technology. Although such determinants can be, and have been, overcome the odds are that they won't be. Nothing more than a mental caveat or a wry comment will take place. This is not a description of heartless technologists, but rather of people just doing their job (cf. Arendt, 1963; Milgram, 1975).

It is, of course, equally irritating for a member of the public to be excluded from knowing about the existence of technologies, to have their questions scornfully dismissed by technologists who may not be able to answer them anyway, or to be propagandized with a half-truths.

The problem, then, with the terms technological literacy and computer literacy is that they obscure the fact that these two different types of questions generate two different types of knowledge.

Whatever the reason behind the demands for computer literacy, society will benefit by having a large reservoir of people who will be computer illiterate enough to ask "Who does that belong to?" or "It's not radiating anything is it?", or "What do you plan on doing with that?" or "Will people lose their jobs?". It is from questions like these that another form of technological knowledge is built up - one which I will call technological sense. For a technology to work requires technological expertise -- for a technological society to work requires technological sense.

Before developing the discussion of technological sense and technological expertise further, it is worth separating the term expertise which means knowledge from literacy which means hype. This is because the hype has obfuscated both sense and expertise in computing.

Trivial and Significant Literacy

Even granting this distinction between technological expertise and technological sense there is a further problem with the term technological literacy. Particularly in the case of computing, "literacy" is used to mean anything and everything and many denoted activities involve a trivial knowledge of computing.

It would be better to use technological literacy in the sense of basic technological expertise. That is, it is knowledge of some complexity which constitutes an introductory, but significant, part of the skills that an individual needs to function in a given environment - vocational or avocational.

Proponents of computer literacy like to point to all the very many places that computers are now being deployed from electronic ignition in cars, to data-processing in banks and robots in industry. A car mechanic who learns how to replace the electronic timing in a car has a trivial knowledge of computers. So does a bank clerk who operates a terminal for data processing or a library patron who uses a computerized catalog system. Operationally, the entire process requires two skills, elementary typing and reading instructions on the screen. These are cases of trivial computer literacy because acquiring the "computer skills" they use needed no prior knowledge of computers, entails no knowledge of the working of computers and often involves less training and easier goal attainment than the situation prior to the deployment of the computers.

By contrast, significant levels of computer expertise are required by people who design, build, program and maintain computers. Others who use computers in research and the design of other technologies may benefit from a fairly sophisticated knowledge of computers if they use them extensively in their work.

Three Ironies

There are at least three ironies involved in the hype for computer literacy.

First, computers have become "people-literate" more quickly and successfully than people have become "computer-literate". This has occurred because "people-literate" computers sell well to those who are short of time or nervous about using a computer. In particular, they sell well in organizations which want to reduce the heavy training costs involved in making employees "computer-literate". Since about 1985, the Macintosh has made a very strong come-back against IBM PCs for precisely this reason.

Second, the "mass" computer revolution has been driven by the microcomputer, a technology that steadily increases in power and decreases in price and size. This revolution has been created and fueled by experts and amateurs who taught themselves. The call for computer literacy, for people to be taught about computers, came after the most important stage had been accomplished by people who were self-taught.

A final irony concerns the use of the term technological literacy. It is typically used in a blanket fashion, if you are technologically literate in one way - you are technologically literate in all ways. In fact, all engineers are technologically illiterate in most ways and technologically literate in only a few ways. Similarly in computing, various languages, operating systems, communication protocols and application software can be very different from each other, and each entails a long learning period even for people expert with other software.

Technological Sense and Computing

It is in the nature of things that technological expertise precedes technological sense. The length of time before technological sense catches up with technological expertise may be long. In the case of nuclear weapons, the gap seems to be growing. In the case of computers, we may do better, but there are many signs that technological sense is thin in this area, also.

Consider, for example, the lawlessness that has pervaded the field of computing. In microcomputing, software is illegally copied on a massive scale by hacker and business executive alike. Hackers slip happily into the confidential systems of government, industry and academia. David Burnham writes of the Orwellian developments in the use of surveillance and data-bases by business and government agencies which violate the privacy and other rights of individuals (Burnham, 1983). There is, of course, much crime elsewhere in society, too, but I have frequently seen people who are otherwise scrupulously honest and law-abiding break the law with a computer. The technological sense just isn't there, yet. One author argues that the law will never keep pace with technological change, "It is like a race between an ox cart and a supersonic jet" (Roszak, 1986:181).

If there were more thought about the questions of the technologically illiterate, the use and deployment of computers would, perhaps, be more rational. But in the case of computers, the illiterate did not ask or were not listened to. Computer illiteracy became unthinkable as a good thing. The illiterates either rushed out and bought one or slunk away muttering derogatory remarks about the direction history was taking.

If we cannot think about computer illiteracy in a positive way, we will have considerable trouble developing computer sense. And a society which does not develop technological sense about computers may be expected to do foolish things with them. Jack Rochester and John Gantz have compiled a numbing compendium of the follies which characterize the short history of computing (Rochester and Gantz, 1983). For example, the computerized air-traffic control system took ten years to operationalize and produced 3,000 near misses due to computer problems in its first year or so of operation (ibid:255). Due in part to repeated changes with inadequate time-lines by Congress, the Supplemental Security Income program had a payment error-rate of 23.7 percent in its first two years after the Social Security Administration took it over in 1976 (ibid:256-7). Further, the computerized command system for our nuclear weapons that stands between all of us and the end of the world has generated thousands of bogus alerts (The Defense Monitor, 1986:1), and the SDI would appear to require a Launch on Warning (LOW) system to be effective, although the Department of Defense has never acknowledged this (Roszak 1986:104). A computer, not Congress and the President (as required by the Constitution), would make the fateful decision under LOW because of the very short time requirement.

It may be argued that not only do many people have both technological expertise and technological sense, but that it is precisely these people who shape policy. I doubt the record supports such an argument, though I wish it were true. The excessive social pressures for rushing to computerize has resulted in many decisions about the use of computers made by persons with neither computer expertise nor technological sense. We cannot achieve technological sense until the questions of the illiterate are treated with respect and even embraced by those in policy-making positions.

Too often a person's status determines the questions they devote their lives to. In the area of computer ethics, a good illustration of this was provided in the August 11, 1985, issue of the New York Times Magazine (Broad, 1985). Peter Hagelstein, a brilliant computer engineer who went through MIT taking a double load, went to work for Lawrence Livermore National Laboratory with very little prior knowledge of what went on there. For a few years in the 1970s, Hagelstein held negative views of nuclear weapons, but after he became the wizard of the nuclear-driven, x-ray laser, he changed. He observed, "Until 1980 . . . I thought there was something fundamentally evil about weapons. Now, I see it as an interesting physics problem." This jump from technological sense to computer expertise which we might call the "Hagelstein effect", illustrates both the paradigmatic distinction that I am making between technological sense and expertise and the reason why the control of expertise cannot be left to the experts. This case would be just as illustrative if Hagelstein had originally thought there was something fundamentally good about nuclear weapons.

The case for computer illiteracy has been made without reference to an equally valid argument that society should embrace a broad spectrum of skills and creative talents. Cultural diversity means a richer life for everyone and; against an always uncertain future, it provides a broad range of knowledge, talents and perspectives to help us adapt to whatever the future brings. This argument complements the case for computer illiteracy, because it is obviously important to encourage people in the pursuit of activities that are not computing and often not technological. It is these people who will help us maintain a perspective on our technological society and who will provide the basis for developing technological sense. This is true even when it is those who have both expertise and sense who figure prominently in the solutions. The technological illiterate can represent the political constituency for technological sense and maintain a demand that their questions be answered by something better than charges of "Ludditism".

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Bull. Sci. Tech. Soc., Vol. 7, pp. 344-356, 1987. Printed in the USA.
0270-4676/87

PUTTING PUBLIC AWARENESS OF TECHNOLOGY ISSUES ON THE LEGISLATIVE AGENDA

Robert Jacobson

In the wee hours of the morning, when policy analysts like me finish reading the score of weekly trade journals and political periodicals pertinent to our work, we sit back and wonder how far removed we are from the public we allegedly serve. It takes me an incredible amount ot time to stay current with policy and technological developments. Citizens who have neither the inclination to devote their few spare hours to this pursuit nor the training to decode technical jargon are obviously less able to fulfill their responsibilities in a technologically oriented society.

Legislative activity, because it is dynamic and constant, is perhaps a better indicator of the vitality of a political democracy than the more common measure of electoral participation. The latter, as is well known, is in serious decline in America. Unfortunately, in the states and at the federal level, citizen involvement in legislative activities relevant to technological developments is even less discemable. The sad fact is that important policy decisions determining or affected by technology are made without public participation. Occasionally consumer groups, environmentalists, or trade unions stand in as institutional surrogates for the broader public. Their presentations, however, are often self-serving and woefully inadequate when measured against those of the powerful and well-organized industrial and bureaucratic interests that dominate technology-policy debates.

Legislators and others who are accountable to the public deserve and require articulate expression by their constituents. Otherwise, they are left to their own uncertain intuitions, as these are influenced by the powerful interests, of what their constituents want from them. This produces a keen anxiety and discourages legislators, on too many occasions, from seriously examining questions of technology. An unhealthy status quo results. Legislators are not intellectually incapable of dealing with technology policy issues, nor are they (usually) venally corrupted and thus induced to leave these issues alone. But they are inclined to back away from controversy where there is no clear expression of the public will: plunging into a complicated issue without knowledge of the hidden obstructions and tricky currents that lie just below the placid surface can be political suicide. The citizens may be slow to catch on, but if they feel a legislator has gotten too far out in front of them or, worse, betrayed their interests, they can easily nurse a grudge until election day.

In Califomia, as in other jurisdictions, individual legislators and, occasionally, whole legislative bodies are taking steps to bring the citizens up to speed regarding technology-policy issues. In so doing they expand the variety of opinions and advice on which to base their decisions and, at the same time, mitigate any possible public backlash against desirable but unfamiliar public policies. Whether these experiments in enhanced technological awareness are theoretically based and planned on a large scale or strictly ad hoc, they indicate a growing awareness among policymakers that public participation is an important ingredient in the policy stew. At the least, participatory policymaking helps avoid recriminations after the fact: everyone who participates in the policy process, to a greater or lesser degree, adheres to some of all of its conclusions. At its best, participatory policymaking may lead to richer and better policies.

But meaningful participaton requires knowledge about the issues at hand and access to the resources to apply that knowledge. This is where the process of public participation breaks down. No army of technocrats is as persuasive as a gallery of agitated constituents when it comes to legislators making up their minds. If, however, public advocates are left ignorant and ill-funded, then legislators will seek out what help they can from the technocrats, who are loyal first and foremost to their institutional patrons. In a technologically dependent society, it would be difficult for democracy itself, let alone democratic policymaking, to survive this state of affairs.

In California, elements of the Legislature have determined to do their best to "open" for public debate those issues dealing with technology, and particularly information technology. I use the term "open" in the sense of "open planning" and "open policymaking," theoretical prescriptions for making these activities more susceptible to participation by the Legislature's public clients. These efforts include holding informal public workshops and seminars in place of more formal hearings, requiring public agencies to be more forthcoming about their agendas, creating new institutions accessible to citizen participants, and taking steps to involve citizens in the day-to-day evolution of technology policies.

The first two of these strategies are familiar devices for opening the policy process. Consultations are commonly used as a method for discussing options without obligating anyone to them, and they serve well to educate affected persons about the implications of technological decisions. Equally educational is the environmental impact report, or EIR. Congress and many state legislatures require federal, state, and local agencies to publish EIR's prior to embarking on major environmental projects (usually those involving alteration of the physical environment). One proposal now before the California Legislature envisions the filing of technology impact reports, or TIR's, by agencies about to implement new technological systems that affect providers and recipients of state services. Another variation might be a regulatory impact report (an "RIR"?) requirement for administrative agencies making technology policy rules.

Creating new, open institutions to deal with technology issues requires greater innovation, if the institutions are to meaningfully deal with issues of substance in a way that encourages citizen involvement. Two institutions have been proposed in California, one a university-based institute to focus on telecommunications and information policies and the other a department of state government with similar operational responsibilities. Neither of these types of institutions is inherently open, so some creativity must be exercised in defining their structures and connections to the press and other organs of public intelligence.

Finally, and most definitively, steps are being taken to involve citizens in the ongoing development of technology policies. My chairwoman has taken it upon herself to set up a statewide network of correspondents whom we will educate in the basics of technological (essentially regulatory) issues, who can catalyze citizen action at the grassroots. One way to coordinate this network is through the use of rapid and interactive computer communications. It is one of the pleasant harmonies of work in our jurisdictional area -- telecommunications and information policy -- that the technology about which we are concerned is also the best means for refining and elaborating on that concern A very advanced, interactive computer bulletin board, "The Capitol Connection," now collects, displays, and distributes information and citizens' opinions about pending legislation and related technology topics.

Should the experiment prove successful, the Legislature may eventually run a number of interactive public-access systems through which legislators and citizens can come together electronically, to discuss issues that matter to both. We can put technology to use in the discourse on technology, which will be a nicely recursive process. Lest anyone think that we are encouraging "have" and "have-not" divisions in society, a bill now progressing through the legislative process will provide every public library in the state with the computer and telecommunications resources necessary for the libraries to become "gateways" for noncomputerists. By stressing the democratic possibilities inherent in this technology, we stand a better chance of fomenting democratic applications of the technology.

I've said relatively little about how one defines issues in a way that they lend themselves to public debate. Perhaps it's because I don't believe it is incumbent on a policy elite to impose "understanding" on the masses. On the other hand, it would be useful if we could distill the remarkable outpouring of methods for learning presented at this and similar conferences into a pedagogy appropriate to the study of technology-policy issues. Citizens should be involved in this effort, drawing on their own experience and emotions. Scholars and a more conscientious press (itself beter informed) can help the citizens by resonating to the citizens' discoveries.

If I have scuttled around the central issue, how to make the policy arena more stimulative of technological understanding, it's because we in California are only part-way through our own learning process. Each two-year session, the Legislature becomes more adept at making technology-policy issues accessible to legislators and citizens. Several legislative policy committees, after the euphoric but unsustainable policy renaissance of the Sixties and Seventies, are settling down to the hard business of educating a generally uninformed and apathetic public about technology issues, with good results (particularly in the toxic wastes and nuclear-power areas). In our own area of utility regulation, we have been similarly successful: this year the California chapter of the American Association of Retired Persons (AARP), one of the more vocal advocacy organizations, declared itself firmly behind a controversial bill regarding the pricing of telephone service. In the process AARP members have demonstrated a fairly sophisticated understanding of contemporary telephony, in all its complexity. But we're only at the beginning.

Legislators in the past did not seek public understanding; in fact, they shunned it, preferring controversies known to those a better-informed public might provoke. If, however, legislators' fear of popular skepticism and cynicism is breeding a new appreciation for public awareness and participation -- and I think it is -- then technological understanding may assume new prominence as a vital element of policymaking.*

* Openness must be gaining currency, because this year, for the first time in its history, the California Public Utilities Commission, long considered one of the unassailable bastions of technocracy, released its first "Work Access Plan." The CPUC claims this plan will open the commission to greater public scrutiny and involvement with its regulatory machinery. At least openness is now on the CPUC's agenda.

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Bull. Sci. Tech. Soc., Vol. 7, pp. 347-356, 1987. Printed in the USA.
0270-4676/87

SCIENCE LITERACY NEEDS OF PUBLIC INVOLVEMENT PROGRAMS (1)

Sheldon J. Reaven

Introduction

A rapidly growing number of federal and state agencies that deal with "science, technology, and society" (STS) problems maintain or are developing far-reaching public involvement programs (PIP's).[2] At many stages of the relevant regulatory or decision process, these programs place citizens on advisory panels or in continuing workshops and seek to encourage public participation in hearings, community issues forums, and other "outreach" or "consultation and cooperation" activities. The idea is to provide "meaningful input" (a phrase that, in practice, can mean almost anything) to the major policy decisions of the agencies. Motives for establishing PIP's vary: a need to comply with laws requiring PIP's; a recognition that the public is more likely to endorse, or at least accept, controversial policies if they are arrived at fairly and openly; a desire to prevent lawsuits and regulatory deadlock by addressing the concerns of interest groups sooner rather than later; and a genuine conviction that valuable scientific and nonscientific contributions from citizens make for better policy decisions.

Whatever the motive, the agencies and participants recognize that PIP's place unprecedented "science literacy" demands on everyone involved. Citizens are charged with hearing and dissec-

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1This material is partly based upon a project supported by the National Science Foundation under Grant No. R11-8419118. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author and do not necessarily reflect the views of the National Science Foundation or others on the project study team, which includes E. W. Colglazier, Jr., D. L. Dungan, and M.R. English, of the Waste Management Research and Education Institute at the University of Tennessee, J. J. Stucker of Carter Goble Associates, and the author.

2Among the more interesting PIP's are those sponsored by the US Tennessee Valley Authority, US Bonneville Power Administration, US Department of Energy Office of Civilian Radioactive Waste Management, and the New York State Department of Environmental Conservation. Some recent attempts at "negotiated rulemaking" (e.g., on the part of the US Environmental Protection Agency and the US Nuclear Regulatory Commission) also have included public involvement components.

ting a massive amount of typically conflicting expert testimony and technical reports, studying the pros and cons of the policies at issue, and rendering reasoned opinions to the sponsoring agency. In the Bonneville Power Administration's PIP, for instance, citizens play a significant role in selecting, evaluating, and criticizing the scientific theories and analytical methodologies used to set electricity rates, forecast electricity demand, and estimate nuclear power risks, as well as in determining which policy alternatives best seem to satisfy community interests and values.

Most participants in PIP's are bewildered at the outset -- by the relevant science and technology *per se*, by the welter of conflicting assertions of environmental, industry, and government groups on technical (and non-technical) matters, and by the complexity of the tradeoffs among health and safety, economic, ecological, and moral considerations presented by each policy option. The standard PIP recipe for lessening the bewilderment is "present scientific information".

The standard approach

Let us explore how this approach to science literacy has worked, or failed to work, in the case of PIP's dealing with the management of high-level radioactive waste (HLW) -- "spent" reactor fuel, essentially -- from commercial nuclear power plants. The landmark Nuclear Waste Policy Act of 1982 requires the Department of Energy (DOE) to choose a site for, build, and (by 1998, now delayed until 2003) operate the nation's first[3] underground repository for the permanent disposal of HLW. The site must be in the western United States; by 1986, the candidate sites were narrowed to three, one each in Washington, Nevada, and Texas. After an evaluation made pursuant to the NWPA, DOE also has applied to Congress for permission to construct a Monitored Retrievable Storage (MRS) facility in Tennessee, for short-term storage of spent fuel in preparation for ultimate shipment to the repository. The NWPA sets out a long-term program of public participation and "consultation and cooperation" with states, which have powerful facility veto rights -- only Congress can override them -- that is unprecedented in kind and scope. In the four states mentioned, PIP's have been mounted by DOE and, with state money or broad grants from DOE, by the states themselves.

On the "present scientific information" approach to science literacy, experts first tell PIP participants the basics of what is generally thought to be known about, e.g:

> types of radiation; constituents of spent fuel and their half-lives; capacity of shipping casks; road and rail

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3The second, "eastern" repository envisioned by the NWPA was indefinitely "suspended" by DOE in May, 1986. Congressional critics saw this move as peremptory, politically motivated (to prevent Republican losses in eastern states in the 1986 elections), and in fact illegal. In February, 1987, DOE stated its intention to resume the second repository project if Congress first meets DOE's request for legislation explicitly telling DOE to do so. DOE's actions and the resulting uproar have broken the fragile consensus embodied in the NWPA. National policy on high-level radioactive waste is (once again) in a state of disarray.

shipping accident rates; waste canister construction; generic properties of different geological "host" formations; factors affecting groundwater flow; radiation dosage and cancer

Secondly, estimated technical characteristics of the policy options under discussion are surveyed, e.g.:

presence (and future likelihood of) faults, fractures, or aquifers at proposed sites; chances of accidents or leaks; migration times for radionuclide plumes; cancer risks of leaks; construction costs; impacts on the local environment and economy; lifetime of waste canisters in the face of radiochemical corrosion processes; number of spent fuel shipments

In some cases (thirdly), scientific and engineering uncertainties are identified -- although this has proved to be a touchy matter since scientists often disagree about the degree of uncertainty and about what is and isn't uncertain in the first place. The discussion of uncertainty also may touch upon the nature and reliability of the often controversial analytical tools used to compare or rank candidate sites (multiattribute utility analysis), estimate the chance and consences of accidents (probabilitic risk assessment, or PRA), and minimize cost and logistical difficulties (systems engineering).

PIP's generally (not only those dealing with HLW) have overwhelmingly followed the same scheme: basic science/engineering knowledge, technical characteristics of options, sporadic attention to uncertainties. The material presented is typically referred to as scientific and technical <u>information</u> (perhaps suggesting that it is not open to debate or cross-examination, but is to be imparted in a one-way process from experts to citizens).

Basic flaws in the standard approach

Does this approach meet the science literacy needs of participating citizens? Does it form an adequate basis for subsequent deliberations? Absolutely not. In my experience[4], most participants end up just as bewildered as they felt at the beginning. Yes, they do come to <u>understand</u> the technical claims and arguments cited by each major position on the issue in question -- and this is an important step. But participants are <u>surprised</u> that the technical presentations do not live up to their expectations. Most people come to PIP's with expectations running something like this:

"I know I don't know much about radioactive waste right now. I am bewildered because I am uninformed. The evening news "bites" I have seen don't help -- they show ten seconds of the government saying one thing followed by ten seconds of the Sierra Club saying the opposite. So I am unprepared to <u>judge</u> the claims of the contending parties in this PIP. Fortunately, however, these scien-

4The author has assessed, helped design, and participated in several PIP's (including ones created in response to the NWPA).

tists and engineers know. They'll show me who's right."[5]

Participants tend to express surprise that this expectation of clear, "Mr. Spock"-like answers from scientists and engineers is not met:

"I have lots more information, and I now understand what the experts are saying -- but things seem much more confusing, much harder to get a handle on, than ever. Each expert disagrees with the previous one (and they even disagree as to who really is an expert). They often seem to talk past one another, assessing the scientific questions differently from top to bottom, and highlighting different facets or using different frameworks of analysis even on the same topic. It's hard to sort things out. I'm still bewildered -- it seems that the more I learn about these issues, the less I am sure of, the less I really know."

The unmet science literacy need accordingly is to improve greatly the ability to diagnose expert disagreement over STS issues (and to enhance the citizen's confidence in his or her ability to do so). The "present scientific information" approach helps people understand the content of scientific claims and disputes, without preparing them to judge and evaluate them.

Two difficulties in diagnosing expert disagreement

How can we diagnose this unpreparedness to diagnose expert disagreement? There are two components. The first is difficulty in comparing the positions of each side as a whole, as shown by comments such as

"The environmentalists and the nuclear industry talk past one another, at cross-purposes; each side cites its favored data, theories, analytical tools, and precedents (let alone values and social concerns),[6] and each side presents an apparently reasonable, coherent story. I follow the train of thought of each side, but I can't quite put my finger on what sways me one way or the other. Sometimes I wonder if it's just that one spokesman seems more articulate, competent, or self-assured than another. Each side says its view is scientifically justified and the other's is politically motivated."

The second component is difficulty in evaluating the validity of individual technical claims.

"I don't know how to cross-examine, what questions to ask, concerning expert disagreements on questions like these: is the standard model of carcinogenesis right? is the computer model of geohydrochemistry valid? how can

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5These and similar "quotes" are composites of typical comments made in actual PIP events.

6For details in the case of radioactive waste management, see Colglazier, Dungan, and Reaven, "Value issues and stakeholders' views in radioactive waste management," in M. Wacks, ed., Waste Management '87, 1987.

they be sure that any leaks will be below the regulatory limit 10,000 years from now? how reliable are the probabilistic risk assessments used to estimate the probability that a nuclear waste facilities will suffer a serious accident endangering the public? is the "multiattribute utility analysis" method used to choose the best site for a nuclear waste repository objective, or sufficiently so? does anyone know how likely it is that the climate in the area of the repository will change markedly in 5,000 years? have all factors affecting the rate at which the waste container corrodes underground been considered?"

Solutions for PIP's: first recommendation

How can these science literacy difficulties best be overcome? While solutions are not easy to formulate or carry out, I would contend that science literacy efforts in PIP's (and elsewhere) ought to be directed to three underlying features of expert disagreement on scientific issues[7]. These are (1) the several "argument styles" employed, (2) the strikingly different, implicit notions of the very nature of science and scientific procedure, and (3) the penetration of conceptual and philosophical assumptions within even the apparently most narrowly technical of claims. These three features help citizens sort out expert disagreements (in part because they help explain them). I shall review these features and their lessons for PIP's.

(1) Experts use different argument styles when they seem to argue about the same scientific question. For example, four distinct argument styles can be identified[8] in debates over the need, expected performance, and proper siting of the HLW repository.

(a) Some stakeholders prefer to make their case (be it for or against the claims and decisions of the repository program) primarily in terms of substantive scientific points directly involved in each particular issue. Examples: "the lab tests of waste package corrosion were conducted in an unrealistically high-oxygen environment;" "increasing the temperature is a legitimate way to simulate long-term bahavior of the waste package;" "the site ranking criteria should assign more weight to long-term climatological considerations;" "the facilitators did not follow the technically correct version of multi-attribute analysis;" "the environmental studies failed to discover readily available historical reports of earthquakes in the area;" "the WAPPA and REPRISK models of waste package behavior and radionuclide migration contain the following simplifications;" "the plate-tectonics theory is established beyond reasonable doubt;" "the report does consider all credible regimes of behavior for the bentonite overpack;" etc. This may be referred to as the "topical" argument style.

7 Equally important is the need for PIP participants to better grapple with disagreements over values; this calls for a different approach, and is discussed in Colglazier, Dungan, and Reaven, op. cit.

8On the basis of stakeholder literature, interviews, and workshops; see Colglazier, Dungan, and Reaven, op. cit.

(b) A second, or "procedural," argument style, while still focusing on the particular repository-related technical claims under discussion, emphasizes questions of scientific procedure. Examples: "the state did not have enough time to conduct an adequate peer review;" "this study was never peer reviewed;" "the peer reviewers were biased or improperly chosen;" "alternative, less orthodox scientific theories of the phenomena in question were not given a fair hearing, or were denied research funds;" "the risk analysis is too complex to check out in a reasonable period of time;" "the data was based on poor controls and inadmissable statistical procedures;" etc.

(c) A third, or "analogical," style relies on substantive empirical evidence concerning the track record (both successes and failures) of science and engineering in dealing with similar problems in other areas (non-NWPA high-level waste programs, low-level wastes, nuclear power, chemical wastes, and even strikingly unrelated fields of science and technology). Examples: "the geohydrological model used for WIPP, as is now recognized, failed to take account of the karst geology, so how can we believe DOE's claim that, say, the Richton Dome modeling is valid?" "the consultant made a major error in its ranking of sites for the Southeast low-level radwaste compact, so why should be trust the current high-level rankings prepared by another consultant?" "why should we rely on current claims regarding source terms, environmental migration and dispersion, etc., in light of the unexpected plume skipping at Chernobyl, unexpected failure of soils to bind certain radionuclides, unexpected recent discoveries in source term chemistry;" "they were wrong about the Shuttle, about continental drift, and could be wrong about repositories, too;" "the experience of the aircraft industry shows that an excellent quality assurance program can be maintained over decades;" "the National Academy of Sciences has flipflopped four times in its successive reports on chlorofluorocarbons in the atmosphere, yet each time, the conclusions were presented with the same confidence DOE exhibits on the repositories;" "people pooh-poohed the scientific problems in landing on the moon, but the program succeeded in spite of the skeptics." In other words, this argument style concentrates not upon the direct scientific evidence per se but on evidence concerning the success rate and time frames with which technically similar (and dissimilar) scientific and technological fields handle evidence, and theory.

(d) A final, "philosophical," argument style appeals to general theoretical and procedural arguments, that do not depend on the particulars of the repository scientific claim at issue. Examples: "even though this report was peer reviewed, this is not enough, because peer review itself is open to several challenges (e.g., because consensus in science often is the reult not of conclusive evidence but of sociological bandwagon effects);" "studies of expert opinion and risk estimation show that experts often place unwarrantedly high confidence in their claims, overestimating the supporting evidence and underestimating the possibility of surprises;" "science is an error-correcting enterprise, but the time frame for recognizing and correcting mistakes is much longer than that of the NWPA;" "whatever its flaws, reliance on scientific experts is the best guarantee of truth humans have;" "sure it's 'only' a theory, but this is no weakness -- a good, powerful theory is the very goal of each field of science;" etc.

All four styles are used by both supporters and critics of the repository program (furthermore, each argument style can garner strong empirical and theoretical arguments in its favor: none of the styles is irrational or "anti-science").

The styles provide a helpful framework for sorting out a complex debate. By observing what sides use what style on what points, the citizen is better able to track the debate and conduct a challenging cross-examination (e.g., by asking if stakeholder A has a topical reply to stakeholder B's topical claim, and by asking stakeholder B to reply to stakeholder A's procedural claim). Secondly, the citizen is better able to consider whether the arguments presented are of a type and strength appropriate for drawing conclusions or taking action on a given issue. For example, tougher standards of proof would be required when human lives are at stake than when the issue is largely one of dollars. A failure to adequately respond to an analogical argument against building a new hazardous waste facility -- "you said the old facility was safe too, but it leaked, so why should we believe your assurances now?" -- may be accorded greater import than a failure to respond to an analogical argument against building a new city hall -- "you said the fire station would come in under budget, but it incurred big cost overruns, so why should we believe your assurances now concerning the cost of city hall?" Thirdly, an awareness of argument styles helps make it clear that judgments of appropriateness of level or quality of evidence are as much ethical as they are doxastic; so that the proposed framework is one tool for leaving such judgments where they belong, in the hands of citizens. For these reasons, I propose

Recommendation #1: <u>Train citizens to be aware of argument style differences, as an aid in spotting when and how the different sides on an issue talk past one another</u>.

Second recommendation

(2) The second feature of expert technical disagreement is that differing expert assessments of the state of scientific knowledge concerning a given claim -- is it true? has it been adequately tested? have alternative claims been explored and ruled out? is the expert's confidence in the claim justified? can we expect definitive answers soon? -- are often underlain by differing views of the nature of science.

One view assumes that, on the whole, at least in the fields relevant to geologic HLW disposal, (a) science produces answers and reduces uncertainties, (b) consensus is normal and desirable in science, (c) peer review and other self-regulatory mechanisms are adequate, (d) science is mainly driven by evidence (facts, data), which can be clearly distinguished from theories, and (e) scientific knowledge is established on a relatively fast time scale (e.g., fast enought to <u>demonstrate</u>, in time for the repository to open on schedule, reasonable sssurance that it will meet the regulatory criteria).

A second view of science holds that: (a) scientific research generates as many questions as answers (so that we should expect significant surprises in the repository testing and research program), (b) pluralism of theories, research programs, and methods is normal and desirable in good science (so that consensus may be a sign of hasty thinking or of bandwagon effects), (c) peer review is too prone to political manipulation and scientific orthodoxy, (d) science is primarily driven by theory and assumptions, which also affect the selection, nature, and interpretation of evidence, and (e) science proceeds more slowly than (e.g.) the repository program appears to asssume, judging from its confidence that remaining scientific uncertainties will be "resolved" within a decade.

PIP participants (and many technical people) are unaware that such wholly different understandings of the scientific process are possible, much less of how they influence assessments of specific scientific questions facing the PIP. Yet (along with the argument styles) these understandings affect one's view as to what claims (or what scientists) are credible, the scope and significance of scientific and engineering uncertainties, and the prospects for resolving them satisfactorily.

Recommendation #2: Teach citizens to be aware of the wide range of views on the nature of science, and how they affect the evaluation of technical claims.

Third recommendation

(3) Many disagreements on individual scientific issues (even seemingly narrowly technical ones) have, at bottom, a large conceptual or philosophical, component.

Consider first the debate over the relation between prolonged exposure to low levels of radiation and cancer in humans. A great deal of the division among experts on this question comes down to certain underlying conceptual dilemmas. Most importantly,these persistent, perennial "idea" problems can be detected and understood not only by nonspecialists, but by citizens without technical backgrounds generally.

For example, one conceptual "theme" runn[illegible] through the low-level-radiation-and-cancer debate is "they're [illegible]ally arguing about similarity" -- between species (in extrapolating from animal experiments to humans), or among bodily organs (in extrapolating from whole body doses to doses to specific organs), or in molecular-biological mechanisms (in extrapolating from the effect of one dose to that of another), or among the diseases grouped under the name "cancer" (in extrapolating from one kind of "cancer" to another). The same fundamentally conceptual questions arise in each case: how similar is X to Y? can similarity be measured on a scale? how much similarity is needed to justify the extrapolation? how much dissimilarity in degree does it take to amount to a dissimilarity in kind? One can appreciate this textural feature of the debate without detailed knowledge of the relevant technical fields. One can also see why definitive answers to the conceptual questions may be unavailable (e.g., because similarity is in the eye of the beholder), so that subjective, meta-scientific judgments are intrinsic to scientific thinking[9] -- contrary to the "Mr. Spock" image of science.

9Even subtle problems in interpreting (often seemingly contradictory) statistics can be appreciated by an audience that knows that different studies often suggest counterintuitive, even paradoxical conclusions (e.g., Simpson's paradox, intransitivity paradoxes), that knows that conceptual differences underlie

The question of the risk of radioactive leaks from repositories offers another example of the role of concepts in technical uncertainty. Here the theme is "there is fundamental diagreement about the legitimate scope of application and very meaning of probability concepts." Repository risks are being analyzed in probabilistic risk assessments that rely on complex theoretical models (since purely empirical results cannot be obtained without running hundreds of experiments for thousands of years). This approach involves several conceptual assumptions -- e.g.: that a theory (say of plume migration) can be said to possess a probability of being true in the same way that an event (getting snake-eyes with dice) has a probability of occurring; that one can tell when "most" of the scenarios resulting in leaks have been assayed in the "fault tree" format used?; that Bayesian approaches are legitimate; that the extensive, acknowledged use of subjective probability judgments made by experts (perhaps supplemented by expert opinion pooling techniques) in probabilistic risk assessments can be countenanced; that problems involving the quantification of uncertainties, human error probabilities, and "common mode" failures can be solved[10].

Stakeholder positions on these risks also reflect argument styles (for instance, "analogical" arguments over the lessons to be drawn from Chernobyl, or from the history of probabilistic risk assessments of nuclear power plants), and presuppositions about the nature of science (for instance, in judging whether DOE be able to resolve outstanding uncertainties within the time frames envisioned in the NWPA).

Many of these conceptual or philosophical components of disagreements on individual scientific issues can be brought out (without being pursued in depth) -- in science literacy mini-courses specially designed for PIP's. The idea is to prepare participants to detect, to "pick up on," the presence of such underlying components. The mini-courses would take advantage of the fortuitous circumstance that the conceptual components (a) can usually be explained and understood in essentially non-technical terms, yet (b) get to the heart of many ostensibly arcane technical disagreements. Inasmuch as many of the conceptual problems may not have a "right" solution, such mini-courses also would help citizens see when (and why) not to expect technical disagreeements

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questions about the meaningfulness and appropriateness of using one statistical tool (regression method, significance test) rather than another, that knows that it is very hard to identify causal mechanisms and distinguish them from spurious correlations, that knows that confounding factors can be cited even in the most rigorously controlled experiments, etc. For examples, see M. DeGroot, S. Fienberg, and J. Kadane, eds., Statistics and the Law, Wiley, New York, 1986.

10For details, see S. Reaven, "The reliability of individual and pooled expert judgments," in L. Lave, ed., Uncertainty in Risk Assessment and Risk Management, Plenum Press, 1986, and S. Reaven, "The methodology of probabilistic risk assessment: completeness, subjective probabilities, and the 'Lewis Report'," in Explorations in Knowledge, Summer, 1987.

to be resolved by data or experiments. Such courses (incorporating recommendations #1 and #2) also would sharpen participant skills in asking penetrating questions of expert witnesses and in critiquing technical reports.[11]. Accordingly, I urge

Recommendation #3: PIP's should develop intensive, science-literacy mini-courses, focused on the "idea" assumptions behind the main technical claims, as an aid to sharpening the evaluation skills of participants.

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11The author has designed and taught science literacy mini-courses embodying these approaches, using case studies of problems facing PIP's, to a variety of audiences. For details, see S. Reaven, "Using science and technology news issues to develop scientific and quantitative literacy," to appear in Proceedings of 4th International Conference on Science and Technology Education, Kiel, W. Germany, August, 1987. Leads to other short courses that may employ similar approaches should be sought in the pages of STS Newsletter, New Liberal Arts Newsletter, and other "clearinghouse" publications in the STS area.

Bull. Sci. Tech. Soc., Vol. 7, pp. 357-366, 1987. Printed in the USA.
0270-4676/87

A TECHNOLOGICAL LITERAC ' CREDO

Leonard J. Waks

The movement for technological literacy and STS education is coming of age. Rustum Roy (1984) noted that STS was "the fastest growing subject matter field" in the United States, having "sprung up spontaneously in dozens of places." Jon Harkness notes (this issue) that the STS programs discovered by NSTA in their "Search for Excellence in Science Education" just five years ago had developed spontaneously in response to local needs and values. The winning teachers didn't even know they were doing STS. John Roeder (also this issue) states "I started teaching one-year STS courses before I even knew what they were." This period of spontaneous development is over. As this issue of the Bulletin of Science, Technology and Society demonstrates, STS is rapidly becoming an established field of teaching and research, with an active and clearly identified community at both school and college levels.

What is the role of STS in the national technological literacy effort? I noted last year (Waks, 1986) that "technological literacy" was a slogan, which has made it possible "to unite disparate groups around common themes," but that there were

> competing definitions of technological literacy, reflecting different values and needs, and promoting different knowledge, skills and attitudes, as well as different forms, processes, and content for education.

The use of a common slogan was to be encouraged, I held, "so long as the different values and proposed educational programs can eventually be brought to the surface and criticized."

The time has come for the STS community to begin debating our values and programmatic emphases. Only in this way can our field continue to develop. To advance this dialogue I am here putting forth my own "credo," consisting of twenty-two propositions for discussion. The credo is an effort to make connections of three sorts:

(a) between STS and three living traditions in American secondary and collegiate educational theory, the liberal arts (Adler, 1982), the progressive (Dewey, 1900, 1916; Kilpatrick, 1918; Dennis and Eaton, eds., 1980), and the convivial traditions (Reimer 1971; Illich, 1971, 1974; Holt 1976);

(b) between STS education and such current educational policy initiatives as community-based, citizenship, environmental and global education;

(c) between STS and forces working toward a convivial values framework -- emphasizing less materialistic, more communal, ecological, and spiritual values -- appropriate for "post-industrial" society (Illich, 1974; Hawken, et al., 1982; Waks and Roy, 1987).

I. Technological Literacy

1. Technological literacy is a practicable goal of secondary education for all students.

Technological literacy -- possession of basic concepts and skills to participate in the technology dominated economy and understand technology-dominated social issues and participate meaningfully in their resolution -- is within the grasp of all undamaged youth of secondary school leaving age.

Scientific literacy is a stronger concept, with additional science knowledge and skill requirements (Shamos, 1984). Educational leaders have not made a commitment to develop scientific literacy, in any robust sense, for all secondary graduates, or even those bound for college. While technological literacy is essential to the functioning of our democratic institutions and our modern economy, scientific literacy for all -- insofar as this extends beyond technological literacy -- may not be appropriate or even possible to achieve in our society.

2. Technological literacy is a pre-requisite of liberty and equality in a technology-dominated age.

The most important labor processes and social issues of our age are dominated by technological factors. Those without the background knowledge and skills to enter the workforce, and to understand these social issues and their modes of resolution, have lost their equal right to participate in our democratic society.

3. The least advantaged groups have the greatest need for technological literacy.

In every choice between technical alternatives there will be trade-offs between costs and benefits. Those groups with the least social and economic power, and those unable to attend vigilantly to the issues and bring forth their own scientific and technological experts to represent their interests in the policy-making process, will bear a disproportionate burden of costs. The least powerful groups in our society have the lowest levels of educational attainment, and their disadvantage is greatest in scientific, quantitative, and technical subjects. Society's first commitment must be to address this basic inequality. All schemes for promoting technological literacy must be judged initially by their probable impact on the least powerful groups in our society. As these groups are concentrated in the core districts of our major cities, efforts to promote technological literacy there must be accorded highest priority. These efforts may require radical revision of curriculum content (see proposition 19).

II. Technological Literacy and STS Education

4. STS education is one among many vehicles for promoting technological literacy.

STS education is only one among several possible means for promoting technological literacy. Others include other forms of technology study in formal education, print and non-print media intended for home consumption, special training activities in the workplace, field trips and other activities sponsored by municipalities and public interest groups. Because technological literacy is vital to economic and political participation in democratic society in a technological age, public educational institutions are appropriate vehicles for promoting it. Whether or not they are effective vehicles, or the most effective, remains an open question.

5. STS and "new liberal arts" technological literacy efforts, though different in emphasis, may be complementary.

The interpretation of the term "technological literacy" has depended upon current social goals and values. The first wave of concern about the impact of technology was focused on harmful social and environmental effects of large-scale technological systems such as nuclear power. STS education emerged along with environmental education, to promote citizen awareness and responsibility. Literacy implied the ability to grasp, and to participate in, technologically dominated social issues.

A second wave of technology studies emerged in the 1980's fueled by the fear that the United States was losing its "competitive edge" in technology. The report "A Nation at Risk" identified technology as a "new basic" for the schools. The Sloan Foundation promoted technology and quantification in the college curriculum as "new liberal arts." Literacy in this context meant the background knowledge and skill to engage productively in rapidly changing, technologically dominated work in industrial or defense-related settings.

As the 1980's draw to a close, a synthesis of these initially antithetical waves may be forming. STS remains focused on responsible social action, NLA efforts on technology content and quantitative skills . However, each now incorporates some of the other's agenda.

6. The goals of STS education are to promote awareness of, and citizen action to resolve, technologically dominated issues, and the methods must be shaped to achieve these goals.

Waks and Prakash (1985) distinguished education for social responsibility, fundamental to STS, from three potential STS counterfeits: technical, academic-rational, and personal conceptions. Rubba (1985) developed a four-level goal hierarchy for STS education: foundational concepts, awareness of STS issues, STS issue investigation skills, and STS social action skills. Rubba has found that while most current STS science teaching is focused at the lower end of the hierarchy, specific training in issue investigation and social action is needed to promote these goals.

7. STS may enter education at elementary, secondary, college and adult levels, in any subject matter field.

Within its overall goal structure, the methods and objectives of STS at various levels, and in various disciplines, will differ. STS belongs to no discipline, but can be shaped as a curriculum emphasis in any. Science, technology, social science, math, English and language arts, area studies, can all spawn unique STS approaches (Science through STS, Social Studies through STS, etc.) Principles, methods, and objectives of these will be shaped by those of the adopting discipline.

Further conceptual clarification of the objectives and methods appropriate for these levels and disciplines is needed, as is research on the effectiveness of STS. The best entry points for promoting the distinct goals of STS are not yet known.

8. When STS enters the curriculum as a component of secondary or collegiate general education, it must be evaluated in terms of the liberal goals of general education.

When STS enters secondary and college education as a component of general education, it must advance not just its specific goals but the liberal ends implicit in all general education. These are (a) general knowledge of concepts and ideas, (b) intellectual skills in critical thinking, reading, writing, public speaking, problem solving, and group leadership, and (c) the understanding of ideas and values (Adler, 1982).

9. Methods and Materials in STS education must be chosen to serve both specific STS and general education goals.

Didactic methods promote the acquisition of conceptual frameworks, supervisory methods (coaching with feedback) promote the learning of intellectual skills, and seminar discussions of individual works and position statements promote the deeper understanding of ideas and values, awareness of one's own evolving ideas and values, and skills and attitudes of critical thinking.

Didactic instruction in lecture form is supported by good didactic instructional materials, including textbooks, text-like pamphlets, programmed learning modules, instructional videos, and computer assisted tutorials.

Supervisory sessions require carefully constructed problems, projects, and activities which are practicable for both learners and teachers. While these include textbook-like problem sets, they should emphasize less structured problems and activities, more like those enountered in the "real world," among which are divergent problems where each "solution" will reflect the individuality of the learner (e.g. solutions to design problems.) Where possible, student-directed learning activities involving social action in community settings should be promoted. Such activities can be the basis for entire courses, or satisfy "community service" or "independent project" requirements (Boyer, 1983).

Ideas and values are best understood through engagement with individual works and position statements. Seminars can be built around the discussion of such statements on STS issues by representatives of important positions, of sufficient length that the individuals are not reduced to types. Teachers, using the socratic method, ask critical questions about meaning, evidence, and value assumptions, while coaching students in critical thinking skills. These may be supplemented by guest lectures and videos of leaders expressing their viewpoints. Both seminar and project methods are useful in building the students' confidence, and encouraging them to form, advance and defend their own positions on social issues. In much didactic science teaching, there is an authoritative "truth" and a single "right" answer. But in STS, where there is no single "right" answer or obviously "best" approach, students need to learn to listen to, assess, support or reject the positions advanced by others, and formulate positions of their own. Seminars and projects both serve these ends.

10. Student-directed projects should be extensively used in STS education.

However learning is organized, some didactic component usually is needed. However, didactic methods are vastly overused throughout formal education. They are the least expensive, because with students in passive roles, one teacher can manage (take custodial care of) many learners. But in isolation these methods don't promote intellectual or social skills or individual values or responsible citizenship -- all basic to STS.

Because of the specific goals of STS education -- issue investigation and social action skills -- effective STS courses should contain a strong component of project-based learning under student control, with supervisory feedback (Della-Dora and Blanchard eds., 1979). The project method can be effectively combined with learning based in the community (proposition 17).

11. When included in science requirements for general education, Science through STS (S-STS) is best conceived as one among several valid science curriculum emphases -- not as the "best" approach.

S-STS does not compete with other science curriculum approaches, and invidious comparisons with others are not useful. STS is a specific emphasis which must be articulated with other emphases. It should not seek to displace discipline-based science, but rather to find an appropriate place in general science education, within and alongside of discipline-based science.

III. Curriculum Organization for STS in General Education

12. Basic STS courses in secondary school and college, whatever their organizing themes or principles, are composed of STS foundation units and STS topic units.

Basic STS courses will typically be composed of STS foundation units and STS topic units. Foundation units contain concepts and heuristics basic to STS issue awareness, investigation skills, and social action. These units will include concepts and definitions of "science" and "technology," as well as a process model of their relations with other social forces, as both effects and causes. They will also systematically develop such topics as probability, risk, forecasting, computer modeling, policy decision-making, ethics and values, cost-benefit analysis and other forms of technological assessment. These topics, abstractly considered, are fairly sophisticated. A good STS Teachers' Handbook, with careful systematic treatment of these, is sorely needed. However, the basic ideas can frequently be presented clearly, even to quite ordinary students, in the context of specific STS issues, through the use of well chosen, simplified examples. Some of these foundation topics may be covered early in the course and further developed and used in the treatment of STS topics. Others will be covered in foundation lessons and mini-units interspersed throughout the course.

Specific STS topic units may be organzed in many ways, and will frequently be built around major areas of human need or activity involving technical means and innovations (e.g. agriculture, communications), or around specific innovations and pressing technology-dominated social issues (e.g. nuclear power, genetic engineering, AIDS).

13. The assessment of current technological innovations should be balanced with other STS topics.

STS units will frequently focus on decisions currently facing society: e.g: nuclear power, manned space flight, a strategic defense in space, mandatory testing for AIDS. While these topics are "hot," units organized around them tend to take the technology already in place as a given. Value deliberation is focused upon the proposed innovation, blocking re-valuation of fundamental questions about technology: the role it should play in our lives, limits beyond which it thwarts the individual or social good (Winner, 1972; Waks and Roy, 1987).

To avoid this pitfall, STS units featuring (a) retrospective technology assessment (focusing on important historical innovations such as the assembly line or the telephone), (b) alternative or utopian communities which consciously shape or limit technological innovation (e.g. the Amish), and (c) utopian and science fiction thought experiments, should be used to balance those focusing on the assessment of current innovations.

14. STS courses are best organized in a COM (core plus option modules) pattern.

Technological literacy is a practicable goal for all students. Multi-tracking by ability or major is not necessary. Options for remedial support, choices of STS topics, and advanced topics in disciplinary science, quantification, engineering technology and STS can be provided in option modules. A COM pattern (Fujuita et al., 1986) for STS curriculum can promote technological literacy for all learners without multi-tracking, yet with full recognition of the different interests and aptitudes of individual learners (see Fig. 1).

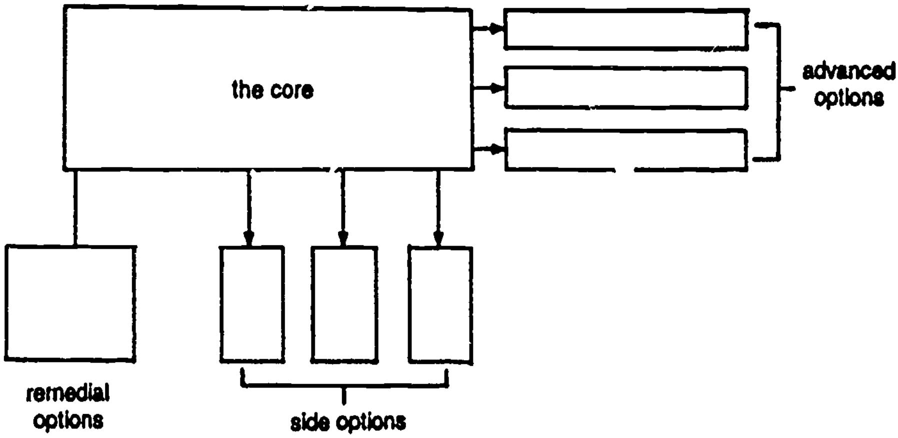

FIGURE 1: A COM PATTERN

Innovations in computerized publishing may soon make it much easier for teachers to design such COM units suited to learners in the geographic region and shaped to accommodate their interests, aptitudes, and knowledge backgrounds.

IV. Curriculum Content for Social Responsibility

15. All components of STS education should support the development of responsible social action.

Although STS must articulate with other components of general education to support liberal educational goals, STS education is primarily aimed at the promotion of responsible citizen participation on technologically dominated issues, and all elements in the curriculum, regardless of other objecties served, should support that end.

16. STS education should concentrate on local and regional issues.

The slogan "think globally, act locally" applies to STS education. Teachers should always keep the "big picture" in mind. Students can learn more effectively and act more responsibly when their understanding is based on first hand experience. Big national and global issues are far removed from the experienced worlds of most 14-20 year olds. But there are STS issues which may be placed in a global context, where the collective experience in a classroom is great, and where enlarged understanding can make a profound difference in student lives. For example, Mary Ann Brearton and C.B. Evans of Baltimore have developed a fascinating STS unit on premature babies. Because low weight babies are frequently born to teenage mothers, inner city students often have first hand experience with this problem.

17. STS education should be community-based.

In all aspects of STS education, but in particular in learning skills and values, the out-of-school community can provide valuable learning resources. Workers, volunteers, public interest activists, personnel from government, business and industry and others can supervise skill learning in real world settings. Representatives of various positions on community issues (e.g. a public relations officer of an industry accused of environmental harm, a member of an enviromental health coalition, a city official) can be invited to classroom seminars to state and debate their positions. Courses can be organized in out-of-school settings, around projects within community organizations, e.g. urban gardens organized by the horticulture society. (See Newmann, 1975; Newmann, et al., 1977.)

Combining community-based learning with self-directed projects can promote STS goals in several ways. Students can:

(a) take responsibility for both their own learning and for beneficial effects in the community;

(b) learn project management skills and exercise will power and self-discipline needed to carry community projects through to completion;

(c) become familiar with the wide range of community resources needed to get things done in "real world" settings;

(d) learn how to communicate with community members to acquire information, and how to report orally and in writing about their findings;

(e) learn to participate with both other students and adult community members in negotiation, investigation, decision-making and social action processes;

(f) learn that commitment, hard work, and effective action with other community members on problems that really matter, are more satisfying than problem avoidance.

18. STS education in schools should be coordinated with adult education efforts directed at parents.

When parents actively support the educational efforts of the schools, the schools do a better job. Technology-related problems affect the community (e.g. job displacement, waste management, water and air quality) and technologically literate adults can participate more effectively in problem resolution. By conducting parallel efforts for school age youth and adults, by combining STS education with an active adult technological literacy program, schools can build community and parent support while helping in the develoment of necessary cognitive and social-political skills.

19. The science content of S-STS should be selected and structured to relate effectively to the interests of specific individuals in their social circumstances.

The laws of nature may everywhere be the same, but the interests of people vary depending on their circumstances. Many science educators see socially relevant STS topics as motivational pegs upon which a study of "real science" may be hung. For example, acid rain is chosen as an STS topic because it is a good vehicle for conveying basic chemistry, ecology, etc. They see this "real science" as ultimately the knowledge which will empower individuals in their lives.

Layton (1986) questions this strategy. The problems faced by citizens, he notes, are "suffused with considerations intrinsic to the social and cultural contexts in which they live" (p. 214). When experts present them with abstract scientific knowledge deemed relevant to their problems, they almost without exception, and irrespective of educational background, reject the knowledge as irrelevant. The scientific knowledge they seek, arising out of their interests and needs, is not in general the knowledge generated by scientific "experts" -- arising of their own quite different and very special interests and needs. Scientific knowledge cannot empower people unless scientific "experts" start by listening to people, and acknowledging the validity of their problem formulations and definitions of their knowledge and information needs. Layton concludes, "if the thirst for science is ever again to become epidemic, then a democratization of science education which takes a greater account of the interests and needs of specific social groups would seem essential" (p. 217).

20. STS education should include training in skills of social and political awareness and effectiveness.

Skills in group relations, group leadership, followership, communications, listening, persuasion, negotiation, conflict management, evaluation of expert opinion, and project management are essential to getting things done. They are the tools of responsible action. Methods in democratic skills training (Benne et al, 1950; Benne, 1967, 1975) should be adapted for use in STS.

V. STS Teachers

21. STS teachers should be models of responsible adulthood in a technological age.

The informed, involved world citizen who "thinks globally and acts locally" is as appropriate an image of leadership for the twenty-first century as the industrial foreman was for the twentieth. The foreman managed the alienated labor of those below him on the authority hierarchy. The new world citizen involves others, inspires by his or her own dedication, manages through motivation rather than coercion, in an organization which is horizontally, not vertically structured. This should be the role model for the teacher in post-industrial society. However, this image should not be idealized, and need not be. The teacher is human, has limits, does not know everything, lives comfortably with his or her own ignorance while striving to overcome its pitfalls in those areas there he or she has taken responsibility.

22. STS teachers, though striving for professional excellence, should not claim a radical monopoly over learning.

STS teachers "work within the system." They understand that mass formal education is a part of the broad social change in the wake of the industrial revolution -- that our schools and colleges are products of the passing industrial age and still contain survivals of its racist, sexist and elitist biases in their hidden inner-workings (e.g. invidious grading, gatekeeping, intelligence testing, multi-tracking).

Ideally, they do not comfort themselves with self-delusions in the face of the many contradictions in the "system." They know that the time has passed when they can style themselves as "subversives," and set themselves apart from other teachers (Postman and Weingartner, 1969). Instead they work cooperatively, across grade level, disciplinary, and ideological lines. They do not fight their destiny, but instead look for and find many opportunities to do good work within the bounds of the evolving American schools and colleges. They seek avenues of professional development and strive for professional excellence.

However, they do not seek professional control of learning in society (Illich, 1971, 1974). They know that people by nature seek to know and to learn. They know that learning is ultimately under the control only of learners -- others can assist but none can learn for another. They know that the hunger for learning and good occasions for learning are both omnipresent despite barriers. They reject the notion that the only legitimate learning is directed by certified teachers in certified schools. They know that assistance is often needed, but they do not think that assisting another in learning is mysterious -- and can be practiced only by those schooled in esoteric arts or occult sciences.

Rather, they know that nothing could be more natural, or more satisfying, to human beings than helping another to learn and to grow. It pleases them that others in society want to share in this work - peers, parents, workers, community members, volunteers. They encourage this, they organize their teaching activities to make it possible, and they lend their authority to knowledge and experience found throughout the community.

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BULLETIN OF SCIENCE, TECHNOLOGY & SOCIETY

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BULLETIN OF
SCIENCE, TECHNOLOGY & SOCIETY

SPECIAL DOUBLE ISSUE ON TECHNOLOGICAL LITERACY

Vol. 7, Nos. 1 and 2 1987

BSTS (1&2) 1-366 (1987)
INDEXED in Current Contents, Sociological Abstracts, Engineering Index and Social Science Citation Index

ISSN 0270-4676
(622)