DOCUMENT RESUME

ED 257 443 IR 011 675

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TITLE Educational Technology: A Critical Perspective.
INSTITUTION ERIC Clearinghouse on Information Resources, Syracuse, N.Y.
SPONS A CY National Inst. of Education (ED), Washington, DC.
REPORT N. IR-68
PUB DATE 84
CONTRACT 400-82-0001
NOTE 65p.
AVAILABLE FROM Information Resources Publications, 030 Huntington Hall, Syracuse University, Syracuse, NY 13210 ($7.95 plus $1.50 shipping and handling).
PUB TYPE Information Analyses - ERIC Information Analysis Products (071)

EDRS PRICE MF01/PC03 Plus Postage.
DESCRIPTORS Curriculum Development; *Economic Factors; Educational Innovation; *Educational Media; *Educational Technology; *Educational Trends; Literature Reviews; *Media Adaptation; Position Papers; *Social Influences; Teacher Education
IDENTIFIERS Social Needs

ABSTRACT

This document reviews writings and studies that raise questions and identify issues about the use of technology in education to help in the development of clear statements of the purposes of educational technology, education, and the needs of society. The collection of ideas, commentary, and discussion reviews a wide range of viewpoints held by both critics and advocates of technology. A variety of views represent the way things are done as well as the tools and machines used in the process. The emphasis is on the context, especially social and economic forces, that shape decisions about technology in education. This review is designed to help the reader frame balanced and constructive responses to technology-related issues and questions, and to encourage initiative in decision-making regarding the adaptation of technology for education. The table of contents and index help identify significant viewpoints represented in the review, and an extensive bibliography is included. (THC)

EDUCATIONAL TECHNOLOGY: A CRITICAL PERSPECTIVE

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by

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1984

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This publication was prepared with funding from the National Institute of Education, U.S. Department of Education under contract no. NIE-400-82-0001. The opinions expressed in this report do not necessarily reflect the positions or policies of NIE or ED.

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PREFACE

Advocates for the use of media and technology in education have been accused of being hucksters and hustlers ever since Comenius published the *Orbis Pictus*. These individuals often displayed characteristics of religious zealots as they attempted to convince teachers, school administrators, and the general public of the extraordinary values of a new instructional material or the latest product of communication technology. Their claims were often more emotional than substantive and the reasoning more logical than rational. These are the innovators of educational practice who are often stymied by satisfaction with the status quo and active resistance to any change that would alter the current flow of teaching and learning.

Claims for the contributions of media and technology in education usually accelerate and reach higher pitches during times of plenty, especially those times when government support seems to encourage acquisition of resources whether they are needed or not, whether they are carefully selected or randomly purchased. The goal seems to be to spend the money while it's there and hope that the claims are true. The launching of the Soviet Sputnick in 1957 inspired the National Defense Education Act (NDEA) of 1958 which included millions of dollars for acquisition of instructional media and technology by the nation's schools. Very little research supported this action but it seemed plausible that more resources and new technologies could advance mathematics and science education and foreign language learning. Few questions were asked during the shopping spree.

After more than a decade of purchasing a variety of tools from the colorful catalogs of the media merchants, the go-go era was over. School budgets were beginning to tighten and the first items to be slashed were usually the instructional materials. Even though scores of research studies had been completed with support from NDEA, the arguments for use of media and technology were not sufficiently compelling to sustain the growth. Not many questions were raised regarding the training which teachers ought to have received so that use of the materials might enhance learning.

Professional educators wondered if they had been on the wrong bandwagon and media specialists began to look for other support as their resource centers began to level off on acquisitions and use. Some of them were even seen wearing badges at conventions which read: "Technology is the Answer! But What Was the Question?"

The doldrums of the mid to late 1970s suddenly gave way to the rush of the microelectronic era which was quickly embraced by schools. Dramatic increases in the number of microcomputers in schools were reported in the early 1980s. Spontaneous meetings of computer users, inservice courses for teachers, and quickly cobbled computer literacy courses for students became the order of the day—all aided and abetted by school administrators, boards of education, and parents. New "hi-tech" terms and techniques began to flow from the schools—electronic mail, networks, videodiscs, and the like came trippingly from the tongue. But there seemed to be no cautions and few detractors.

No one seemed to be asking, "What Was the Question?" Had a collective amnesia gripped the schools of America? The scene began to look like a rerun of the 1960s. Who was going to ring the bell? Who would ask the basic questions? Who would call for technological gradualism?

Robert Holloway is one such person. He has, in his previous writing (1981) called for more thought before moving ahead with new media and technologies. His view is not of the anti-technology Luddite but of the wise inquirer who calls for reason. In this publication Holloway reviews the writings and studies that raise questions and identify issues about the use of technology in education. He properly uses the diffusion of innovation context to conduct his analysis. His concern with the innovators and laggards as dramatis personae in the process helps to view the process of acceptance and rejection of innovations in a systematic fashion. He brings together in this one publication a host of viewpoints which, if heeded, would help educators to make good decisions about media and technology for teaching and learning. Above all, the reader of this monograph should be able to raise the appropriate questions.

Donald P. Ely
Syracuse, New York
August 1984

Purpose

"Scarcely a new invention comes along that someone does not proclaim it the salvation of a free society" (Winner, 1980, p. 122). And, it seems, scarcely a new idea comes along that does not draw criticism. Nowhere is this more evident than in the literature concerning the use of technology in our schools. Applied engineering has made possible many alternative futures. As the decisions become more complex, we must, as Heinich (1983) suggests, become more "sophisticated." To help us develop, implement, and evaluate these alternative futures, clearer statements of the purposes of educational technology, education, and the needs of society are required.

The purpose of the following collection of ideas, commentary, and discussion is to review a wide range of viewpoints held by both critics and advocates of technology. A variety of views of technology are included and represent the way we do things as well as the tools and machines used in the process. The emphasis is on the context, especially social and economic forces, that shapes our decisions about technology in education.

On an average work day, few of the issues discussed here will be urgent concerns. However, issues have a way of being raised without time for preparation, and responses must often be timely and well-framed rather than exhaustive. This review is designed to help the reader frame balanced and constructive responses to technology-related issues and questions, and to encourage initiative in decision-making regarding the adaptation of technology for education. The table of contents and index are designed to help identify significant viewpoints represented in the review.

Perspective

With the introduction of any new idea, time is needed to learn, learning first how to use the idea. In learning to dance, the beginner is stiff, mechanical, unoriginal, and error-prone. The steps blend and movements flow only with practice; gradually, mastering the idea leads to new learning. This cycle is described as a kind of reinvention (Rogers, 1983), knowledge cycle (Rich, 1981), levels of use (Hall & Loucks, 1976), or adaptation (Holloway, 1982), all windows on the process of change.

Problems are typical of change, part of a normal cycle of learning and creation. A fumbling unsureness is to be expected. Those who want the ambiguity removed, the questions answered, will have to wait while others experiment or undertake experimentation themselves. Since the machines and the ways in which they are used are developed outside education, experimentation in an educational setting is essential. This critique advocates a particular kind of experimentation using a grounded or demonstrated theory: the adaptation of technology for learning. Without adaptation, education simply imitates, like a dancing bear in a technological circus.

Defining Technology

Defining the nature of a technology appropriately begins with the physical technology, the equipment itself. Hawkridge (1983) suggests that until very recently, technology "signified materials, tools, systems and techniques" (p. 37). In casual conversation, the physical aspects of technology, the machines, serve as symbols of applied practical knowledge. However, if we are to describe, understand, and eventually shape technology, our definition of a technology clearly must encompass process and knowledge as well as concrete symbols.

Ely (1970) carefully separates (1) devices and equipment, the "physical science" of technology as used in education, from (2) psychology and pedagogy, the "behavioral science" of instructional technology. *Process*, then, is the "how to" knowledge and skills (the art or craft signified by the Greek root "techne"); *product* is the artifact, the equipment and materials used in or output resulting from a process. It is important to examine the process aspect of a technology as well as the tool associated with its use. Yet the essence of a technology, the practice or method, is only incidentally introduced in the commercial dissemination of a product. We receive tools without adequate instructions.

It may be more useful to think of technology as a verb which describes a process rather than as a noun which refers to a static physical object. Thus, if one is "technologing," the image of a dynamic process is evoked. A dynamic definition of technology is necessary to counter the natural tendency to concentrate on tools or products, which are easily observed, to the exclusion of the less publicly visible dynamics of applied practical knowledge.

"Definitions have followed the changing paradigms of the field. . . . In the pre-World War II period, the term visual education or audiovisual education was used. The definition(s). . .emphasized products or things . . . physical science. This definition persisted through the post World War II period and well into the 1960s" (Ely, 1983, p. 2). Change in the field is easily traced through shifts in its name: "visual aids" to "audiovisual education" to "educational media" to "educational technology" to "instructional technology" to "information technology."

- The shift from "visual aids" to "audiovisual education" stresses new equipment.
- Educational media" is more emphatically centered on learning than on a particular medium.
- "Educational technology" reflects the influence of "educational engineering" and behaviorism. The concern is with the application of knowledge to the practical tasks of education.
- "Instructional technology" indicates a redefinition beyond the school setting, including military and commercial sectors.
- "Information technology," initially a subspecialty in library science, has growing acceptance, perhaps as a result of the increasing emphases on the economic importance of information, mass media, and the processing-storage-transmission characteristics of the machines.

This "new information technology is founded upon recent developments in three fields: computers, microelectronics, and telecommunications" (Hawkridge, 1982, p. 330). The primary significance, however, is not in the equipment, but in how it is used, the *techne* or practice. This practice can be good or bad. A social critic such as Ellul (1966) attaches a negative connotation by casting technique as rigid processes and practices.

The word "technology," then, is confusing since it may mean social technique, a procedure for a task analysis, any applied science, a rigid procedure, or equipment and related artifacts. Each view has a set of perceptions and expectations. Each has important messages. If we use the word "technology" as a shorthand reference, we must be clear which definition and concerns are referenced or discourse will simply turn into disagreement.

The emphasis for education must be on how the artifacts are to be used, not on what they are. "Educational technology is concerned with design in the precise sense that the term is used by Simon (1969) to indicate a 'linking science' between theory and practice" (Winn, 1983, p. 12).

Factors That Shape Technology

There are several problems in adapting technology to facilitate educational goals. Adapting storage and counting machines to learning environments is one of the most significant design, or redesign, problems. Important factors in teaching and learning must be identified and methods demonstrated. But how people perceive technology, as a social and economic force, must be understood if adaptation is to be facilitated. These broad problem areas cannot be resolved with ease. Their individual complexity is compounded by the interactions among them. To make progress in solving these problems, we need to maintain a public discussion of the processes used to investigate the problems. An important part of the discussion is defining the problems. As problems are acknowledged, educators can be more helpful in providing guidance to government on policy or to producers on criteria for materials.

Technological Determinism. Historically, there has been a tendency to adapt *to* technology rather than adapt technology itself. "In our times people are often willing to make drastic changes in the way they live to accord with technological innovation at the same time they would resist similar kinds of change justified on political grounds" (Winner, 1980, p. 135). A good example, though far afield from education, was the development of a tomato harvester that offered great benefits in terms of speed and decreased labor costs but damaged easily-bruised tomatoes. The problem led to the development of a thick-skinned, less easily damaged, less flavorful tomato, rather than the refinement of the harvester. Winner (1980) describes this tendency as "technological determinism [or "technological drift" (Winner, 1977)]—the idea that technology develops as the sole result of an internal dynamic, and then, unmediated by any other influence, molds society to fit its patterns" (p. 122). The harsher critics of technology often speak of technological determinism as if there exists a conspiracy aimed at subjugating human needs and objectives to the "technocracy." Winner, however, suggests that we need not look for "conscious conspiracies or malicious intentions" and that technological determinism is "an ongoing social process in which scientific knowledge, technological invention, and corporate profit reinforce each other in deeply entrenched patterns that bear the unmistakable stamp of political and economic power" (1980, p. 126).

Technological determinism is also used to describe the forces that bear on the development of a technology by ruling out certain choices and alternatives during the R&D process, where there is the greatest degree of latitude.

Alternative uses of the technology are limited further by marketing and advertising strategies that promote particular functions and uses without mentioning the fact that others might exist. And, the longer the technology exists in the marketplace, the more firmly its "appropriate" uses are fixed, and the original flexibility of the technology vanishes. The more institutionalized the use of a technology becomes, the more resistant it is to change (Steele, 1983). "In that sense technological innovations are similar to legislative acts or political foundings that establish a framework for public order that will endure over many generations" (Winner, 1980, p. 128). And, because of the power technology is perceived as having over the way we conduct our lives, technological innovation is "increasingly seen as a villain that pursued the wrong objectives, was socially unresponsive, and, worst of all, was ineffective" (Steele, 1983, p. 133). This is "the zeitgeist theory of technology, which holds that man's inventions have a lift of their own, beyond man's control, alien to his aspirations" (De Lauretis, Huyssen, & Woodward, p. 31).

An example of technological determinism in education is found in the search for computer uses that has tended to build from computer strengths, not student weaknesses (Ragsdale, 1982). Rather than look for creative ways of harnessing the power of the computer in the service of specific learning needs, education has tried to "fit" its needs to the technology, often resulting in inappropriate or ineffective applications. Rather than adapt the technology through experimenting with alternative uses, education has adapted its goals and methods to a technology designed for other markets.

Design. There are problems with machines, serious problems in adapting information storage and counting technology to serve learning, unless one wishes only to learn how to store and count information. The problems for education are built into the machines, stemming from basic incompatibilities between educational aims and the machines' intended functions as they are developed. Machines are built to store, transfer, and count information. It is at the point of design and development, the creation the machines, that the greatest latitude of choice is available. Decisions to improve the design of a machine to enable it to perform a specific function are rarely, if ever, related to learning. The use of the machines for purposes other than the original intent takes extra effort—adaptation rather than simple adoption.

Winner (1980), writing on technology and social policy, reasons that seemingly innocuous design features are, in fact, choices of profound significance and that subsequent choices tend to become strongly fixed in material equipment, economics, and habit. In effect, technological ideologies are built into the machines as they are created. The ideologies are convergent, task oriented, relatively fixed, and constructed for doing, not teaching or learning. Redeveloping the technology for learning requires adaptation.

Adaptation, however, is not as simple as creating a "spin-off" from other technology. In industry, for example, studies suggest the cost to transfer a new technology from one plant to another costs about the same as the initial invention and development of the technology, mostly because of the adaptation required. Unfortunately, in education little or no allowance is made for adapting technology originally intended for other purposes. The simple adoption (without adaptation) of technology by education over the last few decades has been a sort of Children's Crusade; the cost has been dear and the results quiet failure.

Pedagogy. The pedagogical problems in adapting machines and techniques to teaching and learning are dramatic in what is not addressed. Learning efficiency and effectiveness, the reasons used to justify most educational policy, including acquisition of machines, are not justified by technology as it has been practiced. Major summaries of research in the use of many media conclude there are no significant learning differences that are measurable. One medium appears to be as effective as another because the powerful variables are in how the medium is used rather than what it is. Obviously some media lend themselves to different techniques. Our problem is that these differences, such as interactivity, are not developed. "Interactive" technology exists primarily in the imagination of futuristic writers. Test this proposition by sitting through a few machine-based instructional programs. There are, fortunately, exceptions, some borrowing heavily from arcade-type games. But, unfortunately, there is no widely agreed-upon concept of interactivity—another proposition that can be easily tested: ask several people to define "interactivity."

A number of other advantages often used to justify investment in emerging technologies are similarly suspect. "Motivation," "interest," and "curiosity," are only incidentally related to technology; they were around before the technologies and, to the degree that they are associated with machine-based technologies, are poorly understood. This weakness is not unique to education. Training literature suggests industry has similar problems; motivating employees is at least as important as skills training, though no better understood than in education.

What technology "should" do or potentially can do for learning has not been demonstrated. To gain an understanding of the current state of technology in education, then, we must seek reasons beyond an oversimplified invocation of "better learning." Our concern must be to ask the right questions, such as "What can we educators do to make a proactive response to computer technology?" (Wedman, 1983, p. 148).

Social and Economic Factors. Clearly, many of the problems surrounding the use of technology in education stem from perceptions and expectations. Parents fear that their children will not learn, will not be able to use technology, and, ultimately, will suffer in life because they lack a technological edge in the economic marketplace. Machine-based technology has been touted as the solution. ("It can give your child a head start that could last a lifetime," maintains Texas Instruments.) Educators are realistically concerned about appearing up-to-date and responsive in the eyes of the community and their peers. Technology, as symbolized by machines, is one solution. However, there is no central purpose for the technology and vastly differing opinions about what it can or should do. This forces the schools into a technological tokenism to nominally satisfy several, sometimes conflicting, agendas. This is easier to understand through sociological analysis than research on learning. For instance, Turkle, of M.I.T., suggests that the computer is "a medium in which people work through personal and political concerns that are far from any instrumental use of the computer. . . . When people talk about computers they are often using them to talk about other things as well. . .feelings about public life—anxieties about not feeling safe in a society that is perceived as too complex, [and] about more private matters, even reflecting concerns about which the individual does not seem fully aware" (Turkle, 1980, p.15).

Curriculum and Technology. The debate over the implications of technology continues with no immediate resolution in sight. Educators increasingly are becoming embroiled in the dispute, desirous of reaping the benefits technology offers but wary of the ideologies that accompany it. "Powerful computer ideologies can decrease our sensitivity to the technology's limitation and dangers as well as blind us to some of its positive social possibilities" (Turkle, 1980, p. 16).

Technology did not create human conflict or inequities and neither will it solve them: "The convergence of computers and telecommunications doesn't resolve the ancient puzzles about human rights and responsibilities" (Cleveland, 1984, p. 13). While some contend that "technologies offer a real—and perhaps only—hope of fundamental rethinking and improvement [of education]" (Bonham, 1983, p. 72), others are more cautious: "The introduction of the computer into any problem area, be it medicine, education, or whatever, usually creates the impression that grievous deficiencies are being corrected, that something is being done. But often its principal effect is to push problems even further into obscurity—to avoid confrontation with the need for fundamentally critical thinking," cautions MIT's Weizenbaum (Giesbert, 1983, p. 22).

Those who adopt a more cautious stance usually do so out of concern for the human elements often overlooked by uncritical advocates of technology. "The Information Age may have come," suggests Murphy (1983), "but it came from somewhere and as a result of human processes, and it will continue developing through on-going human processes. One would wish that the human dimensions of technology would receive as much scrutiny and respect as the economic and political" (p. 327).

Table One. Summary of Curricular Reform Recommendations

Author/Year	**Educative Goals**	**Curricular Reforms**
Andrusin 1976	Education based on the concept of life-long learning, the positive worth of the individual, and the optimization of an individual's potential	Active learning environments, positive experiences, and positive self-image building situations; broad-based curricula (e.g. communication, survival, mental/physical, cooperative and values clarification curricula)
Botkin 1978	Innovative learning	Emphasis on anticipation, participation, rights, responsibilities, and the human dignity of the individual
Bowers 1977	Knowledge is power	Accurate depictions of societal conditions; teachers should provide students with the background information that will demystify the material
Earl 1979	Life-long learning	Man/machine learning systems
Gay 1981	Education for revitalization	Experiential, affective-based process-oriented programs; inquiry and critical analysis; student selection of courses and learning methods

Author/Year	Educative Goals	Curricular Reforms
Liss 1981	Incorporation of career and life-long learning concepts	Proficiency in the use of technology
McClure 1981	Excellence and equity	Multi-disciplinary curricula; broader-based math and literacy skills; renewed emphasis on skills, knowledge, and attitudes needed for participation in a democracy
Meade 1981	Literacy and individual growth; participation in the commerce of the nation and the world; effective participation in the governance of the American democracy	
Mirabeau 1981	Life-long learning	Programs preparing people of all ages to deal with the changes they will face as they go through each stage of human development
Smith 1978	Humanistic education as an alternative to the dehumanizing aspects of technical society	
Tyler 1981b	Socialization; social mobility; self realization	

Author/Year	Educative Goals	Curricular Reforms
Venn 1973	Career education; preparing people to lead productive lives in society	
Virgin 1976		Flexible and varied curricula; greater concentration on values clarification; self-controlled learning; realistic learning situations; learning activities concentrating on higher cognitive skills; greater utilization of local resources; greater individualized instruction in less formal settings; emphasis on cooperation as opposed to competition

This long-standing controversy has given rise to a plethora of recommendations for curricular reforms which reflect the search for appropriate goals and objectives for education in a technological society. (Representative recommendations are summarized in Table One.) Bowers (1977), for example, advocates curriculum reform to "help teachers demystify societal conditions for students as well as teacher training on the function of public schools as carriers of technological beliefs and values. Such reforms are essential to understanding the context of change and the ways in which it can be directed."

The nature of our public education system does not permit sweeping changes on a nationwide basis, nor should it. The implementation of fundamental curricular reforms, like the adoption of educational technology, is best done cautiously with much experimentation and adaptation to local conditions and needs.

The Arguments For and Against Technology in Education

Understandably, discussants of technology and its educational applications carry their own particular definitions, perceptions and expectations into their arguments. Their opinions and predictions, expressed frequently and emphatically, indicate an advocate/critic dichotomy that is likely to play a very real role in decision-making about the uses of technology in education. While advocates and critics can be arrayed along a continuum ranging from blind enthusiasm to staunch opposition, many appear to come down firmly on both sides by advocating one approach to technology and criticizing others. This is complicated further by the fact that similar proposals may stem from greatly different motivations and ideological orientations, making the continuum multidimensional rather than linear.

The common ground upon which advocates and critics meet is an acknowledgment of the information and education needs of a society in the electronic "information age." "Unlike coal, . . . information is expandable. It grows with use, and enhances its value through dissemination. It is also diffusive (it leaks at nearly the speed of light, and is therefore harder to hide)" (Cleveland, 1984, p. 12). It is the belief that there is a new value on finding and using information that drives the arguments, both for and against technology in education.

Reservations about a Revolution

Advocates for technology appear to be optimistic. The optimism is based on a belief that the increase in machine invention and use will motivate us to find better ways of doing things. This change is often described as "revolutionary."

> We are in the midst of a microelectronics revolution which is having profound influence on education. Modern electronic information technologies— microprocessors, computers, video recording devices, and inexpensive means of storing and transmitting information—are creating a revolution and are changing the world as we know it. This revolution is making profound changes in the way business and industry is conducted and in the nature of many jobs. (U.S. Department of Education Task Force, 1981, p. 3)

Does this revolution pose problems? According to some advocates, no. Caldwell (1981) explored the promise technology holds for improving instruction and for broadening alternatives for instructional delivery, noting and "dispelling" three myths: that computers dehumanize the learning process; that computers will replace teachers; and that technology has not fulfilled its promise.

On the other hand, some advocates believe that our present educational institutions are unresponsive to the needs of our society and place great hope in the ability of technology to rectify the situation. Bixby (1980) views positive human progress as the real challenge to education in a technological society and suggests that electro-chemical technology may someday make knowledge of basic skills unnecessary. He further suggests that individualized learning, using technological aids, should occur in schools so that students can realize their own individuality and potential rather than be dependent on technology to do their thinking for them. Uhlig (1982) sees the computer and laser videodisc as two technological advances which have the potential for making a significant impact upon education within the next twenty years. His premise is that it is necessary for teachers to become technologically literate and for education to develop and adopt microcomputer technology if schools are to remain relevant. The advocates are optimistic: "Short of some cataclysm, the computer will become as much a part of learning as the pen, or blackboard, or textbook" (David, 1978, p. 20).

Earl (1979) holds that the "silicon revolution" will lead to a situation in which the primary form of educational interaction is between machine and student, rather than teacher and student, because the former will prove to be more cost effective and efficient and better able to provide individuals with life-long learning opportunities. Similarly, Liss (1981) stresses the need for students to become proficient in the use of technology both for career and lifelong learning. Such advocacy for literacy carries strong vocational (economic) and access implications.

Some advocates are well intentioned but often uninformed of the history of technology in education. They are conceptually seduced by what could be, not by what is. An experienced researcher in industry opined there is more opportunity for hard work than for optimism. That is, solutions are more likely to be specific than general—technology will not be a generalizable solution for education.

Those with experience in using technology have concerns about unqualified advocacy of technological solutions. (See especially Pitts, 1981.) They have seen the cycles of "hot" topics. Brusling (1982), for instance, found that R&D projects in programmed instruction catalogued by the National Board of Education in Sweden fell from eight in 1971 to zero in 1980. These more cautious advocates, some of whom are pioneers in computing such as Bittner, Licklider, or Weizenbaum, recognize the potential of technology, but unlike the stronger advocates, they express the realistic acknowledgement that "information technology provides the essential raw materials for revolutionary advances in education, but they are raw materials. They have to be processed into educational technology" (Licklider, in U.S. Department of Education Task Force, 1981, p. 14). At the same time, they have experienced the ups and downs of different machine-based innovations.

> The people in education who advocate microcomputers demonstrate some of the same characteristics as their earlier colleagues who believed that one medium or another was about to revolutionize education. They

feel that they have discovered a device or medium which will engage the learners as no teacher has ever done; they see potential for optimum learning by creating replicable instructional packages which can be used throughout the nation; and they feel that the use of microcomputers is consistent with the American technological psyche, which embraces new technologies as new religions. There is nothing inherently "wrong" about these perceptions; they are simply naive in light of the history of innovations in schools. (Ely, 1983, p. 3)

Disillusionments . . . Unanswered Questions

How much of a change has occurred with the advent of various technologies? "Throughout the history of education several technologies have developed which have had potential for major changes in educational practice. With the possible exception of the printing press, technologically derived educational changes have been minimal" (Teague & Rogers, 1983, p. 18). Paisley and Butler (1983) remind us of earlier disillusionments with the narrowly technological view of education prevalent in the 1960s, while Bonham (1983) suggests that the "dazzling possibilities [of microcomputer technology] may also lead to a stampede that could come dangerously close to education's earlier failed flirtations with television and computer-aided instruction" (p. 72). Hawkridge (1982) urges extreme caution: "we may use the new information technology in education, but we may do so with disastrous effects" (p. 331).

Many of the most vocal critics speak of the social implications of the new technologies in general—there is less separation of sectors, such as education, since the impacts are society-wide. Major themes are wide ranging and touch on basic human concerns which must be addressed regardless of one's attitude toward technology. For instance, we are warned "against the myths of the electronic revolution, reminded of the inherent limitations of communications for the solution of pressing problems and the risk of replacing the ill-famed 'homo economicus' by a new reductionism in the form of 'communications man' or 'homo informaticus'" (Ploman, 1983, p. 84). In the same vein, Tittnich and Brown (1981) suggest that the current emphasis on technology is at the expense of human understanding and development and may produce children who are unable to sustain human relationships and interaction, turning instead to machines for gratification. This is augmented by long-standing concerns that "educational technology is committed to excluding the possibility of anything new or original happening while a student is learning any given material" (Stansfield, 1969, p. 54). Illich (1973) believes that technological society has created highly manipulative schools whose purpose is to teach or train individuals for their places in society rather than to provide them with learning experiences that will help them grow as individuals. Similarly, Sizer and Kirp (1970) suggest that educators who hold humanistic views of the learning process criticize the regimentation and regulation necessitated by new technologies.

One response to such criticism has been to look into the "black box" of how people learn to see how a variety of educational aims, humanistic as well as career-oriented, can be met through the use of technology in education. How people think, the cognitive process, has become a popular research topic. The number of cognitive development research projects in Sweden, for example, went from zero in 1971 to eight in 1980 (Brusling, 1982). Artificial intelligence programs are of both popular and financial interest so research and development on cognitive processing is likely to flourish, regardless of criticism.

The "mechanization" of people and their interaction is an evident concern. The move from behaviorism to cognitive processing provides support for both advocates and critics. Chapple (1978) describes the family as being at the mercy of corporate and governmental structures as a function of the transformation to a technological society. Shane (1981), concerned that technology will be limiting, says schools "should serve to increase rather than decrease human differences in the ability of learners to contribute to society" (p. 266). Both worry about the mechanization of processes in learning or social interactions—a legitimate concern but not unique to machine-based activity. Treating people as objects seems to have been an accepted mode of operation well documented in the chronicles of old civilizations.

Closely related to mechanization of people and relations are vocational issues—the on-going arguments on the purpose of schools: are schools to teach people to think or to work? However contrived this division is, it provides ammunition for advocates and critics alike. "Prevailing opinion is that future jobs will be mostly high-tech, requiring an extensive math, science and computer skills background, and requiring a labor force of highly skilled people. But prevailing opinion is wrong. . . . Most future jobs will be low-skilled or middle-skilled positions, many existing jobs will disappear, and the existing jobs that survive will require lower levels of skill than they do now" (Hollifield, 1983, p. 2). McRobbie agrees that the "white hot technological revolution has destroyed jobs and brought about more hazardous, fragmented and de-skilled work" (1981, p. 91). Hollifield suggests that vocational issues have served to mask the true issues: "Politically, high-tech is helping to focus attention on education. It's easy to pump up the importance of education by talking high-tech, by emphasizing how we need to produce highly skilled students who can meet the technological demands of this new world. . . . The computer should be used as a tool for learning, not as a subject that will displace more fundamental learning" (1983, p. 5). The idea that technology is a means to an end rather than an area of instruction in and of itself is not a new one; many have long recognized that consideration of the issues raised by the existence of a technological capacity must start with the problems and needs of our educational system (National Academy of Engineering, 1973).

A Problematic Reality

What will happen is more than the critics expect and less than advocates hope. Although people perceive themselves as living in a time of change unparalleled in human history, this perception has frequently been the case with people in any age. Clifford (1981) cites present trends, including the technological revolution, and agrees that they seem to suggest change. However, she notes that a trend is only a historical construct indicating a tendency rather than an inevitability and, in fact, trends are reversible; they can stop abruptly, or die out. In 1982, Wagner indicated that "the explosion in the use of media has shown signs of slowing down" (p. 137), because of "disillusionment with the ability of education in general and educational media in particular to meet the needs of society" (p. 138). Further, schools have remained fundamentally the same because society perceives school as intended to transmit culture, not create or invent it. Goodlad (1981) indirectly supports the evolutionary case for change in education by reporting little headway over a twenty year period: problems addressed in a 1959 NEA report remained through the 1970s. In fact, Finn describes "education, as a sector of life [that] has, for the most part, been cut off from the technological advances enjoyed by industry, business, the military establishment, etc. . . . Consequently, the American educational enterprise exists out of technological balance with great sectors of the society, and can therefore be merely viewed as a relatively primitive or underdeveloped culture existing between and among highly sophisticated technical cultures" (in Finn, Campion, & Perrin, 1962, pp. 1, 21). In other words "technology is flourishing everywhere but in education" (Deringer, 1981, p. 69).

In the '60s a shortage of teachers was used as a justification for machine-based learning. The teacher shortage passed and, as it comes again, there is little change in capitalization for machine-based learning. Rationale for new policy, based on new needs, such as demographic projections which "point to need for change," has not been compelling. For instance, coping with the symbiotic relationship between man and machine, a connection made by Buchen (1980) in policy recommendations for the House Subcommittee on Elementary, Secondary and Vocational Education, is posed as a factual argument but is treated as speculation—no facts are cited. This does not mean that needs do not exist, just that they are not presently documented. It is a guessing game about the future. The game will be played better if, as Gay suggests, we "develop attitudes and skills that transcend present realities" (1981, p. 80). The means by which this may be done have little precedent.

At the political and economic policy planning levels there are those who idealistically exaggerate benefits and those who play fearful critics. The realists are somewhere in the middle, suggests Dizard (1982). Table Two summarizes the predictions of all three groups. The extremes represented suggest a need to moderate the discussion about educational technology, and to encourage experimentation that will reap the educational benefits of technology while tempering the natural tendencies of the zealots and the skeptics. There are truths in both camps: the idealists can conceive a better world, the critics a worse one.

The least constructive discussants are those who, like Mirabeau (1981), lament the rapid decline of liberal arts in general and the humanities in

Table Two. Views of Technology

(The views do not, in all cases, form a smooth continuum.)

OPTIMISTIC	PESSIMISTIC	PROBABLY
Improved quality of student-teacher contact	Reduced direct contact between student and teacher	Reduced direct contact for a few special students
Prescriptive and diagnostic help from records	Violation of privacy of test results; labeling	Less "personal" data more privacy
Equal opportunity; increased mobility	Unequal access; increased differentiation; reinforcement of prevailing inequalities	Increased differentiation; meritocracy
Elimination of unqualified teachers	Technicians will eliminate teachers	Demographic/economic changes only
Discretionary time and lifelong learning	Vocationalism and close monitoring of work	Both, in greatly differentiated jobs
Decreased cost of education	Increased cost of education	Displacement of some current costs
Teacher as manager	Teacher displaced	Teacher harried

OPTIMISTIC	PESSIMISTIC	PROBABLY
Need career training in higher order skills	Work will be simplistic and fragmented	A general education for flexibility
Many good jobs will be available	Underemployment and unemployment common	Same type but more service jobs
Technology solves problems	Technology creates problems	Technology is a symbol of problems
Schools will operate efficiently	Schools will be social warehouses	Technology will make little difference
Emerging technology is substantively different	Emerging technology is a cyclic fad	Small differences will evolve
Techn·'ogy enables the individual	Technology creates a mass culture	Societal forces shape technology's uses

particular as a "result" of our loss of control over language as a communication tool due to the rapid changes fostered on us by technological society. This appears to be a somewhat doctrinaire anti-technological movement intent on creating a new mythology of its own. Florman (1981) describes it as a "pastoralism," a displacement of anxieties. The concern of such critics is the locus of power in the social structure—a legitimate concern—and the lack of attention paid to their respective fields. In brief, they don't get the respect they feel is their due and technology is the scapegoat.

Excitement about microcomputers needs to be directed or results will more likely be failures than learning (Becker, 1982). Unfortunately, the history is one of "failure of the educational technology industry to provide any significant examples of successful new technology (Andrews & Hakken, 1977, p. 102). A large part of the problem is that there is no "educational technology" industry as there is an "electronics" industry. The educational technology industry serves primarily as a conduit for equipment and materials developed for other markets. (Successful applications do exist, but are difficult to identify, and offset by an equal number of failures and a large number of applications where no change is realized.) In the short term, the failure to provide successful examples does not seem to be changing. A 1983 Johns Hopkins study found no significant increase in academic achievement due to the use of microcomputers (Staff, *Electronic Learning*, Sept. 1983). "Most students do not get a sufficient amount of time for any appreciable skill building to take place, even if the computer programs were up to the task—which is itself another issue" (Center for Social Organization of Schools, 1983, p. 8).

It is the informed skeptics in the middle ground that are best equipped to provide the direction needed to ensure both access and quality of instruction. Unfortunately, "the peculiar nature of the educational subsystem is that decisions to use or not to use technology are most frequently made by those who are potentially threatened by the technology and not by those who potentially benefit from the introduction of technology" (Heinich, 1983, p. 25). Though some schools have worked to adapt technology, most see it as a frill or a threat—or both. Lipson (1981) suggests that "decisions are driven by emotions and until the problem of educational technology has emotional and political force, little is likely to happen." (Lipson assumes educational technology currently has these forces but the forces are either negative or apathetic.) The decisions most urgently needed at this point are not of a yes/no nature but rather "why, how, and to what end," requiring rational, thorough, informed discussion, and valid research and experimentation. "The correct position for the 1980s is optimism tempered by caution; optimism because of the positive factors in favor of increased media [and technology] use. . . . Caution, for the evidence of media [and technology] experiments and projects over the preceding two decades is that the undoubted successes must be balanced by the equally undoubted failures" (Wagner, 1982, p. 148). As Mumford (1964) points out, "We must settle down to the long process of rethinking our basic premises and refabricating our whole ideological and cultural structure. . . . We can stop saying 'yes' so automatically to the automation of knowledge" (p. 276).

A Matter of Responsibility

If the cycles are mostly surface disturbances, and nothing much will happen in the short term, why is technology an important concern? Throughout our history, schools have willingly taken on whatever tasks society has assigned them. Because of this, Aiello suggests, schools have failed to secure for students "that which is basic and necessary in the learning process and our responsibility to them" (1979, p. 39). Neither passive acceptance of new roles and tasks nor uncritical large-scale adoption of technology unproven in educational use will ensure that we meet our responsibilities to students. There is widespread agreement that the ability to use the information bombarding us from all directions is the single most important ability needed by citizens in a modern society. "To a remarkable extent, information is a source of power in Western society. Information technology is becoming a means of wielding power" (Hawkridge, 1983, p. 4). Economists equate a developed nation's capital stock with its body of scientific knowledge and "its capacity to train its people to use knowledge effectively" (Molnar, 1978, p. 281). Stonier (1983) suggests that information has upstaged land, labor, and capital as the most important input into modern productive systems, and Read (1979) describes information as a basic resource that is central to the conduct of international relations.

Clearly, the consequences of not providing students with the means to develop information utilization skills would be disastrous. The consequences of leaping onto the first technological bandwagon that passes with the expectation that it will provide those means also has great potential for disaster. Buying the product without ensuring that the process is appropriate may result not only in economic loss to schools but in lost time and lost potential which, unlike money, are impossible to recoup. This is significant because it is the students themselves who suffer from inappropriate product purchases.

How significant is the purchase of a marginally adequate product? Several studies suggest that much classroom activity (up to 90 percent) is shaped by materials, and that as much as one-third of the materials are non-print (EPIE, 1977, p. 22). Marginally adequate products increase "the probability of a backlash from great expectations unfulfilled by the new technologies" (Holloway, 1982, p. 3). Yet there are indications that we may be heading in that direction.

Norwood (1981) urges us to temper our enthusiasm with wisdom, not by rejecting the new technologies but by making informed decisions. "The members of the education community have only two choices: they can participate or they can leave the decisions to others. What they cannot do is escape their consequences" (p. 44). Others propose careful scrutiny of the forces that bear on the development of educational technology and of how educational technology can be shaped to meet the changing needs and expectations of society, with the ultimate goal of making technology a more responsive and effective tool of education (National Academy of Engineering, 1973).

Technology will have an increasing impact on economic activity, especially as a way to find, create, and use information. Information is power—the ability to understand and create events. How we adapt technology for education and education for technology will have significant effects on individual, national, and international progress.

How Are We Doing?

A pundit writes, "If the gadgets fail to achieve their purposes, which certainly seems likely at this stage in their development, they will soon be stored away in closets and labeled another 'innovation failure.' Such failures, we have learned from our earlier experiences with curriculum development, tend to haunt. . . [education] even years later" (Pitts and Schneider, 1981, p. 3).

The legacy of the grand educational technology experiments of the 1960s which, despite great capital expenditure and emotional investment, failed to produce significant results, is with us still. The enlightened seek the reasons behind the failures and ways to prevent history from repeating itself; others persist in viewing the new technologies as "panaceas for inefficient teaching" (Husen, 1984, p. 9). Kaufman and Fishman (1977) suggest that it is just this crisis-oriented search for immediate panaceas that has frustrated significant and positive educational change. We have choices, of course. We can work on making better decisions in times of crisis, implement policy which provides guidelines for decision-making, undertake long-term planning, or some combination. Whatever the choice, decisions must take into consideration the impact of technology on (1) traditional concerns of learning (pedagogical issues, the quality of materials, learning goals, and needs), and (2) traditional implementation concerns (teacher resistance, teacher training, costs), as well as (3) concerns outside the direct control of educators (market pressures, social pressures). A key to the correct mix, however, may well be how well the decisions consider factors beyond the traditional concerns of learning.

The Traditional Concerns of Learning

Learning remains a central concern, but may be better understood by recognizing there are differences between learning and production. Brusling (1982), in exploring the socioeconomic factors and educational trends which contributed to the rise and fall in popularity of educational technology in Sweden between 1960 and 1980, attributes disillusionment with educational technology to its inability to translate norm dominated educational theory into practice in a manner that accommodates differences in individual aptitudes and abilities. Husen (1984) cites as the fundamental reason for the failure of educational television, teaching machines, and computer assisted instruction in the 1960s the fact that "education is not a manufacturing industry. In manufacturing you plan a process where you know exactly what the final products are going to be. But in education, there is a wide margin of uncertainty, because its 'raw material' has a wide, and largely unknown, range of possibilities" (p. 9). Thus, the emphasis may be misplaced. Bonham (1983) suggests that "attempts to deal with the computer's emerging role in education have tended to focus on technology rather than long-term educative and intellectual objectives" (p. 72).

The book, a medium with a significantly longer history than most contemporary media, serves as a metaphor for perspective on newer media. Books, we know, serve some purposes better than others. Some books are better than others. And, the characteristics of the reader or audience and conditions or setting create great variance in the outcome, whether measured in learned facts or changed behavior. We know the size of the page, the quality of the paper, and similar technical and production properties have much less effect on learning than what the author and the learner bring to the experience—and how what they bring interacts.

Kemp et al. ask a crucial question: "Can we profit from our earlier mistakes as we develop our newest resource, the computer?" (1980, p. 27). Although the technological innovations of the 1960s did not prove to be panaceas for all that ails education, we have learned much from them. "The fascination with teaching machines didn't last long, but the concept of 'programming instruction' persisted. . . . Language laboratories. . . were heralded as the salvation of foreign languages. Gradually much language instruction shifted back to the classroom, yet the labs have remained. . . [and] are used by disciplines other than languages" (Kemp et al., 1980, p. 27).

Learning. Unfortunately, we know a great deal more about the physics of our machines than we do about how people think and learn. Fundamental differences of opinion on the pedagogy underlying educational technology and differing perceptions of the role of technology within our existing educational system are the springboard for many of the arguments for and against adoption of educational technology. They manifest themselves again and again in discussions about the desirability of individualized instruction and in the kinds of software available. MacPherson (1972) speculates that

> someday, someone will explain why we in education were captured by psychology rather than sociology. Perhaps the psychologists simply got here first. Whatever the reason, we were! In all sorts of subtle ways, we think about learning as though it were an individual phenomenon. In fact, it is possible that we are, by some instinct, herd animals and that some learning is, to begin with, most naturally a group phenomenon. (Cited in Logan, 1982, p. 146)

Some critics' arguments are grounded in psychology, identifying unintended learning outcomes that result from inattention to, or misinterpretation of, the psychological ramifications of technology. Weizenbaum fears that "video games are, if anything, more harmful than TV, because they *actively* teach disassociation between what one does and the consequences of one's actions." Weizenbaum also lambasts the often made claim that computers enhance creativity:

> As for the computer itself, I think it inhibits childrens' creativity. In most cases, the computer programs kids and not the other way around. Once they have started a program, the computer may leave them a few degrees of freedom, to be sure, but on the whole it will tell them what to do and when to do it. My colleague Seymour Papert claims that he has a radically different approach: with his system, he says the children program the computer. He made a film that was supposed to illustrate his thesis. In it one sees children working on Logo in Senegal, Scotland, and Texas. As if by chance, they all drew exactly the same picture on their computers: a flower made out of ellipsoids strung together. Strange, isn't it? (Giesbert, 1983, p. 22)

The crucial question that remains is, knowing as little as we do about how people learn, how can we best harness the power of technology in the service of learning? Should computers be employed as "automated tutors to deliver the content of standard courses," as "tools to train junior programmers," or as "resources to enrich the curriculum?" (Staff, *Time*, Oct. 10, 1983, p. 64). There are fundamental distinctions among these methods that reflect different beliefs about the purpose of education. It is not just learning methods, but the kind of learning that is implied. Information, the descriptive "what" of knowledge, must be unlocked by the problem-solving "how" of techniques. One of the key differences, highlighted by the futures forecasting of the Club of Rome, is anticipatory learning, learning "seen as promoting solidarity in time, through anticipation as the capacity to face new, often unprecedented situations and to create new alternatives where none existed before" (Ploman, 1983, p. 82). Thus, the apparently simple question of what method we should use may determine the real goal of education.

Those who look to educational research on learning for resolution among the different methods will be disappointed. Hawkridge (1982) claims that "there is little evidence, from many evaluative studies, of substantial increases in the rate of learning by students in classrooms served by technology when compared with those not so served" (p. 326). Lidtke (1981) maintains that there is little concrete evidence of the effectiveness of educational uses of media, and Ragsdale (1982) predicts that "Educational research may not have a positive influence on computer uses in education" (p. 3). "Decision-makers who turn to the research on mediated instruction will find little to guide their decisions" (Richardson, 1983, p. 57). This is not an indictment of educational researchers, but a realistic assessment of what Clark and Angert (1981) describe as the evolutionary state of research.

Quality of Materials. "The existence of computer assisted instruction is made tenuous by problems of poorly developed materials, limited availability of properly developed materials, locally produced materials, and widespread copying of materials" (Ragsdale, 1982, p. 1). Knapper (1982) correctly concludes that "there are no easy solutions to the problem of selecting appropriate instructional media for particular educational needs. What is certain, however, is that the starting point should be the learning requirements of the students in a particular context, and not the delivery system that happens to be the latest fad among researchers or that is being promoted by commercial interests" (p. 56).

This conclusion, although qualitatively correct in perspective, does not suggest methods to deal with "fads." The very term, used to minimize the importance of social and economic forces, asks us to turn a blind eye to the reasons why few appropriate materials are produced and selected for use in education.

A 1970 report of the Commission on Instructional Technology admitted that "education lags behind other fields in providing help to practitioners in making wise choices among competing products, and in spelling out its precise needs" (p. 59). Nor has education been particularly helpful in providing guidance for development of materials. But it is quick to criticize materials that fail to provide immediate, visible improvement in learning. Much of the software available commercially is of dubious educational value; content errors, spelling errors, activities that are inappropriate for the skills or knowledge to be learned, poor or no feedback, and inadequate learner control characterize many programs. This should not surprise anyone since until the 1960s, the education industry was virtually synonymous with textbook publishing and textbook publishers have, to a large extent, established themselves as the purveyors of educational software. Only recently have "many [other] private sector companies . . . made tentative forays into developing technological products and services for education. The outlook for future efforts to expand the impact is not bright, largely because education systems provide few significant incentives for private sector entrepreneurship in this area" (U.S. Department of Education Task Force, 1981, p. 6).

Part of the problem can be traced to the widely-held concept of educational software as mass-produced self-contained programs that provide the same "canned" learning experiences and responses for all learners. Kemp et al. (1980) attribute the failure of the teaching machines and other technological innovations of the 1960s to an assumption that there is one best way to learn: "These massive efforts to set a single path for instruction were unsuccessful because alternative methods are needed to serve the individual differences for both teachers and learners" (p. 26). Electronic technology provides the means to accommodate individual differences, but as yet commercially available software takes little advantage of this capacity.

There are indications that a more practical concept is evolving. Virgin (1976), for instance, advocates the need for realistic learning situations, regardless of the medium chosen for instruction, with emphasis on values clarification and higher cognitive skills. There is a trend away from a sequence delivered under rigid control. It is likely that future systems will use organized files of information and procedures. Users will work with tools for information management, computation, and composition. Exercises will be characterized by practice in information acquisition and decision making and students will take more control over their learning environments.

This seems, however, to be more of an ideological trend than a trend in practice. Few of the programs produced commercially for the education market display such characteristics and few school systems have the financial or technical resources to produce materials locally. Much software is still developed traditionally using "little more than 'traditional wisdom,' that is, usually the manuscript is written by a publishing company's editor, who often is a former teacher, and it receives as 'input' critical readings by those who are listed as authors and suggestions from sales representatives and production staff members" (EPIE, 1977, p. 22).

Significant improvement in the quality of mass-marketed materials is not likely until education makes its needs known to software producers and producers acquire the instructional design expertise needed to produce materials that meet those needs. "At the present time, few educators understand information technology, and few information technologists understand education . . . . It is going to take a very large amount of software development, oriented toward education and carried out by groups that understand both education and information technology, to create the essential base of educational technology" (U.S. Department of Education Task Force, 1981, p. 14). The conditions required to create this essential base of applied technology would appear to be assured since the Federal government will continue to support efforts, especially in science education, to "develop quality instructional materials" (Staff, *Electronic Learning*, 1983, p. 22). This base need not rest on theory or traditional experimental research since, "as Travers points out, there are and have always been technologies without a scientific basis" (Brusling, 1982, p. 382). It is reasonable to anticipate there will be a modest number of programs with careful attention to production values in high-status disciplines such as the hard sciences. Such growth may be better described as evolutionary than revolutionary, however, and curriculum integration will take decades.

Goals and Needs. Clearly, there is a lack of agreement among educators as to the goals and needs of education. Some of the confusion is caused by the gap between education's needs and the technology produced by and for industry. Over a decade ago, a national Commission on Instructional Technology (1970) reported that "educators themselves have not always demonstrated a realistic understanding of technology's potential for instruction, nor of industry's problems in meeting educational needs" (p. 60). But most of the confusion is caused by conflicting views of the purpose and methods of education. Even in administrative uses in schools, "educators do not appear to be capable of completely specifying their information needs *a priori*" (Vigilante, 1981, p. 33). In the absence of this input, "attempts to deal with the computer's emerging role in education have tended to focus on technology rather than longterm educative and intellectual objectives" (Bonham, 1983, p. 72).

Many of education's problems can be attributed to the fact that the traditionally stated goals of our schools are ambiguous. Sine (1979) states that the "fundamental character of the schoolhouse has been determined by its role in society" (p. 470), a role that is increasingly vague as society becomes more pluralistic. Increasingly, that role is to produce graduates who are able to function in a technological world, but there is little agreement as to what kinds of educational experiences will serve this purpose. Tyler (1981b) holds that our country's school system has three functions: socialization, social mobility, and self-realization. Sine (1979) cites Ellul's belief that the aim, if not sole purpose, of education is to foster social conformism, Illich's belief that the schools function as society's "gatekeeper," and Spring's belief that the school is the "central institution for machine-tooling the young to serve the needs of the corporate, technocratic state" (p. 470). Sine concludes by suggesting that the problem technocracy have entered the schools, and that, although schools appe have a limited view of human potential, students should be provided with humanistic education.

Fortunately, there need not be an "either/or" decision to provide vocationally-oriented technical education *or* humanistic education. Although Seif (1979) views the purpose of schools as preparing students to become effective citizens of a technological society, he makes nine curricula recommendations for a "new age" which combine technical skills development with personal development in areas such as socialization and self-realization. Goodlad (1981) acknowledges the persistence of the vocational versus educational argument and suggests that the major problem continues to be developing individual potentialities "within the framework of a society that values both unity and diversity" (p. 72). Goodlad's recommendation is that part of each student's curriculum should be designed to develop his or her unique talents.

Another significant area of dissension is that of basic skills education. While traditionalists express concern at declining competency levels in basic skills. Wagschal (1981) suggests that the reason students lack basic skills is because they can function in today's society without them and that the need for basic skills will continue to decrease as society becomes more and more dependent on technology for its sources of information. Because jobs in the future will not require high readability, Wagschal proposes that schools stress intelligence, knowledge, and skill development rather than traditional literacy. Similarly, Ploman, observing that the trend toward "de-skilling" that started with the industrial revolution is accelerating with electronic information-oriented technology, describes a

> larger concept of literacy which seems to link up with traditional concepts beyond the narrow confines of conventional literacy. Traditional literacy in the form of ability to read spatial forms, to interpret features of the natural and social environment, is now complemented by the expressed need for new, modern forms of literacy: visual and audiovisual literacy, computer literacy or overall media literacy, as well as the reading of what in a print-oriented culture has been called the "silent language." (1983, p. 83)

Caldwell (1981) describes the educational problems of the United States as having reached critical proportions with serious implications for the nation's ability to maintain leadership in high technology industries. Many of those attempting to influence educational policy decisions respond to these problems as a challenge or dare. Bonham (1983) describes the situation as "a historic opportunity to redefine the academic enterprise and mission," suggesting that "what is missing is the requisite quality of thought and breadth of vision, and there is an almost total absence of national initiatives to deal comprehensively with the issues" (p. 72). If the aims and purposes of education are determined by the needs of society, we can expect little resolution of the problems of education until society's agenda is more clearly defined. This requires, above all, agreement as to what the relationships between producers and users of technology and technology itself will, or should, be.

Traditional Implementation Concerns

Teacher Resistance. Teacher resistance is primarily a failure of leadership. The literature, however, identifies a number of concerns leadership must address. For instance, a factor cited as contributing to the low level of use of technology in education—in about half of the schools with microprocessors, only one or two teachers are regular users (Center for Social Organization of Schools, 1983, p. 1)—is the resistance of some teachers to anything new and perceived as potentially threatening.

> The problem of the resistance to instructional technology is a continuing one and provides a fascinating example of how an array of social and psychological influences may block what would at face value appear to be a logical progression of diffusion of innovations. . . . As used in the literature, the innovation as a component seems to have two subcomponents. First is the idea or item, novel to a particular individual or group, and second is the change that results from adoption of the object or idea. (Evans, 1982, pp. 89, 91)

Moore and Hunt (1980) identify three levels of resistance to the use of technology in education: resistance to innovation in general; resistance to new and different teaching techniques; and resistance based on genuine concerns, misunderstandings, or unpleasant experiences. Most of the reasons for resistance advanced in the literature fit into one of these categories.

Molnar suggests that "at the small-scale level of the individual item of equipment in a particular institution, [non-use] may often boil down to inadequate training of staff to use the machinery effectively, and a lack of service" (1978, p. 140). Lidtke (1981) suggests that "failure to use technologies are traced to. . . lack of training in the use of equipment . . . lack of adequate hardware, software, and courseware. . . the need to change teaching style" (p. 281). Hershfield (1981) focuses more on perceptions and feelings regarding the role of technology in education by listing barriers to developing new technology-based courses such as displacement of faculty members, the reduction of direct student-teacher contact, distrust of the adherents of different new technologies, and faculty training and prejudices that encourage the status quo. David (1978) observes that "teacher resistance is quite high. . . . There is little general impetus to experiment with new techniques which are not all that clearly understood" (p. 19). Kemp et al. (1980) attribute the failure of many media innovations to the changes they require in the educational environment—in personnel, students, facilities, and equipment, and Earl (1979) adds to this list methodologies for curricula transfer.

One of the major reasons educators distrust the new technologies is, says Wagschal (1981), because they believe that by using them in the schools, they will be "at the mercy of a minority of programmers and technicians" (p. 246). There is little doubt that increased use of educational technology will necessitate some redefinition of roles and responsibilities. Hawkridge bluntly states that "Teachers will have to change their roles and some will lose their jobs. Certainly a good deal of retraining will be required" (1982, p. 333). But schools do not "retrain" or even train teachers. With less than three days of training per year on the average, most get no formal training with current, much less future, technology. A 1981 survey showed that "less that 40% [of schools surveyed] provided or supported formal training for teachers'" (Dickerson & Pritchard, 1981, p. 10). What training has been provided has been of questionable value.

Although there are indications that teachers' colleges have capitalized on a demand for "computer literacy" courses, current inservice training efforts, when such exist, have done little to allay teachers' fears about and resistance to educational technology. Even those who appear to be on the leading edge may not be well trained enough to cope with the adaptation needed for the new technologies. This "rapid development of the computer in schools has brought about the emergence of a new group of specialists who are calling themselves 'educational technologists.' They have embraced the label but not the concepts of the field" (Ely, 1983, p. 2). Worse, advocates hyperbolizing the future of machine-based learning do not even know that college-level programs have existed for three decades. One editorialized that "educational technology as a subject will likely be introduced at teachers' colleges in the next few years. . . ." (Staff, *Newsweek on Campus*, 1984, p. 7).

While effective teacher training, if it existed, might alleviate concerns about the actual use of technology, it could not be expected to alter significantly perceptions of technology as a disruptive force. Traditionally, there has been little accountability for schools' internal operations and there is a "tendency among teachers to avoid working conditions that could eventually mean accountability" (Brusling, 1982). This is particularly significant because, although change may be mandated or brought about by political pressures, unless an innovation is perceived as advantageous, teachers will adopt it overtly but reject it attitudinally, eventually asserting their autonomy in the classroom and making informal decisions to discontinue the innovation (Archibald, 1980; Parish & Arends, 1982).

So where does that leave us? What exactly is the role of educational technology at present? Heinich suggests that "because of potential threats to job security, teachers tend to reduce all technology to the status of aids—to the status of tools used at their discretion" (1983, p. 25). A teachers' union recently proposed a resolution affirming the concept of technology as tools: "RESOLVED, that computers and other forms of educational technology must be recognized as supplementary teaching aids which cannot replace the human and specialized skills of the teacher." This fear of technology, Glines points out, increases our problems (1980). "Schools are intent on avoiding the controversial. [They] 'take on' computation as a cost-effective adjunct to their standard curricula. It is not in their immediate interest to 'see' other aspects of the computers they have taken on" (Turkle, 1980, p. 24).

There has been little progress even where one has reason to expect leadership. "The degree to which the new technology has penetrated [universities] is inversely related to their relative educational prestige. . . . The elite stratum. . . may dabble a bit with fancy technology," observe Andrews and Hakken (1977, pp. 85, 88). For instance, over twenty years after land grant institutions such as Indiana University established faculty positions and graduate degree programs in educational technology, Harvard University created a single position. The in-depth experience to judge the direction of development has generally resided in a few, mostly land grant, colleges. The balance has tried to graft paradigms, status, and research traditions onto funding opportunities. For instance, the major research journals in the field have in over three decades published the work of only a few authors representing high-status schools of education. Worse, if leadership is a criterion, only one faculty member from an Ivy League college has served at the policy making level in the national media organization. Current production leadership, especially for television, resides almost entirely in the community colleges.

What, then, can be done to overcome teacher resistance? Today's teachers are unlikely to be much impressed with the sort of appeal that worked at the turn of the century:

> Splendid offer to teachers: This magic lantern with fifty bright colored pictures given free for selling twenty-four packages of bluing to your neighbors at ten cents each. For extra premium, twenty-five exhibition tickets, a show screen, and large posters for advertising your show. (Freedman & Berg, 1961)

Jorgensen (1981) calls for three types of relationships between educational technology and teaching that might alleviate some of the problems caused by teacher resistance. The onus on the educational technology industry is to:

- assume a more open and attentive posture toward teachers, teaching, and classroom communication processes in order to stimulate ecologically valid research efforts in educational technology;
- continue to seek ways to play a directive, or instructional, role in teacher education, especially in advancing systems approaches to instructional problem solving; and

- engage in collaborative ventures in inquiry and development with teachers, teacher trainers, and researchers to establish cooperation and collaboration where competition and condescension now exist.

Stewart (1982) suggests these approaches to reduce resistance to innovation: establishment of work teams, modification of organizational procedures to encourage use of computer technologies, and consideration of human factors. Human factors, or foibles, require close observation. For instance, a recent computer program for record keeping has been one of the most popular marketed by the company. Why? It produced a current alphabetized class list. It made the teacher's job easier! The obvious benefits, making teaching easier and more effective, have been glossed over. The new technologies currently take more time and more effort than traditional teaching methods, and still yield mixed results.

Teacher Training. Since teacher resistance has been a significant barrier to the successful implementation of educational technology, it must be confronted if efforts to ensure the effective use of technology in education are to succeed. Whether resistance stems from (1) reluctance to take on additional work for no observable benefit, (2) unfamiliarity with and thus inability to use technology, or (3) fear of changing roles and responsibilities, comprehensive teacher training in educational technology is an appropriate and necessary remedy.

Clearly, teacher training efforts to date have been far from adequate. "What you have now," says Alan Kay, chief scientist at Atari, "is a bunch of people attempting to teach violin who have had a six-week course in what the violin is and who have never heard violin music before" (Staff, *Time*, Oct. 10, 1983, p. 64). Williamson's 1970 claim that teacher training programs "know too little abc • new developments in educational technology, and do not have the financial resources to purchase equipment for training purposes" stands virtually unchallenged today (p. 68).

> At the present time, the dichotomy between the sophistication of the technology and the sophistication of the training would seem to be increasing: computers are much easier to mass produce than trained teachers. A conscious and deliberate effort of will and planning on the part of teacher training institutions is required to overcome this gap. (Dickerson & Pritchard, 1981, p. 12)

One important element missing from most teacher training in education technology is the concept of technology as process. Most computer training has made little distinction between the training of teachers and computer professionals, and few of the professional training courses discuss the fundamental elements of curriculum revision (Winner, 1983). Merely knowing one's way around a keyboard and being able to load a program do not enable a teacher to make intelligent decisions about the appropriate uses of technology in a particular classroom situation or even to select appropriate software. A reasonab[illegible] ate step is to use the technology itself to provide inservice teacher education and short practical skills training in the use of technology as a means of overcoming fear of the equipment.

Humanistic issues are concurrent concerns. Tyler (1981a) advocates teacher preparation courses which stress fostering positive self concepts in children and inservice courses which give teachers the opportunity to resolve problems within their own schools as ways of improving the quality of education and providing the kinds of education demanded by the complexity of life in a technological society. Similarly, Bowers (1977) advocates teacher training on the function of public schools as carriers of technological beliefs and values. One possibility, suggests Lidtke (1981), is to provide a specialist to consult with teachers on computer applications in the classroom and conduct training sessions for teachers on computers. Using another approach, the United Nations International [Elementary] School computing implementation program, designed, implemented, and evaluated as a change process, serves as an example of a successful inservice training effort. Its goals were to demonstrate an increase in faculty awareness of possible computer classroom interactions and to extend this usage to demonstrated exploratory and experimental usage (Winner, 1983).

Regardless of the methods used, teacher training can be an expensive undertaking. "As a rule of thumb, each dollar spent on computers requires two more dollars to teach the teachers how to use them. 'If you don't change the preparation of the teachers,' says Tucker [of the Carnegie Corporation's project on information technology], 'putting a lot of computers into our schools would be an appalling waste of money'" (Staff, *Time*, Oct. 10, 1983, p. 64). We might, in fact, find that "we have dream devices which we cannot make work effectively" (Oettinger, 1969, p. 221).

Cost Concerns. Some of the resistance impeding adoption and adaptation of educational technology can be traced to "the fact that extra time and preparation are required to use these technologies" (Lidtke, 1981). Clearly, additional costs are involved. That is, the initial investment in educational technology is comparatively small, especially when amortized over a period of years. However, the repair, materials production and purchase, maintenance and proper operation of this technology is large. The large cost of time, money, and effort is such an impediment that technology is not used even though the initial investment is made and the equipment is available. The technology cannot then be adapted to use in an educational setting. If the technology is not regarded as central to teaching and learning, if it is reduced to supplementary status, it becomes an add-on cost that is regarded as a dispensable luxury or, worse, as a reminder of poor decision-making.

"The textbook endures for two main reasons: cost efficiency and the symbiotic relationship that has developed over a long period of time between teacher and textbook" (Heinich, 1983, p. 25). As yet, there is little evidence of technology's cost-efficiency. In fact, Hawkridge (1982) suggests that "the evidence on costs tells us that technology does not bring lower costs per student except in very exceptional circumstances. Instead, technology is likely at present to constitute an added cost" (p. 326). Before microcomputers became a commercial success, David found CAI implementation costs especially high for courseware, with costs running two to three times more than traditional instruction (1978, p. 19).

"Mountains of research done over the last 30 years have revealed that only a fraction of the new learning systems—notably PLATO's physics courses and 'Sesame Street'—showed solid evidence of educative and, just possibly, cost-effective values. With such general ignorance, how are we to judge the learning benefits of the billions of dollars about to be spent by educational institutions on computing?" (Bonham, 1983, p. 72). Although substantial capital investment is unlikely, given the history of education, Hawkridge posits that doubling U.S. educational budgets for materials and equipment and spending the extra money entirely on new technology would not have a significant impact until years later (1982, p. 33). Mumford's (1964) counsel that restructuring will be a "long process" still bears heeding.

Concerns Outside Direct Control of Education

Market Pressures. "The [computer] vendor is the fox among the lambs" said an attorney in an interview (Staff, *Time*, October 3, 1983, p. 68). And most educators agree. One viewpoint in the commercial sector is that the lambs must be willing if the fox is to be changed. An executive opened a conference with the premise that "for the microcomputer courseware industry to continue to supply a stream of new and improved products, the business must be profitable." Technologies that become obsolete or fall out of favor do not survive long in the marketplace. The market momentum built up in the 1960s as a result of the injection of federal dollars for the purchase of AV equipment, media-based instructional programs, and programmed instruction peaked and subsided drastically during the past decade. "Big business saw education as a mass market. Giant corporations believed they could make money by employing their skills and experiences to solve the problems of education. . . . In large part these business ventures failed. Educators rejected the industrial methods as too impersonal, unsuited for the human factors of educational programs" (Kemp et al., 1980, p. 26).

However, hope springs eternal in the hearts and minds of both buyers and sellers. Current efforts to evaluate the present and future markets for information-oriented technology focus, naturally, on the microcomputer. Lehmer, a Kaypro account executive, describes the U.S. market for personal computers as a bell curve. The leading edge "would be the innovators and early adopters. The big bulge in the middle of the curve—most of the U.S. population—is the 'mass market.' And the trailing edge of the curve represents the laggards who catch on to a trend only after everyone else has" (Shea, 1984). Now, he says, the "mass-market" phase has arrived and selling micros is no different from selling so-called packaged goods. "Hypesters," Shea maintains, "venture where technocrats dare not go" (p. 69).

Unarguably, technology sales have experienced rapid growth and will continue to do so in the foreseeable future. Sales of factory consumer electronics in 1973 were $6,934 million (EIA, 1983). In the decade since, sales have doubled, and there are no indications that this growth rate will decrease in the near future. One engineer estimated that fundamental physical limits will not retard progress through this decade, and that we will continue to see near-exponential growth in numbers of components. If nothing else, we have seen exponential growth in magazine titles and sales in emerging technologies.

Rapid growth is accompanied by declining prices and increasing competition between vendors—"the vicious price war raging in the U.S. home computer industry" (Staff, *Business Week*, Oct. 3, 1983, p. 59). In an economy that measures the success of a product by sales volume, there is a natural tendency to use statistics such as these as a blanket endorsement for all technology. "In the best of all possible worlds, [however,] sales [of technology to education] would be a function of how much the product aided learning" (Holloway, 1982, p. 3). There is no evidence, alas, that there is any relationship between sales and learning. There is a relationship between consumer sales and educators' interest—and educational sales may be inferred. Figure One illustrates the two to five year lag between growth in the consumer electronics market and activity in education as represented by the number of articles and papers written on related topics. Clearly, education responds to the marketplace, albeit slowly, and economic activity may be a successful predictor of future trends in education.

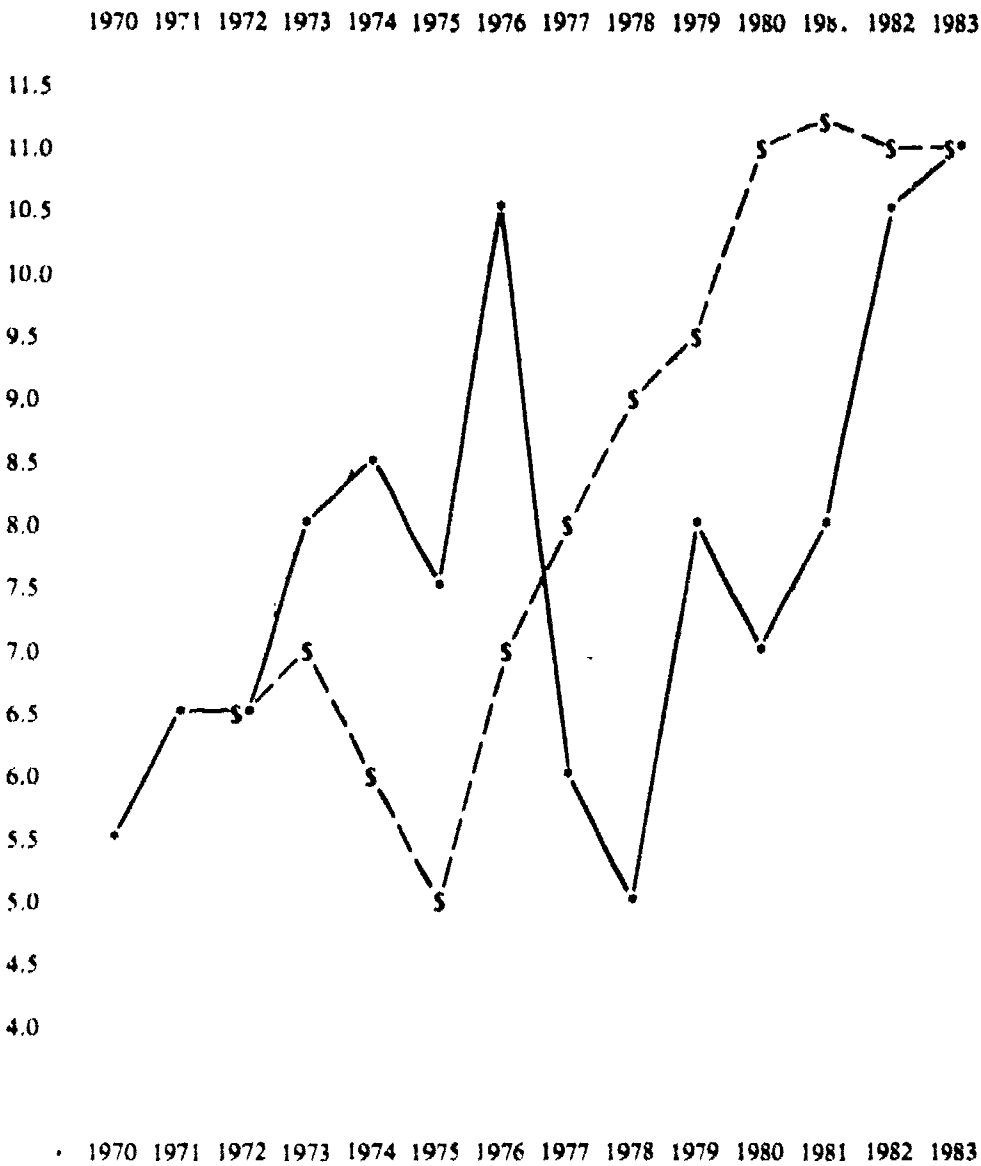
To date, education has not been a major segment of the market for technology. "Knoware," for instance, aims at a broad market: "American businessmen, American students, American homemakers, are getting Knoware fast!" (Lois Agency creates, *New York Times*, October 3, 1983, p. D-12). But three-quarters of Knoware's $775,000 advertising budget was aimed at business executives, not education. "As yet, manufacturers and purveyors of new information technology are not looking to educational systems for large sales. Their first targets are commerce and industry, and no doubt, the military" (Hawkridge, 1982, p. 333).

It is not only marketing that is targeted at other sectors; the products themselves are developed for non-educational use. Hawkridge suggests that "manufacturers of technological equipment for use in education are, almost without exception, aiming to make profits. They have been accused at times of being irresponsible in selling technology because they have tended to leave its use to the purchasers" (1982, p. 327). The alternative is that education has been irresponsible in buying technology.

The general economic growth and federal funding reached a peak for nontextbook instructional materials in the early 1970's. Since that time, the proportion of education's budget for nontextbook materials has been steadily decreasing. This contradicts the assumption one might make based on the surveys purporting dramatic increases in the number of schools with computers.

Figure One. Consumer Electronics Annual Factory Sales in Billions of Dollars ($).
(Electronic Industries Association, 1983, p. 1);
ERIC Postings by Major Descriptor by Hundreds (*) (1983 estimated)
(B. Minor, personal communication, 1983)

Consumer Sales Precede Academic Citations



Several inferences can be drawn from this discrepancy between hardware sales and materials sales. For example, it may indicate a growing recognition among educators that commercially marketed materials do not meet education's needs or standards of quality. But the most significant conclusion is that the exponential growth in hardware sales to education is evidence of schools' concern with appearing to be involved in the computer revolution. Ownership of hardware is the most visible indicator of technological involvement, even if in actuality it is being used for very limited purposes, such as teaching programming or computer literacy.

Education functions as a market, is treated as a market, but educators do not acknowledge market forces. The use of technological devices in education is determined by sales in other sectors—and sales are slower and smaller in education than in other sectors. Historically, any "significant new force is almost exclusively controlled by profit-making corporations" (Bonham, 1983, p. 72), and technology, obviously, is no exception. Nor is technology immune from the advertising ploys used to stimulate demand for new products. Weizenbaum complains that in

> the fad for home and school computers. . . a new human malady has been invented—it's computer illiteracy. The future, we are told, will belong to those familiar with the computer. What a joke this would be if only it didn't victimize so many innocent bystanders. It reminds me of the old encyclopedia fad: "If you buy one," proclaimed the salesmen, "your child will do better in school and succeed in life." (Giesbert, 1983, p. 22)

Thus, access to educational technology takes on social implications not dissimilar to those surrounding print technology four hundred years ago.

The psychology/sociology tug of war is at the root of virtually every discussion of technology in education. It appears that

> what is being sold is a concept. But what is needed is a function. Concepts which are sold are several: being up-to-date or modern; appearing efficient, innovative, especially in use of technology; status and individualization. These sell books, modular scheduling, equipment, and a variety of movements and programs to schools. This is sociology. Function can also be sold as a concept. Often the words "potential" and "future" appear when the function is a concept instead of a suitable program. Functions that are needed are student control, interactivity, motivation, feedback, practice, and a host of others that relate to learning or learning logistics. This is psychology. (Holloway, 1982, pp. 4-5)

Both the need for demonstrated functions (does it work?) and the purchase of concepts (does it sound like it will work?) will remain forces in decisions that are made about technology in education.

Social Pressures. Technology, both product and process, does not occur in a vacuum, but rather in a specific social context that both shapes and is shaped by technology. "Technology is always applied by somebody within a specific social context and cannot be understood as an independent force or a socially neutral one" (Andrews & Hakken, 1977, p. 79). Woodward refers to technology as part of a culture, "part of the domain of economic and functional efficiency, related to the rationality, science, and industrial production. . . [as opposed to] the humanistic, or humane aspect of culture—the fine arts, literature, and entertainment" (De Lauretis et al., 1980, p. vii).

Clearly, there is a tendency to associate technology with the economic, scientific, and production-oriented aspects of our culture, blaming it for the "dehumanizing" of post-industrial society. Bowers (1977) maintains that technological society has fostered the concept of efficiency instead of human fulfillment, disrupting traditions and organizing reality in such a way that it can only be viewed objectively. Buchen (1980) credits technological society with creating institutions and systems of organized complexity that call for increased accountability and quantification. Chapple (1978) suggests that technological society has, in addition to creating new institutions, caused changes in the organizational structure of all institutions and changed people's attitudes toward and involvement with these institutions so that they no longer reflect traditional patterns of response. The institution most affected, says Chapple, is education, which, because the close relationship between the family and the school has eroded, has come to be looked upon as just another human service.

The introduction of technology into the educative process becomes problematic when the educational environment itself is seen as disrupted by the technological nature of modern society. Educational policy decisions, such as whether or not to adopt a particular technology, "are not made on the basis of research evidence" (Heinich, 1983, p. 26). Rather, "most important changes in educational aims and instructional practices can be attributed to particular social, political, and economic influences" (Saettler, 1979, p. 3). Indeed, the decision-making process itself is largely political, confusing, as Richardson (1981) suggests, rather than clarifying issues. And, "education-policy decisions. . . [that are] politically expedient and educationally unwise" are a likely result (Bonham, 1983, p. 72). Weiss (in Rich, 1981) describes such decisions as emerging out of a complicated web of pressures and influences.

Rarely are educational policy decisions regarding technology utilization made by the people most likely to be affected by them—the students, teachers, and parents. Yet, states Heinich, "the extent to which any technology is welcomed into an economy or economic subculture depends on whom it affects, how it affects them and whether potential beneficiaries are in a decision-making position" (1980, p. 25). "Decision-makers underestimate the importance of local practitioners and local conditions in bringing about instructional improvement" (Richardson, 1981, p. 214).

How, then, can the educational policy decision-making process be made more rational and more likely to serve the interests of the people affected? A comprehensive information base is a logical first step. Congressman George Brown, in his introductory address to the 1981 National Conference on Technology and Education, urged government development of an information policy and support of information research (1981). And, Tornatzky and Solomon (1983) suggest that "a major science and technology policy for the next decade, in both the public and private sectors, will be identifying and implementing mechanisms aimed at integrating the conceptual frameworks, findings, and methods of social science research to maximize their utility in the decision-making process," but, they acknowledge that "an awareness of the connection between social science phenomena and economic and technological revitalization has been slow to evolve" (p. 737). One inference could be to involve the potential beneficiaries of implementation decisions in the decision-making process rather than leaving the decision to politicians and administrators. "We must become more sophisticated in how we assess the relationship of technological innovations to levels of decision making and then we must pursue adoption at the appropriate level" (Heinich, 1983, p. 26).

Involving others in the decision-making process would not necessarily make technological change any smoother, since each participant would be operating with his or her own set of attitudes, concerns, and expectations, all of which might act as barriers to innovation. Undiscriminating advocates would still push for large-scale adoption of technologies unproven in education, and critics would still raise questions about humanistic education, equity of access, and basic freedoms. Opinions on the aims and purposes of education would still differ, with many seeing the role of education as equipping students to cope in a technological environment and promoting the "positive freedom" that has been lost as a result of technological society. Since there is general agreement that the schools are no longer meeting societal expectations (cf., Aiello, 1979; Clifford, 1981; Meade, 1981), discussions related to educational policy decision-making might, in fact, lead to resolution of long-standing disagreements and redefinition of the educational mission.

Whoever the decisionmakers are, "future thought about planning for information technology is less likely to be concerned with technology than with the human factors at the interface between the machine and its user" (Resnikoff, 1982, p. 5). Turkle recommends consideration of the

> subjective side of the computer presence. . . [as] highly relevant to understanding issues concerning computation and public life. When people talk about computers they are often using them to talk about other things as well. In the general public, a discourse about computers can carry feelings about public life—anxieties about not feeling safe in a society that is perceived as too complex, a sense of alienation from politics and public institutions. (1980, p. 18)

The same can be said about discussions between members of the academic community on the issue of technology.

Critics of educational technology, citing past failures of technology in education, have fostered a recognition that there are issues other than learning at stake and that technology should serve human needs—a growing awareness that is likely to influence future trends. Technology, for determinists such as Winner, has invisible politics built in as a function of how the equipment works. The power of social forces is more significant for others. Knapper (1982), for instance, suggests, "Technology itself is neither good nor bad, but depends for its success on how it is used. This in turn is as much a sc·:ial, psychological, and political matter as it is technological" (p. 58). "The basic issues. . . do not depend on the course of development [and deploymen:] of the technology" (Grayson, 1976, p. 130). While educators as yet have scant influence on the development of technology, they can have profound influence on perceptions of technology, reminding us that "man makes technology in his own image" (De Lauretis et al., 1980, p. 7) and helping in a search for an answer to Hilton's question, "What is to become of Man? If he no longer can be Man, the Producer, will he become merely Man, the Consumer? Or could he possibly become Man, the Creator?" (1968, p. 11).

Conclusions

Where are we going? The hazy alternatives for the future, the unknown potential effects of decisions, and the powerful conflicts of interest make the topic of educational technology a difficult one to analyze. Yet, decisions must be made—decisions to buy, to wait, to train, to develop—and with each we risk the future. Evaluation of the risks each decision entails, on the basis of existing literature and documented experiences, will, in the absence of direct experience, facilitate informed decision-making in specific and unique local settings.

Economics obviously plays an important role. Products that work, bombs, for instance, or telephone switching systems, usually go through a long and expensive process of research and development. To do this, major developers maintain both "in-house" testing laboratories, such as Bell Labs or Los Alamos, and a string of independent contractors, such as Sandia or Battell. Even with the world's best minds and biggest budgets, development of new technologies "from scratch" is a risky business, occurring only when and where there is a viable existing market with potential for large profits. This is a rarified stratum. For example:

> There are probably between three and five thousand people on the planet who can design chips. The majority of them work in the mass market semiconductor industry and for computer manufacturers. Users are not prepared to go through, or do not understand, the sometimes complex routines and procedures that would have to be learnt and followed to make standardized chip-based systems cope with company or user specific tasks. What this means is that designing chips, and thus systems, for specific purposes does not happen at the pace one might expect. It happens, all right, but only for the mass markets. The smallish markets [education] are not having enough attention paid to them, which is inhibiting the penetration of chip-based devices into many products. (Malik, 1983)

It is unlikely that education will be considered a large enough market to warrant special R&D attention for some time to come. (The seemingly large expenditures for education are mostly salaries for teachers and administrators. The percentage spent for non-print materials is small, from nothing to three percent for most districts. Compared to the home and business market, a vendor views the purchase by education as insignificant. This is likely to remain so since there is little discretionary money and operating costs continue to rise against a decreasing tax base and relatively static birth rate.) Nor is there likely to be much technology developed by education for education considering the controversy surrounding uses of technology in education and the limited resources available. The question that remains, then, is "What can we as educators do to make a proactive response to computer technology?" (Wedman, 1983, p. 47).

The introduction of a new pattern of behavior is an innovation. This can best be understood by studying the relationship of innovative behavior to such variables as (1) characteristics of users, (2) characteristics of innovations, and (3) strategies of diffusion and dissemination. Optimum strategies can be selected to the degree we understand how they interact in different environments. The last two decades of research have confirmed the complexity of these interactions. The complexity has been a bit humbling and most authorities have shifted from a rigid paradigm of inquiry to one which accommodates multiple perspectives as advocated by Rogers (1983).

A perspective on technical changes in education will help us make decisions to the extent that the perspective matches with reality. The factors involved in change are evident and well-documented in analyses of education as well as other fields; the spread of a new computer or information about hybrid corn is explained by such factors as cost, ease of use, or relative advantage. The difficult part of the explanation is identifying how the factors interact and which are most significant.

The following arguments are advanced as assumptions based on recognized factors. The factors are similar across situations—changes in the way technology is used in education are not different from other fields—but the factors do differ in how they interact and how significant they are. To assume the technology in education is the same as technology in the military or business ignores the position of education in society and the economy and how technological practice is developed. Status may be the first priority for a school—the winning team for instance—while increased yield may be first priority for a farmer. Thus, while the propositions are straightforward— buyers are influenced by status, for instance—it is less clear which factors are most important and how they interact. Some of the basic propositions for education are:

- Technical artifacts do not originate in education nor are they intended for teaching or learning.
- Initial uses of technical devices are designed for the general consumer market, industry, government, or the military.
- The use of technical devices in education is determined by sales in other sectors—and sales are slower and smaller in education than in other sectors.
- Educators' purchase patterns are similar to those of the consumer market in general—and for the same reasons.
- Education functions as a market, is treated as a market, but educators do not accommodate this in planning.
- Technical devices must be adapted for education; they cannot simply be adopted.
- Storing and retrieving information is not the same as learning.

Adaptation Not Adoption

There are two ways to acquire a technological capacity: develop it from existing resources or adopt a technology developed for other markets. Since the first is not a viable alternative for education at present—there are no Bell Labs for education—then the issue is adoption. Direct adoption, however, is not the solution either; past experiences with technologies have taught us that "the infusion of large sums of money to purchase equipment, materials, and facilities does not automatically pay off in greater use of media [technology] or better instructional programs" (Kemp et al., 1980, p. 27). "Versatility comes not from the simple direct adoption of technology, but from the rapid and practical adaptation that occurs" (Holloway, 1984). Adoption of an innovation without adaptation to fit local conditions and needs leads almost invariably to discontinuance; local adaptation is an important determinant of both the implementation and continuance of an innovation (cf. Berman, Greenwood, McLaughlin, & Pincus, 1975; Parish & Arends, 1982). Technological transfer does not take place unless the idea of the product or the process is fused with existing situations, products, or processes. Successful implementation of an innovation depends, to a large extent, on its demonstrated effectiveness, and "instructional media and materials produced by educational technology must be in keeping with, and matched to, the educational objectives selected for a specific program, in order for effective permanent learning to take place" (Williamson, 1970, p. 66).

As Tornatzky and Solomon (1983) suggest, "The process of creating and deploying new technologies is not merely mechanistic; it is inherently a *social* process that depends heavily on human actors as well as machines" (p. 737). And, human beings are not fond of taking risks unless the benefits of doing so or the dangers of failing to do so are clearly demonstrated, preferably by a peer or co-equal. "Once a technological advance has demonstrated its utility and value, the probability that it will 'take' soars" (Steele, 1983, p. 140).

> There is adequate time to introduce the technology in a planned implementation; to develop model programs that demonstrate an educational advantage and make mistakes quietly. . . . To do this, all that is known about instructional design needs to be applied. Conversely, our ignorance of how we learn requires many formative field tests. . . . We must attend more closely than ever to the student's view of the experience, put the technology in the classroom, and watch and listen to what happens in a natural setting. (Holloway, 1982, p. 17)

Process changes are more frequent than product changes in industry (Utterback, 1974). The same is true in education; the way we do things is changed more often than the kind of product. Sometimes, as in industry, these process changes are to save money. At other times they are to improve the product. It is safe to predict that print will continue to be important in education. It is likely, though, that the way print is used will change. So, even though the physical technology or artifact remains the same, it may be used in very different ways.

The way something is used is much harder to observe or measure than the existence of the artifact. Recent surveys of computers in schools, for instance, suggest that a majority of districts have computers. However, many have had computers for years. They are used by advanced math students, usually the college-bound, in a calculus class in senior high school. Asking if a school has a computer or if it is used for instruction may misrepresent the new role of technology. A computer used for instruction is cast as a supporting statistic in a new movement rather than a traditional and limited use. Making the slight discrimination between microcomputers and terminals in a survey does not help, since the first courses to get microcomputers were in math and the first uses for them were the same uses the terminal had served for the last decade: no revolution there.

The kinds of information collected on new technologies must include the ways in which they're used. We know that decisions are made on soft "knowledge of social impact of policy" (Caplan, 1977); and catering to the "polity" rather than "policy" means short-term planning. Conclusions about use of equipment are highly inferential if they are based on (1) the existence of the equipment and (2) the limits of the imagination of the advocates.

Educators will find little comparable guidance in their traditional information sources for adapting technology to meet specific needs. "The 'cutting edge' of the literature on the relationship between computer technology and education is not found in the educational journals. It is found in trade magazines, technical journals, and professional publications apart from the traditional educational arena. While the educational community reads general information telling the reader 'You should use this technology' other journals are saying 'This is *how* to use the technology'" (Dickerson & Pritchard, 1981, p. 8). Even in large scale (national) applications for mass communications and information technologies, problems "have been dealt with as they arise, largely on an ad hoc basis, with no conceptual underpinning" (Signitzer, 1980, p. 186). This is, in part, due to the "natural tendency to publicize successes while allowing failures to die quietly. In addition, the data needed to analyze a failure—even for an internal study—are usually skimpy and difficult to assemble. In reality, the failure rate of innovations is high. This fact reflects the intricacy and interdependence of modern advances in technology" (Steele, 1983, p. 136). It is regrettable that information about technology failures is not readily available to guide the efforts of others.

Fortunately, innovators in emerging technologies in education, especially computing, are discovering instructional design and development. They bring a much needed fresh perspective to the field and may break the grip of experimental psychology research methods that have strangled so many possible adaptations. Adaptation is a fairly common practice in other sectors. In a major study of 157 innovations in industry, for example, Myers and Marquis (cited in Utterback, 1974) found that 98 of the ideas came from outside sources. Openness and flexibility are more likely to yield answers than narrow inquiry. "Educational technology is basically the product of a great historical stream consisting of trial and error, long practice and imitation, and sporadic manifestations of great individual creativity and persuasion" (Saettler, 1979, p. 3). While instructional developers fumble with the machines and the computing experts fumble with instructional development, a new synthesis is being formed—a synthesis that will facilitate the adoption of technology for education and produce the evidence of effectiveness needed to spur further experimentation and implementation.

The new information technologies are our current philosopher's stones. Certainly we will learn much, but it will be "on the road." We must experiment, play with novelty, try things out, and take care to avoid building psychological palaces on foundations of silicon physics. Changes in how information and experiences for learning are supplied will take place at different rates as a function of the kinds of learning involved and the resources available. Generally, change will be relatively slow, since there is little evidence of what changes are needed, but the stability of the system is a protection for society and for children. Adaptation of information technologies for school use will be gradual, with progress best measured over decades. Along the way, many of the outstanding issues and controversies will be resolved.

Grounded Theory: Praxis for Adaptation

If, as Steele suggests, "There is no substitute for real-life demonstrations" (1983, p. 139) and adaptation to local conditions is necessary for successful adoption of an innovation, how is technological determinism best overcome? Pursell (De Lauretis et al., 1980) contrasts the "integration and uniformity" tendencies of an authoritarian technics with "openness and diversity, characteristics of a democratic technics, [which] are essential for the kind of successful adaptations which our society must make to survive" (p. 25). Openness to alternative possibilities and diversity in thinking about learners' needs and how they can be met through appropriate uses of technology are also key ingredients of the type of experimentation through which adaptation of technology for educational purposes can occur. And, teachers are learners.

Adaptation is like invention; it requires realistic trials and sensitivity to unexpected interactions and unanticipated outcomes. Since there are no rigid objectives in this formative process, it is hard to measure progress and easy to lose direction. Like invention, adaptation is difficult to do on a schedule and, when it does happen, it is likely to be overlooked.

Adaptation requires us to "adopt a *learning* rather than a *knowing* stance toward most problem-solving situations we are involved in" (Richardson, 1981, p. 211). It is, to a large extent, a process of inductive inquiry: "It requires patient industry, and a humble and conscientious acceptance of what Nature reveals. The first condition of success is an honest receptivity and a willingness to abandon all preconceived notions, however cherished, if they be found to contradict the truth" (Tyndall in

Spencer, 1860, p. 80). Adaptation has its basis in "grounded theory"—theory that is grounded in demonstrated events and observable facts (as Newton's theory of gravity was grounded in the observation of the falling apple). The incontrovertible event or fact leads to experimentation.

An example of grounded theory leading to adaptation in the classroom is a teacher's decision to use LOGO after observing that students learn effectively by tutoring each other. By using LOGO to "tutor" the computer, the students themselves are learning. Similarly, the potential of instructional television (ITV) for creating excitement for learning has been demonstrated by such broadcast productions as The Electric Company (Pekich, 1979) and has spurred efforts to bring such programs into the classroom. The rationale for using grounded theory as the basis for experimentation and adaptation is that, while "the prediction of eventual educational roles for computers [and other technologies] is difficult" (Ragsdale, 1982, p. 5), we may find guidance in inferences drawn from observation of successful practice—recalling again that practice often precedes theory.

Grounded theory provides focus for adaptation: "Diluting effort by aiming at several potential applications, or seeking refinement of properties without a specific application in mind, is an invitation to failure" (Steele, 1983, p. 139). Grounded theory narrows the range of possible experimentation without limiting what may be learned from any one experiment. When fishing for trout, the fisher has a better chance of reeling in a catch if he casts his line in a spot where trout have been sighted; experimentation is more likely to lead to successful adaptation if it is grounded in observed instances of reality.

Collaboration for Adaptation

"At the present time, few educators understand information technology, and few information technologists understand education. . . . It is going to take a very large amount of software development, oriented toward education and carried out by groups that understand both education and information technology, to create the essential base of educational technology" (Licklider, cited in U.S. Department of Education Task Force, 1981, p. 14). but first the agenda and the participants must be defined:

> It is important to draw attention to a difference in emphasis between those who see technology-based instruction as primarily a matter of using technological hardware for teaching and others who espouse a definition that stresses any systematic approach to learning, whether or not it involves machine-based technology. (Knapper, 1982, p. 42)

This difference in orientation can, in fact, confound efforts to develop the capacity to adapt and implement technology in education. It also has led to new organizations centered on a particular medium, such as videodiscs or computers, and existing organizations splitting into divisions representing different processes and machines.

Who, then are the most appropriate participants in efforts to develop educational technology as a linking science? Teachers can be initiators of necessary educational changes, as Virgin (1976) suggests, but it is a poor use of resources to admonish teachers to change the system when their loads are heavy and their decisions few. They have "little or no time to be innovative and creative" (Williamson, 1970, p. 67). Nor do they, for the most part, have the necessary technical expertise. Industry can provide the creativity and technical expertise but is not conversant with the learning process or the needs of education. Clearly, no one economic sector can provide all the ingredients necessary for success; some degree of collaboration across organizational boundaries is in order, bearing in mind that,

> in general, any successful collaboration should be based upon at least two considerations:
> (a) Each party must perceive a potential benefit, and
> (b) in the long term, neither party should benefit at the expense of or to the detriment of the other. (Lynn & Long, 1982, p. 203)

The "whatever will be will be" approach to technology, that only one line of development is open, is nonsense. "Basic" research is rarely value free. Those who fund it and those who carry it out do so from their own particular perspectives with their own goals and preconceptions. "The basic issues, however, do not depend on the technology, but rather on the goals that are set and the values that determine the course of development of the technology" (Grayson, 1976, p. 130). Further, "the distinctions between basic and applied research are uncertain and changing, and often related to a state of mind rather than differences in problem selection or approach" (Lynn & Long, 1982, p. 202). Teachers are at the "interface" between children and technology. They, even more than the children, must be involved, observed, and satisfied if the research is to have an impact. A traditional basic research project is unlikely to meet these criteria. The rigors of a paradigm are not as important as the rigors of the field in the development of externally valid solutions.

Predictions

Based on existing forces and demonstrated rate of change, it is not unreasonable to predict some short-term changes in education—but the advocates will be disappointed and the critics unmollified. For all the discussion about artifacts, such as videodiscs or computers, minor changes in curricular content in some disciplines are more likely than major changes. Math is an obvious example. Students will, of course, be exposed to programming—chapters will be added to relevant texts—and computers will be demonstrated. Writing may also be affected—but this will be done with little or no equipment. Why? Because there is no history of capital intensive innovation in public education. Even the simpler technologies, such as the typewriter, are still not available in schools except in a specific formal class situation—the typing class. A decade and a half of decreasing approval of bond issues, less proportional monies for materials, and an average of two hours of staff training a year mitigate against large scale adoption or use.

Equipment will get smaller, as demonstrated over the last few years. More computers will be battery operated, light, and even more powerful. By 1988, if industry forecasts are correct, battery powered computers will increase their market share by 500 percent for a dollar value greater than $2 billion (In a shifting market, *New York Times*, Sept. 16, 1983, p. D-1). And many experts believe short, simple commands in English will replace the codes now in use—something anticipated years before the "user friendly" movement. Each new generation of software keeps this hope alive and frequently demonstrates this prediction is likely to come true.

Equipment will be cheap by any standard. However, the hand held calculator and small cameras have met these criteria—and the schools have not made mass purchases or changed curricula in major ways. Neither, in their millions, did the manufacture of these items change the career paths of school children. Generally, the same is true for the home market. Thus, while sales and apparent growth of new technology will continue, it will mostly be through one vendor capturing another vendor's market. Engineering marvels will continue but will be, for the most part, for military and industrial training where development and capitalization is the norm.

Again, these are changes that can reasonably be expected to occur if present conditions and trends continue. Education still will be reacting to what happens in the marketplace and in other economic and social sectors rather than playing an active role in shaping technology for education. Some ground will be gained but education still will be playing the "catch-up" game.

An Alternative Path: Enabling Policy

An alternative, and much preferable, scenario would place education in the forefront of technological innovation, playing a leading role rather than a bit part. Futurists, such as Toffler, have maintained the theme that we must create the consciousness needed for man to undertake the control of change. If educators are to create this consciousness, it will require dramatic changes in the way they view themselves in relation to the current creators and purveyors of technology as well as in the way educational policy decisions are made.

Educational technology must be a "linking science." We must distinguish "between technologies for transmission and technologies for instruction in analyzing educational problems and their solutions" (Richardson, 1981, p. 213). Tornatzky and Solomon (1983) make this distinction emphatically, underscoring the interdependencies between those who create policy and those who create technologies:

> A major science and technology policy issue for the next decade, in both the public and private sectors, will be identifying and implemen-

> ting mechanisms aimed at integrating the conceptual frameworks, findings, and methods of social science research to maximize their utility in the decision-making process. . . . An awareness of the connection between social science phenomena and economic and technological revitalization has been slow to evolve. (p. 737)

A change will require coming to terms with the needs, goals, and methods of education, making them the primary considerations in determining appropriate uses for available technology and communicating them to those who create technology. Above all it will require critical thought and creativity. Constructive proposals for new policies at federal, state, and local levels are already advanced by activists such as Pogrow (1983). Pogrow acknowledges the difficulties in developing new policy, but sees the challenges as opportunities rather than problems.

The process of change can be initiated in a number of ways, most importantly by public discussion of (1) factors which determine the uses of technology in education and (2) methods of adaptation. Without "policies" for adapting technology, opportunities will be lost, failures will continue, and eventually, some researchers warn, there will be a backlash when "the general public will realize that technology has made little difference in either the productivity of schools or the quality of their instructional programs" (Pitts, 1981, p. 19).

Attitudes don't change overnight, nor do firmly entrenched patterns of resource allocation and decision making. Facilitation suggestions have been made ("If both industry and education recognize the nature of their convergence, and the government commits itself," pleads Offiesh in 1969). The obstacles to technological innovation in education are many but are surmountable. The basic ingredients for success are present already, although they may not be recognized as such or employed to their best advantage.

We need not start from scratch; analysis of successful innovations, both in education and in other fields, will provide guidance, as will careful observations of reality. We will experiment, learning from our successes and failures alike. We will pursue adaptation, bearing in mind what we have learned, looking for optimal solutions rather than settling for what's readily available. We will collaborate with our colleagues in education and our counterparts in other sectors, sharing the most important of resources—information. Acknowledging the need for adaptation and the context of powerful social and economic forces that thus far explain most adoption, we will identify and build upon success, and each will add to a body of practice grounded in demonstrated effects of technology.

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