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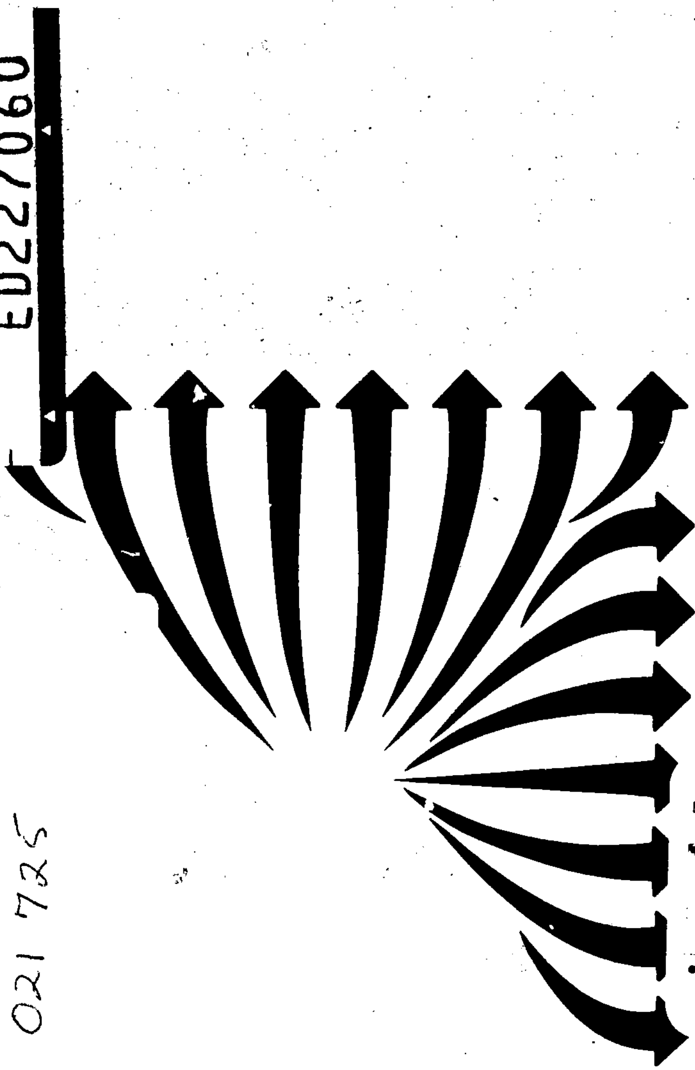
ABSTRACT

This publication considers the broad relationship between technology and education and what it implies for teacher training. Chapters discuss: (1) "Technological Literacy: A New Purpose of General Education;" (2) "The Character of Technological Literacy in General Education;" and (3) "Responses to the Need for Technological Literacy." As seen by the authors, the concept of technological literacy is broader than computer literacy (though the terms are often used interchangeably). Technological literacy is viewed as encompassing the capabilities and applications of the physical and natural sciences as they affect daily lives. A list of 22 references is included. (Authors/CJ)

by Joost Yff and Michael J. Butler



Current Issues

TECHNOLOGICAL LITERACY

CHALLENGE FOR TEACHER EDUCATION

by Joost Yff and Michael J. Butler

ERIC Clearinghouse on Teacher Education

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FOREWORD

In his 1983 State of the Union Address, President Reagan alerted Americans to the need to keep our "technological edge" in the world economic environment. "To do so, we need to begin renewing the basics, starting with our educational system."

The impact of technological development on our quality of life, our economic position in the world, and on our society as a whole is correctly identified as a matter with which educators must be concerned. The degree to which this impact can be controlled and directed in a democracy is dependent upon how broadly among the entire population a level of literacy about technology is held.

Although a commonly accepted definition of "technological literacy" is not yet in place, the idea is being discussed by many in education, industry, and government. The idea is one that is accompanied by some urgency since technological development continues to accelerate. While businesses seek personnel to perform high-tech duties, local school boards struggle with the undersupply of science, mathematics, and industrial arts teachers, and legislators (and people generally) try to cope with an increasingly dense technological environment, educators must develop and offer relevant curricula to meet these needs.

In keeping with the purpose of Clearinghouse "Current Issues" publications, this monograph examines present concerns regarding technological literacy, discusses the literature on the topic, and examines the issue as it relates to teacher education.

JOOST YFF
Director
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Introduction

Scientific discovery and application of its results through technological development are an accelerating synergistic force in modern society. Together, science and technology have spawned an unprecedented growth of knowledge and the development of a whole range of new machines and techniques. Added to a host of pressing needs that the public looks to education to help satisfy, a requirement is now emerging to accommodate these rapid rates of change and the growing complexity of everyday living. Not only is our supply of scientists and technicians of current concern, but so is the public's level of understanding of technology and technically related issues. For it is an understanding of technology that characterizes the informed citizen of a more and more complex world.

This monograph will consider the broad relationship between technology and education and what it implies for teacher training. As seen here, the concept of technological literacy is broader than computer literacy (though the terms are frequently used interchangeably). Technological literacy encompasses the capabilities and applications of computers and computerization, of course, but it also includes the applications of the physical and natural sciences as they affect our daily lives. Joseph Gies clarifies the relationship between science and technology as follows:

> Technology is not to be confused with science. Science is what the universe, macrocosm and

microcosm, consists of--stars, planets, galaxies, cells, atoms, 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. (Gies 1982, p. 17)

In our efforts to control the environment and to improve the quality of life by technological development, we have complicated our existence in numerous ways. For example, our ability to manipulate our physical surroundings results in an Aswan Dam that provides electricity and irrigation water, but at the same time alters the age-old refertilization patterns of the Nile delta and increases the salinity of the eastern Mediterranean Sea. Our efforts to control mosquitoes through the use of DDT achieves its purpose, but it endangers species such as the bald eagle and other wild birds. Our adoption of the private automobile and the interstate highway system speeds transport of individuals and goods, yet increases personal isolation, destroys inner-city neighborhoods, and encourages urban sprawl. Our research into new forms of energy led us to a way to extract electricity from the atom, yet we are stymied by how to invent storage containers for nuclear waste products with a half-life of 3,000 years.

Not the least of the complications that result from our increasingly technological world are the potential for exacerbating the inequities between groups that compose American society, for increasing the disparity between nations, and for increasing the likelihood of self-destruction on a global scale. Technological development has reached the point where our ability to destroy the planet is more certain, and better and more fully analyzed and documented, than our ability to eradicate world hunger, poverty, disease, disaffection, and alienation. With the help of computers, our ability to amass, aggregate, and process information outstrips our ability to comprehend either the multiple uses to which this capability might be applied or the constitutional and policy implications that accompany them. Programs controlling other programs--that in turn control nuclear power stations, weapons systems, and test sites--still suffer from the potential for failure that results from human error.

National concern over how education can be made to respond to the numerous and varying challenges of life in a technologically rich and complex society is the reason for this work. It is a current contention that educators, in addition to handling all of the other factors with which they must deal, are charged with new responsibilities. These are to strive to develop an understanding of the ways in which technology affects lives and to foster the ability to function in an informed, effective manner on the basis of this understanding.

Technological Literacy: A New Purpose of General Education

The question of what is basic to education has been probed on a recurring basis. In 1918, the National Education Association (NEA) Commission on the Reorganization of Secondary Education arrived at a brief but comprehensive list of educational purposes, which have become known as the "Seven Cardinal Principles of Secondary Education." These seven principles are health, command of fundamental processes, worthy home membership, vocational competence, citizenship skills, worthy use of leisure time, and ethical character.

In 1972, the Seven Cardinal Principles were revisited by the Bicentennial Committee of the National Education Association. A group of fifty world leaders was asked to consider the relevance of the principles of 1918 to the year 2001--as they perceived it. The committee's goal was to assess the validity of the principles to educational programs and policies during the last quarter of this century. The panel was charged with the tasks of identifying the characteristics of the future, spelling out the "imperative skills that education should seek to develop," and evaluating the principles within this framework.

The Bicentennial Committee participants agreed that the principles were still "suitable, but the meanings of the goals needed modernizing" (Shane 1978, p. 110). Redefinition of the principles by these leaders in 1972 was marked by a recognition of the need to deal with accelerated rates of change, increased complexity of life, hunger, overpopulation, and domestic inequities. In many cases the new definitions showed a hint of global awareness not found in the original formulation of the principles: in health, the need to extend services to the world's masses; in command of fundamental processes, the need to include cross-cultural insights; in vocational skills, the need to set learning in an ecological context; in citizenship skills, the need to decrease world inequities; in ethical character, the need to improve and preserve the biosphere.

Jack Culbertson (1981) formulated another analysis of the current relevance of earlier prescriptions of education's purposes. Identifying the nation's condition as one of transition between the "descendent industrial" and the "ascendent microelectronic" revolutions, Culbertson used the 1938 prescription from the NEA's Education Policies Commission of four fundamental purposes (self-realization, economic efficiency, civic responsibility, effective human relations) as a framework for constructing a picture of education in the future. Culbertson's focus in this analysis was on the "phenomena of technology and societal values and to some of their contrasting expressions within the industrial and microelectronic revolutions" (Culbertson 1981, p. 14).

Study of Culbertson's analysis leaves the clear impression that education, still guided primarily by the mindset of the industrial revolution, is in need of substantive revision to meet the needs of American society today and in the future. However, this task is complicated by a general lack of agreement on the purpose of education, according to Culbertson.

> ... education finds itself in transition and in between the ascendent microelectronic and descendent industrial revolutions. Because education is in-between, its purposes are ambiguously linked to both revolutions, and a

growing number of leaders and scholars are pointing to the need for greater clarification of purpose. The question is posed as to how those leading schools can effectively help establish priority programs, if education's purposes are unclear or inadequate. (1981, p. 38)

It would appear that both NEA's 1918 Commission on the Reorganization of Secondary Education and its 1938 Education Policies Commission cast purposes of a lasting, generic character that gives them relevance today. However, as educators, our pursuit of those purposes or goals must take into account the changed societal context in which we function and for which education presumably exists.

Technological development, especially of the electronic sort, has brought advances in computer programming and in control systems that store large masses of information and permit highly complex processes to be handled with minimal human effort or intervention. Culbertson and others point out that what the industrial revolution had done to amplify human muscle power the microelectronic revolution is doing to amplify brain power.

While the cardinal principles of 1918 and the four fundamental purposes of 1938 still seem appropriate, we now recognize the importance of keeping up with technological development before our technological creativity outpaces our ability to control and manage its results and consequences.

It is commonly accepted that democratic systems are vibrant and robust only as long as their citizens are both informed and involved. Technology holds out the promise of a better life for all provided that it is intelligently applied. Yet, the complexities resulting from applying technology also raise the level of understanding required to be a basically informed citizen. The danger is that these complexities also threaten to reduce citizen involvement by creating an elite that controls the agencies and processes of public and private life.

Edward Friedman makes a similar statement in The Forum for Liberal Education:

> For me, the most compelling reason for technological literacy is the survival of the democratic process. Daily we read about such matters as information satellites, robotic manufacturing, vast data banks, synthetic fuels, and fusion reactors. How many of us can claim to understand an in-depth newspaper article on these topics? American productivity is lagging intolerably. Judgements 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 zest and intelligence that they require. (1980, p. 2)

Education, as the institution charged with preparing an informed citizenry, has a crucial role to play in preserving a democratic society. Preparing a technologically literate citizenry will come about by studying the applied scientific discoveries and developments that have led to our present condition, and by examining the problems that may and may not be solved by technology. The curriculum must include the study of major social, economic, and geophysical problems that face us today, including nuclear war, pollution, power generation, housing, transportation, communication, conservation, waste disposal, productivity, health, poverty, hunger, and social inequities. Study promoting technological literacy should also encompass computer applications, logic, information systems, systems dynamics, industrial processes, government, politics, democratic values, and the history of humankind.

A curriculum of this kind will result in a citizenry that will be able to address the problems that face it. Course content aimed at technological literacy should enable the public to weigh alternatives and make informed decisions. It should enable them to manage their lives and cope with change to their best advantage. Finally, and most important, it should enable these citizens to recognize when others, to whom they have entrusted the management of their social institutions, are not acting in their interests. Our democratic government empowers citizens with the right to effect change. Education of a literate population, as it is defined here, will empower citizens to make these changes in an informed and effective manner.

Looking squarely at the democracy-technology issue, Milton Shamos lays out the minimum benefit society will win if it develops a large, technologically literate population:

> The technological literate would at least be conversant with the technical bases of such issues as nuclear power, environmental pollution, genetic engineering, robotics and the like, and hence would not be easily misled by demagogues or incompetent reporters. (1982, p. 5)

A recent statement from Gordon Bowden takes up the challenge:

> If we as a nation are to retain influence over our destiny, rather than become hapless victims of our own ignorance and the mystique with which we have surrounded science and technology, we must gain a better common understanding of these disciplines... . Today, we are poorly prepared to make the political, economic, and social decisions that science and technology present to and impose on us. (1982, p. 5)

Noting that the public's current negative attitudes toward learning act as a source of major difficulty for educators, Bowden calls for improved teaching standards, clear goals, and individual discipline:

> To improve the general public's understanding and appreciation of science and technology requires that we address a more fundamental problem: how to change the prevailing attitude toward learning and toward science and technology as unappealing fields of study. Beyond lies the challenge of determining what a minimal understanding in these fields should consist of, for the public and for the student in the elementary and secondary schools. Ultimately, this means making it clear to the public that science and technology are not villains, but rather our <u>use</u> of them in our personal, communal, and national lives may be. If this is understood and widely accepted, we will have taken a major step toward scientific and technological literacy. (1982, p. 6)

Hence, the attitudes of teachers and teacher educators toward science and technology, learning, and the mission of schools in today's new world need to change. The public, too, must be brought to recognize the importance of technological literacy for its citizens. In urging major change in national and local educational policy, Bowden observes:

> Literacy in science and technology is necessary to the extent that they have become embedded in the social, economic, and political fabric of our society. The need is further reinforced by the increased degree to which science and technology have permeated other developed nations with whom we have complex relations and interdependencies. Cultural attitudes toward learning in these countries may give them an advantage, but the attitudes of educators toward science and technology are critical in the achievement of greater literacy

> in these fields in any nation. To change the attitudes of educators in the United States requires first changing public attitudes toward learning standards, student responsibility for learning, and the importance of fundamental skills and knowledge. Such cultural reform depends on adjustments in both national and local educational policy and practice, and their vigorous promotion through new programs by the mass media. (1982, p. 8)

The Character of Technological Literacy in General Education

Educators contend that technological literacy cannot be achieved by requiring a new, separate course in the elementary, secondary, or postsecondary curriculum of our schools because technology is all pervasive. What must be developed is a new framework for organizing and rationalizing general and liberal education.

The issue raises these questions: What dimensions of a technologically rich society must educators take into account? What does technology mean for the aims of education? Several researchers cast light on the queries. Among them are Louis Iozzi, who deals with the importance of a values dimension in developing decision-making skills; James Botkin, who identifies the kind of learning that most appropriately closes the gap between human and technological growth; and Irving Buchen, who advocates a futures-basics curriculum. Shane and Culbertson's analyses of educational aims also tie in closely to how educators must face up to a rapidly changing, technically oriented world.

Iozzi stresses the importance of a values dimension in developing decision-making skills for the future. In his view students should develop the ability to handle "should we" as well as "can we" questions. The reason for developing such decision-making ability, he asserts, is that the knowledge explosion and accelerating rates of change have rendered education, as a process of teaching fact and transferring information, obsolete.

> ... we must develop in our youth skills that are generalizable, highly flexible, and enduring; we must emphasize the development of what I consider to be skills which are at least as basic as any of those proposed to date. These basic skills, I submit, are problem solving, decision-making, and a variety of analytical and critical thinking skills. (Iozzi 1980, p. 552)

Iozzi argues that, in developing these skills, students must become and remain aware of the ethical and moral consequences of their actions if the quality of humaneness is to be important as a force in the future. He draws from research on cognitive development, logical reasoning, moral and ethical reasoning, and social role-taking to develop the "socio-scientific reasoning model." The model has been applied to the development of teaching materials designed to raise the thinking and reasoning abilities of secondary students. It takes into account how technology, ethics, and social consequence interact in future decision making and the need for education to cultivate this capability at increasing levels of complexity.

Friedman, in arguing that technological studies are fundamental to a truly liberal education, is stirring the traditional liberal arts community to address the question of why technological literacy is an important outcome of liberal studies. Friedman suggests that those who perceive technology as inconsistent with humanistic values should view technological literacy as a way to prepare for battle. "Knowing the enemy in order to be better prepared" has value in liberal studies. Those who perceive technological studies as foreign to the content base of liberal studies should realize that technological subject matter has "intrinsic merit" worthy of respect by the community of scholars.

I contend that a review of technological literacy courses, especially those developed by historians of technology, allows colleges the opportunity to keep a strong foothold in traditional humanities while meeting pressures from students and governing boards for education that relates better to the world around us. (1980, p. 2)

Another slant on what education can and must do comes from Botkin in a synopsis of a report to The Club of Rome. Viewing education in a world context, Botkin evaluates "conventional schooling" as a "huge enterprise" that has totally failed its mission. The disparity between growing complexity and our capacity to cope with it is labelled by Botkin as the "human gap" because both phenomena are of our own making. Both the growing complexity and our current inability to prepare to deal with it are products of human activity.

Conventional schooling is, at best, "maintenance learning," which, whether by design or default, does little more than perpetuate our current condition. Botkin suggests that we must push beyond this level to one of "innovative learning"--the type that brings "change, renewal, restructuring, and problem reformulation" (1980, p. 530).

> We do not assert that innovative learning _by itself_ will solve any of the pressing issues. What we do assert is that _innovative learning is a necessary means of preparing individuals and societies to act in concert in new situations_, especially those that have been, and continue to be, created by humanity itself. (pp. 530-31)

Innovative learning is defined in the Club of Rome report as having two dimensions: _anticipation_, which is the ability to deal with new situations, and _participation_, which is the ability to cooperate with others and to partake in decision-making processes in local, national, and global arenas.

Botkin notes that a basic part of the right to effectively participate in the social contract of the coming century must be a realization of the responsibility that this right imposes. If this is to be an age of rights rather than of license, demands for rights must be balanced by the fulfillment of obligations. He explains the concept in more depth:

> Learning, if directed more towards enhancing individual and societal anticipation and participation, will be an indispensable prerequisite in preparing humanity for its own future. This is a positive sign, for it indicates that human potential can be guided towards improving the human condition. Thus we conclude on a note of optimism: for all practical purposes, there seem to be no limits to learning--even though in a theoretical sense some absolute limits surely must exist. But the optimism must be tempered by caution. While the theoretical limits, if any, to human potential do not seem to come into question presently, there is still a very real question whether innovative learning will be allowed to play the role it could and should. (1980, p. 535)

Buchen advances a different concept of what is basic in light of current and future scientific and technological development, in which he calls for an "adaptability curriculum for an uncertain future" (1980, p. 380). He identifies five developmental trends. The first--and most pervasive--he identifies as uncertainty. The other four are: emergence of an "incredible" information society, emphasis on quantification to the point where numeracy becomes the only definition of literacy, increase in the amount and complexity of institutions and systems, and development of technology toward complete man-machine systems.

Earl Joseph also treats the notion of man-machine systems or, as he prefers to term them, "human amplifier" systems. He details and projects into the near future some of the "people amplifier appliances" that will produce "new cultures or ethnic groups" composed of "amplified humans and smart communicating and cooperating machines" (1981, p. 28). Joseph attributes "ethnotronics," the name for this area of study, to the University of Minnesota's Arthur Harkins. Ethnotronics, according to Joseph, is most aptly described as "the science of the relationships that humans and society have with inorganic systems which amplify their mutual capacity for learning, reasoning, decisioning, accessing information and knowledge, and communication." (1981, p. 27)

Buchen identifies a road block to the attitude shift needed to foster technological literacy in the schools. The technophobia that characterizes the attitude of humanities faculties is in direct conflict with the technocratic tendency of members of science faculties. Buchen identifies this conflict as a thorny educational problem and suggests a framework for appropriate curricula. Labeling the "back to basics movement" as too timid, he advocates "futures basics."

> (Back to basics) stopped short of what it should have advocated--what I call futures basics. My rationale for including these futures-oriented basics as part of Curriculum 2000 is the notion of leap-frogging, while we are catching up let us try to leap ahead... . What I am proposing by future basics is implementable without dispossessing or dislodging any substantial portion of the current curriculum. In other words, what I am proposing is an overlay of different kinds of organizing principles over existing content--in short, a series of process disciplines, which are durable, flexible and transferable. (1980, pp. 388-89)

The assurance that the "futures basics" notion can be put in place without an upheaval of the current curriculum is attractive. For that reason--as well as the apparent validity of "futures basics" to technological change--the concept seems worthy of consideration in developing teacher education's response to the need for technological literacy.

As noted earlier, scientific and technological literacy are often confused. Morris Shamos helps to differentiate these concepts and to explain how technological literacy is a reasonable objective for liberal education. He suggests that, while true scientific literacy on the part of everyone may be too much to expect (everyone need not be a scientist), literacy in the applications of scientific knowledge (known as technology) are within the reach of the masses. "Most students and the public generally relate more easily to technology than to science simply because of their daily contact with the products of technology" (Shamos 1982, p. 3). In supporting the notion of incorporating general technological literacy into the liberal education sequence, Shamos argues that the purpose in doing so is to reduce fear and suspicion of technology and to enhance feelings of competence to deal with the issues and decisions that arise in a technologically dense society.

> One should know, for example, the meaning of energy and its various forms from which we derive useful work. One should understand how energy can be transformed from one form to another, and to be cognizant of the conservation principles both of matter and of energy so as to be able to distinguish between the plausible and the fanciful when energy questions are at issue. (1982, p. 5)

Shamos identifies additional examples of how technological literacy is manifested in the capabilities of the informed citizen. The examples include the meaning of probability and statistics, the interpretation of graphs, and an understanding of the physical structure of the universe and man-made structures.

> As always, when assessing the vistas of technology, it is better to know its limitations than its prospects. Our technological literate would be aware of this subtle distinction between knowing what can be done and what is beyond reasonable expectation. (1982, p. 5)

In encouraging curriculum development centering on the impact and consequences of technology rather than its specific processes, Wes Face writes:

> I cannot encourage enough the need to look at the various dimensions of technology from a conceptual, generalizable standpoint, rather than from a point of specific study of processes... . What we must turn out is a populace which understands, can have some full appreciation of the impact of technological decisions so that when allowed to participate in making decisions which advance one technology versus another, will do so from a generalizable set of understandings. To expect them to be made from specific understandings is impossible... . They (decisions) will have to be based on philosophical and value loaded issues, and that must be the center of our study of technology, or we will waste enormous amounts of time and energy of ourselves and our students. (1981, p. 61)

Finally, both Shane and Culbertson, in their respective treatments of historical educational purposes in today's world, extracted prescriptions from their analyses. Looking at the "imperative skills" identified by the NEA Committee's panel of 50 leaders, Shane sums up:

> ...emergent educational development, 1976-2001, presumably would help young learners acquire a knowledge of the <u>realities</u> of the present, an awareness of <u>alternative solutions</u>, an understanding of <u>consequences</u> that might accompany these options, development of insights as to wise <u>choices</u>, and help U.S. youth to develop the skills and to acquire the information that are prerequisite to the <u>implementation</u> of examined ideas, policies, and programs. (1978 pp. 109-110)

Culbertson, reflecting on how to prepare school administrators with technological literacy in mind, calls for an "extended leadership adventure." The adventure would be designed "to give technology eyesight and education new meaning and new expression" (1981, p. 39).

Among the "action design elements" that Culbertson suggests are: (1) to make a concerted effort to relate educational purpose and societal change, (2) to revamp preparatory programs to produce technologically literate school administrators, (3) to develop anticipatory learning skill, (4) to examine appropriate adjustments in school structures, and (5) to use electronic media in teaching.

> We have choices to make and developments to undertake, then, which the largest computers and the most advanced artificial intelligence systems produced by the microelectronic revolution cannot handle for us. Only the highest levels of human scholarship, imagination, commitment and leadership can. If this condition fills us with awe, we might remind ourselves of the significance of the processes required and the outcomes projected. The processes, if effective, will bring new excitement and vitality to our field. And those leaders in institutions who produce outcomes in the form of needed post-industrial training and

> inquiry patterns will make a contribution to education, leadership and society of immeasurable short and long range significance. For society's stakes are high as we look ahead, given the dark image of an Orwellian automated state, on the one hand, and the bright image of a more informed, humane and globally oriented democracy, on the other. The tenet that education represents the keystone in the arch of democracy, eloquently articulated by our forefathers, assumes new significance as we move toward the 21st century. So does the recruitment and preparation of those who will lead education toward and into the third millenium. (1981, pp. 49-50)

Both liberal education and general education have long been held out as the most effective ways of assuring society an informed citizenry. The danger of not promoting technological literacy raises the probability of education becoming even more correlated with socioeconomic status (SES) than it now is. Ignoring technological literacy could result in a role for general education of training people to serve the needs of computers. The possible connection between technological literacy and SES is even more likely in the event that the current move toward public support for alternative, nonpublic, schooling services--where more advantaged youth will be trained to join the scientific and technical elite--continues. If successful, such a trend would relegate the public school systems to training "good citizens" from youth of less advantaged families. The likelihood that people would not only be unable to reach the level of an informed citizen through a public general education, but as a consequence, would also thereby lose the opportunity to influence the direction of public general education, would lead to the double disenfranchisement of large portions of the population.

Like Botkin, Culbertson maintains that failure of the schools to respond to the need for general technological literacy makes it likely that participatory democracy, which has been the hallmark of our political system, will cease to exist in any meaningful form. If our system is to survive, he maintains, general and liberal education must include--along with numeracy, literacy, language study, human relations skills, international and multicultural understanding, and artistic appreciation--a comprehensive infusion of technological training.

Stanley Pogrow, analyzing the changing nature of the U.S. work environment, pursues the question of how relevant current curricula are to the emerging environment. Like Botkin and Culbertson, Pogrow warns of the emergence of increased functional illiteracy if education does not change its definition of literacy and adjust its programs accordingly.

> Because work is becoming increasingly technical, those students who acquire only minimal competences (as these are currently defined) will be as functionally illiterate and unemployable in 1990 as are individuals who do not possess such competences today. (1982, p. 610)

To heed Pogrow's warning, massive curricular overhaul is needed. He suggests the following.

> 'Technological relevance' implies a comprehensive restructuring of the curriculum. A technologically relevant curriculum must not only provide the specific skills necessary for effective uses of particular technologies. It must also prepare <u>all</u> students to engage in sophisticated forms of reasoning. This new curriculum must break down the distinctions that now exist between: (1) children who are expected to learn how to think in a mathematical mode and those who are not, (2) 'artistic' activities and 'technical' activities, and (3) the liberal arts and the sciences. Technology is blurring such distinctions. (1982, p. 610)

Responses to the Need for Technological Literacy

The concerns raised about a technologically deficient populace and the broad suggestions for curricular change presented in earlier parts of this work lead naturally to the question of what educators must do to promote technological literacy among themselves and their students. If technological literacy is to receive the attention it needs, it seems that concerted efforts should begin with the training of school personnel. Schools and colleges of education, under mandate to prepare new teachers and to update today's teachers, seem best suited for this role.

Assuming that general technological literacy is important to the survival of our country's democratic system, to maintaining productivity and the economic health of the nation, to enhancing an individual's employability, and to assuring a reasonable quality of life, how does technological literacy actually come about? What, if anything, can or should teacher educators do about it? How do activities aimed at technological literacy get incorporated in teacher education curricula and worked into the continuing professional development plans of our nation's school teachers?

In his discussion of a futures curriculum, Buchen identifies a problem that exists in school-based and higher education faculties--that of a "pervasive technophobia among the humanities and social science faculty, and an embrasive technocracy among the scientific faculty..." (1980, pp. 387-388). Both faculty groups will be required to broaden their views if progress is to be made in establishing a liberally educated, technologically literate population. Buchen wonders:

> ...whether or not this century will yet see the convergence of these two cultures. What is clearly needed is the creation of a new category of technological literacy as minimum knowledge required to be a reasonably educated and civilized human being. (1980, p. 387-88)

Despite the degree to which the attitudes identified by Buchen are operating to the contrary, technology has become a topic of study in some colleges and universities. It is being taught both in science/engineering departments and in humanities divisions. In a recent issue of AGB Reports, Gies writes:

> To the honored list of subjects that make up the traditional liberal arts curriculum--language, literature, history, economics, sociology, mathematics, the physical sciences and the life sciences, art, music, philosophy--a new entry has been added at a growing number of colleges and universities. The new entry, like some of the old ones, comes in a variety of forms, but what it is in one word is technology. (1982, p. 17)

That science and humanities faculties in higher education have begun to consider technological literacy as an important requirement of a liberal education is encouraging. Also, that technology has become identified with the humanities as well as the sciences indicates recognition that developing technological literacy will require the attention of experts from a variety of disciplines.

Because technological literacy is an integral part of liberal education, it also becomes an integral part of teacher education. However, incorporating technological literacy in preservice teacher education programs is complicated by the problem of defining just who "teacher educators" are. Teacher educator can mean anyone in higher education and school systems who has a role in instructing future and working teachers.

Yet, a large segment of higher education faculties hold little, if any, allegiance, interest, or identity with teacher education. College and university faculty who are engaged in the liberal education and content specialty portions of a future teacher's undergraduate program--portions that represent by far the greatest share of undergraduate time--do not think of teacher education or the future direction of schools as their priorities. This means that much needed expertise found in university liberal arts disciplines will not simply and naturally fall into line with schools and colleges of education to help work toward the nation's goal of technological literacy.

In addition, we must take into account how high a priority technological literacy is among education faculty. This group deals with the mechanics and substance of pedagogical training--which now comprises only one-third of a future teacher's undergraduate program. These teacher educators also must contend with the ways in which those elements are improved, controlled, and otherwise affected by various processes, agencies, and organizations. Among recent analyses of primary issues in teacher education, technological literacy did not rank high on the agenda when compared with other, more immediate and pressing concerns (Andrews 1982; Fox 1983; Imig 1982).

Finally, a trend to overemphasize computer literacy complicates the growth of technological literacy among teacher educators and in the curricula of colleges of education. Although the increase in the availability and use of small computers supports the need for computer literacy and may be the most visible aspect of current technological development, we should not rely solely on computer and information technology to improve education.

However important a dimension of general technological literacy that computer literacy may be, it is not enough, given the broader scope of technological literacy.

While cautioning against overreliance on computers, it is important to note that computers do hold promise for increasing the capability of education to deliver. There is now the opportunity to apply the microprocessor, with its remarkable data and information handling capacity, to the instructional process. However, relying simply and passively on the microprocessor to make things right in education, will not in and of itself achieve general technological literacy.

If technological literacy is to become a reality in teacher education, from whence shall come the energy and resources to change current preparation programs? Does the decentralized nature of undergraduate teacher education programs also scatter the responsibility for training technologically literate teachers?

Considering the urgency for technological literacy, who, if not education faculty, will continue to take the responsibility to see that all the components of the teacher education program are integrated, related, synergized, and upgraded? How much can teacher educators shape those portions--the liberal arts and content specialty components--of the undergraduate curriculum over which they now have the least control? Is it in the liberal arts and content specialty components that we would expect technological literacy to be developed? Or is it appropriate to incorporate technological literacy into the professional component? What steps can teacher educators take to begin making technological literacy an integral part of education? The following points are offered as ways in which the production of technologically literate teachers and teacher educators may begin.

1. Education faculties and school development personnel must themselves become and remain technologically literate

Until scientific discoveries in genetic engineering can produce "superfaculty" who can easily keep up with rates of change and the knowledge explosion, teacher educators will suffer. They, more than their predecessors, will continue to find their training to be deficient and their research methods outmoded.

The need for lifelong retraining, as pointed out by Stephen White (1981) and reiterated in a 1982 report from the U.S. Office of Technology Assessment, the rate of scientific and technological change and the rate of faculty turnover are not synchronous. This suggests that the length of the productive life of educators formerly exceeded the cycle of significant change in knowledge since the total accumulation of knowledge was largely controlled by the new knowledge productivity of faculty. As long as faculty changed and grew faster than knowledge, initial training and ongoing research were sufficient. Now, however, as the rate of accumulating information--especially in scientific and technical fields--increases, faculty's ability to keep pace is falling away.

Technological literacy among teacher educators must be widespread if America's profusion of scientific discoveries and technical developments is to become a boon to a growing segment of the general population. Recognizing the school's role in responding to the quality-of-life needs of the nation's entire population, teacher educators must become increasingly alert to the need to develop new preservice teacher education programs. They must remain attuned to their own opportunities for continuing professional development as well as for those of teachers currently employed in schools.

With current conditions of resource scarcity, requests for sabbaticals and other kinds of institutionally financed study for faculty are now getting closer scrutiny. Deans and department heads are expected to show how these plans further the institution's mission and goals. Progress toward technological literacy on the part of faculty will be made when universities recognize that technological literacy for their education faculties is a prerequisite to sound program development and school curriculum improvement.

2. Education faculties must use their internal resources better for both self-development and program development

Schools of education have at their command a number of resources for developing general technological literacy among teachers. These are the faculties of industrial arts, mathematics education, science education, educational technology, and business education. However, in many instances education faculties have considered these areas as relevant only to the training of teachers of these specialties. For example, they have branded industrial arts for industrial arts teachers and mathematics education for mathematics teachers. The potential exists for considerable cooperative effort to respond to the need for research and program development in technological literacy.

3. Education faculties must continue to work within the higher education governance system to enlist the participation of faculties in other fields. They must work toward making technological literacy a requisite of the general undergraduate curriculum

It is essential that teacher educators seek the involvement of faculty outside schools of education to see to it that technological literacy becomes a goal of the undergraduate population at their institutions. Because the general education and content specialty components comprise the largest proportion of the total undergraduate teacher education program, it is here that levels of technological literacy can best be improved. Working in this way not only will promote the education faculty's purpose of furthering technological literacy among student teachers, but also will enrich all liberal education undergraduate programs.

4. Education faculties and staff development personnel must work through state and national forums for recognition of the need for technological literacy and for definition of the nature of technological literacy

While it is true that when technological literacy becomes a program goal for a particular education faculty it falls under the control of that faculty, the fact cannot be ignored that other forces are also at work. How much a part of the program technological literacy becomes also will depend on consideration and action by extra-institutional bodies, including state legislatures, state licensing boards, state departments of education, and regional and national accrediting bodies.

5. Education faculties must help give technological literacy credibility as a field of inquiry

We must recognize that technology and its consequences comprise a field of scholarly study that has stature and credibility equal to other fields in the academic community. By its nature, technological literacy has to be treated as a cross-disciplinary concern. Though the history of science and technical development abounds with examples of how bits and pieces of knowledge from various disciplines came together--either intentionally or serendipitously--to produce new breakthroughs, technological literacy may be jeopardized simply because there is no natural, organizational "home" for it in the traditional university departmental structure. The way in which knowledge historically has been compartmentalized may severely hamper any cross-disciplinary effort such as the development of technological literacy.

Faculty of education, with their strong legacy of treating knowledge in cross-disciplinary ways, can take the lead in developing technological literacy programs for the schools. Establishing a faculty task force to deal with the issues and to develop a plan of action for faculty consideration is a possible first step. Creating centers or institutes for technological literacy may be an effective way to bring together the interests and expertise of faculty from various departments. It can focus energy on developing courses and programs for faculty, devising preservice teacher education curricula, and setting up resources for teachers in the field.

The challenge to teacher education--to create a technologically literate population--is one which, if avoided, will have grave consequences for our nation. As it stands, our system of education is effectively preparing America's population to live and function in 1975. Education is doing a moderately effective job of preparing the public to function in the world of 1980, but without providing students and teachers the skills to live in the technological world of 2000 and beyond, they will be prepared only to live in a world that is no more.

References

Andrews, Theodore E. Current Issues in Teacher Education: A Northeast Perspective. Chelmsford, Mass.: Northeast Regional Exchange, Inc., 1982.

Botkin, James W. "Education and Global Problems: A Note of Cautious Hope." In Needs of Elementary and Secondary Education in the 1980's: A Compendium of Policy Papers, pp. 528-35. Washington, D.C.: Ninety-sixth Congress, Second Session. Subcommittee on Elementary, Secondary, and Vocational Education, Committee on Education and Labor, January 1980. (ERIC Document Reproduction Service No. ED 195 514.)

Bowden, Gordon T. "Becoming a Scientifically Literate Nation." Educational Record 63, 4 (Fall 1982):5-8.

Buchen, Irving H. "Curriculum 2000: Futures Basics." In Needs of Elementary and Secondary Education in the 1980's: A Compendium of Policy Papers, pp. 377-99. Washington, D.C.: Ninety-sixth Congress, Second Session. Subcommittee on Elementary, Secondary, and Vocational Education, Committee on Education and Labor, January 1980. (ERIC Document Reproduction Service No. ED 195 517.)

Culbertson, Jack A. "Moving Education and Its Administration Into the Microelectronic Age." Paper presented at University Council for Educational Administration Career Development Seminar, 19-21 May 1981, Austin, Texas.

Face, Wes. "Technology--Where Are We Going?" In Technology Education Symposium II. Program Theme: Technological Literacy, edited by Lee Smalley, pp. 58-61. Menomonie, Wis.: University of Wisconsin-Stout, 1981. (ERIC Document Reproduction Service No. ED 206 915.)

Fox, G. Thomas, Jr. Challenging How Teachers Are Educated: A Source for Dialogue and Action. Washington, D.C.: American Association of Colleges for Teacher Education and the ERIC Clearinghouse on Teacher Education, 1983. (ERIC Clearinghouse No. SP 021 494.)

Gies, Joseph C. "Technology: A New Liberal Art?" AGB Reports 24, 1 (January/February 1982):17-20. (ERIC No. EJ 259 945.)

Greene, Maxine. "What the Known Demands: A Philosophical Orientation to Teacher Education." In Alternative Perspectives for Program Development and Research in Teacher Education, R & D Report No. 9019, edited by Gary A. Griffin and Hobart Hukill, pp. 5-15. Austin, Tex.: Research and Development Center for Teacher Education, 1981. (ERIC Document Reproduction Service No. ED 202 825.)

Imig, David G. "An Examination of the Teacher Education Scope: An Overview of the Structure and Form of Teacher Education." Paper presented at the Airlee House Conference on Teacher Education and Special Education, 10-11 September 1982, Washington, D.C. (ERIC Clearinghouse No. SP 021 740)

Iozzi, Louis A. "Education for the '80's--And Beyond: The Socio-Scientific Reasoning Model." In Needs of Elementary and Secondary Education in the 1980's: A Compendium of Policy Papers, pp. 549-67. Washington, D.C.: Ninety-sixth Congress, Second Session. Subcommittee on Elementary, Secondary, and Vocational Education, Committee on Education and Labor, January 1980. (ERIC Document Reproduction Service No. ED 180 917.)

Joseph, Earl C. "Computer Futures: Beyond the Next 5 Years." In Technology Education Symposium II. Program Theme: Technological Literacy, edited by Lee Smalley, pp. 26-33. Menomonie, Wis.: University of Wisconsin-Stout, 1981. (ERIC Document Reproduction Service No. ED 206 915.)

Masat, Francis E. Computer Literacy in Higher Education. AAHE-ERIC/Higher Education Research Report No. 6. Washington, DC: American Association for Higher Education, 1981. (ERIC Document Reproduction Service No. ED 214 446.)

Murchland, Bernard. "Technology, Liberal Learning, and Civic Purpose." Liberal Education 68, 4 (Winter 1982):297-309.

National Education Association, Education Policies Commission. The Purposes of Education in American Democracy, Washington, DC: National Education Association, 1938.

Pogrow, Stanley. "On Technological Relevance and the Survival of U.S. Public Schools." Phi Delta Kappan 63, 9 (May 1982): 610-11. (ERIC No. EJ 263 036.)

Shamos, Morris H. "Science for Everyone?" New York University Education Quarterly 13, 4 (Summer 1982):2-10.

Shane, Harold G. "The Future as a Force in Educational Change." Phi Delta Kappan 57, 1 (September 1975):13-15. (ERIC No. EJ 122 527.)

__________. "The Views of 50 Distinguished Citizens and Educators: 1976-2001." In 1999: The World of Tomorrow, edited by Edward Cornish, pp. 105-110. Washington, D.C.: World Future Society, 1978.

U.S. Office of Technology Assessment. Computer-Based National Information Systems: Technology and Public Policy Issues. Washington, D.C.: Ninety-seventh Congress, 1982. (ERIC Document Reproduction Service No. ED 214 500.)

__________. Information Technology and Its Impact on American Education. Washington, D.C.: Ninety-seventh Congress, 1982.

White, Stephen. "The New Liberal Arts." In The New Liberal Arts: An Exchange of Views, edited by James D. Koerner, pp. 1-12. New York: Alfred P. Sloan Foundation, 1981.

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