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ABSTRACT

This study examines the potential application of educational technology to vocational training and retraining. Its purpose is to assist program planners in the U.S. Department of Education to make more informed decisions concerning the federal role in the use of educational technology. Five questions are addressed. General findings include the following: (1) technology producers and the public are leading the movement for educational technology, but no coherent federal policy exists regarding educational technology; (2) educational technology, particularly software, is not at present cost-effective; (3) educational technology is not necessarily more effective than conventional educational techniques; (4) educational technology is used more for "value-added" instruction that has a positive effect on students; although it is difficult to measure, its future use may best be to extend instruction to groups who are underserved now; and (5) vocational education uses mainly simple technology; computer applications to training and retraining are limited. Given the uncertain role of the federal government, restrictions on budgets, and limitations on the effective use of educational technology, any policy initiative probably should be modest. (Seven policy recommendations are offered in the report.) (KC)

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Information Series No. 276

ADDRESSING VOCATIONAL TRAINING AND RETRAINING THROUGH EDUCATIONAL TECHNOLOGY: POLICY ALTERNATIVES

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The National Center for Research in Vocational Education
The Ohio State University
1960 Kenny Road
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1984

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TABLE OF CONTENTS

FOREWORD

Vocational education programs in the United States serve a diverse clientele with a multitude of programs in complex and diverse settings. The diversity and complexity of these settings contribute, in fact, to the federal policymakers dilemma: how to formulate federal educational policy that is relevant in all settings.

Policy analysis, too, is complex and multi-opinionated. This dual complexity of programs and policy analysis presents special problems for developers of policy options. The policy analyst's role is seldom simple, but the search for policy alternatives that are meaningful and usable is an essential undertaking if vocational education is to move forward.

Federal policymakers are the primary audience for this policy paper. However, state and local policymakers should find the presentation of policy options and the discussion of their advantages and disadvantages useful.

The National Center expresses its appreciation to Dennis R. Hershbach, the policy paper author. Dr. Hershbach is an Associate Professor in the Department of Industrial, Technological, and Occupational Education at the University of Maryland. He received a Ph.D in education from the University of Illinois. Dr. Herschbach has been a Peace Corps Volunteer in West Africa and was a Fulbright-Hayes Senior Research Scholar at Technical University, Twente, Enschede, The Netherlands.

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The National Center is indebted to the staff members who worked on the study. The study was conducted in the Information Systems Division, Dr. Joel Magisos, Associate Director. Dr. Floyd McKinney, Senior Research Specialist, served as Project Director and Alan Kohan as Graduate Research Associate. Dr. McKinney, a former secondary vocational education teacher, holds a Ph.D. in vocational education from Michigan State University. He has served as a university coordinator of graduate vocational education programs and as a division director in a state department of education. Mr. Kohan is a doctoral candidate in comprehensive vocational education at The Ohio State University and has a M.Ed. in Curriculum and Instruction from the University of Hawaii. Patsy Slone served as secretary for the project. Joan Blank and Roxi Liming provided technical editing, and final editorial review of the paper was provided by Janet Kiplinger and Connie Faddis of the National Center's Editorial Services area.

Robert E. Taylor
Executive Director
The National Center for Research in
Vocational Education

PREFACE

Federal policymakers need to be aware of alternative policy options before they can make decisions regarding the optimal resolution of critical problems in vocational education. By utilizing the expertise of vocational educators, the policy options should provide policymakers with information about anticipated impacts, advantages, and disadvantages of each alternative.

Recognizing this need of federal policymakers, the U.S. Department of Education, Office of Vocational and Adult Education (OVAE), requested that the National Center for Research in Vocational Education conduct a study for the purpose of preparing policy analysis papers in eight priority areas of high national interest. The areas identified by OVAE were (1) private sector involvement with the vocational community, (2) entrepreneurship, (3) defense preparedness, (4) high technology, (5) youth employment, (6) special needs of special populations, (7) excellence in education, and (8) educational technology.

In accordance with the instructions received from the Office of Vocational and Adult Education, the National Center for Research in Vocational Education conducted a limited competitive search for authors to develop policy analysis papers on the eight critical issues in vocational education. Vocational education faculty members from educational professional development (EPD) institutions of higher education entered the competition by submitting a five-page proposal. No proposals were received on the topic of defense preparedness. After an extensive internal and external review process, eight authors were approved by the Assistant Secretary for Vocational Education, U.S. Department of Education.

The authors were provided assistance in policy analysis procedures, identification of relevant literature, and feedback on draft papers by policy analysts and educators. The authors presented their papers at a seminar in Washington, D.C., for key federal vocational education policymakers.

Other policy papers produced in this series are these:

- George H. Copa, University of Minnesota
  Vocational Education and Youth Employment

- Andrew A. Helwig, East Texas State University
  Alternative Training Options for Srructurally Unemployed Older Workers

- Ruth P. Hughes, Iowa State University
  Secondary Vocational Education: Imperative for Excellence

- Clyde F. Maurice, The Florida State University
  Private Sector Involvement with the Vocational Community: An Analysis of Policy Options

- L. Allen Phelps, University of Illinois
  An Analysis of Fiscal Policy Alternatives for Serving Special Populations in Vocational Education

- N. Alan Sheppard, Morgan State University, formerly at Virginia Polytechnic Institute and State University
  A Policy Analysis of Professional Development and Personnel Preparation for Serving Special Populations

- Gordon I. Swanson, University of Minnesota
  Excellence in Vocational Education: A Policy Perspective

Floyd L. McKinney
Project Director and
Senior Research Specialist

Alan Kohan
Graduate Research Associate

EXECUTIVE SUMMARY

The primary audience for this policy paper is federal policymakers. The secondary audience is state and local level policymakers. This paper provides alternative policy options that contain information about anticipated impacts, advantages, and disadvantages for each alternative. Recommendations for solving the problem are given.

Educational technology has attracted considerable attention recently. This study examines the potential application of educational technology to vocational training and retraining. The purpose is to assist program planners in the U.S. Department of Education to make more informed decisions concerning the federal role in the use of educational technology. The paper is based primarily on secondary sources of information and examines the application of educational technology to vocational education within the larger context of education in general.

Five questions are adressed. General findings include the following:

- **What is the role of different stakeholders in education technology and what is the federal policy in this area?**

  To a considerable extent, the current movement for education technology is driven by the producers of technology and by a public concerned with the cost of education and the quality of instruction. The public school market for educational technology is large, but actual use is limited. Vocational education primarily uses little media. Private industry represents a potent market, but overall use has been modest and the more advanced and costly forms of educational technology are approached with caution.

  The federal government lacks a coherent policy regarding educational technology. Although there is considerable interest in it, there is a need to balance this interest with the reduced role of the federal government in education. Substantial reductions are occurring in research and development funds. Block grant funding, moreover, is probably retarding the application of educational technology to vocational education at the local level.

- **What is the cost of educational technology? Can it be expected in the long term to increase productivity?**

  Educational technology does not now lead to reduced instructional costs. It is mainly an added-on cost, and use levels are not high enough to result in cost-effective applications. Software in particular is expensive. To achieve higher productivity and cost-effective use of educational technology will probably require a changed perception of the conventional teaching role and altered staffing, instructional, and administrative patterns.

- **How effective is educational technology?**

  Students learn from all forms of educational technology, but there is little research to support the suggestion that technology is superior to conventional instruction or that one technology is superior to another. There is little evidence to suggest that more sophisticated technology is more effective. The single most important problem is the development of appropriate high quality software.

- **How is educational technology used within the instructional context?**

  Educational technology largely contributes "value-added" benefits to vocational instruction, that is, positive effects on student performance that are difficult to achieve through conventional instruction. It is not easy to estimate the cost of these benefits, but they are thought to be justified, even if not on economic grounds. Included is the introduction of new technical content, the simulation of processes, or the enhancement of teacher-led instruction.

  Perhaps one of the more important future uses of educational technology will be to extend instruction to individuals and groups not now adequately served. This may include retraining programs for displaced workers, remedial instruction for students with special needs, or small rural or evening programs run by community organizations.

- **What are the instructional capabilities of different technologies?**

  Vocational education mainly uses simple technology. It is effective, low-cost, and easily used. At this time, computer application to vocational training and retraining is limited. Probably the greatest current need is to interface educational technology with the competency-based paradigm.

Any policy initiative probably should be modest, given the uncertain role of the federal government, restrictions on budgets, and limitations on the effective use of educational technology. The following policy recommendations are offered:

- Claims about the efficacy of educational technology should be moderate. Federal policy should not stress cost-savings or learning effectiveness.
- Use of educational technology should be extended in the instruction of non-conventional client populations.
- Preservice and inservice teacher training activities should be encouraged.
- Vocational curricula should be revised to reflect business and industrial application of technology, regardless of the success of educational technology.
- Research and development results of other federal agencies should be explored for relevant applications to vocational education.
- A modest research effort in software development should be supported.
- Cost-savings of educational technology should be documented. Until it can be demonstrated that educational technology is cost-effective, use will continue to be restricted.

CHAPTER 1

INTRODUCTION

Improving instructional quality through the use of educational technology is an old expectation. The appearance of the motion picture shortly after the turn of the century and of radio broadcast in the 1920s. for example. was quickly followed by predictions of revolutionary applications to education. More recently. programmed learning and teaching machines introduced in the 1950s were touted as an innovation of great importance. Instructional television and large, centralized computers were the premier technologies of the late 1960s and early 1970s. The educator of today is surrounded by enthusiasm for low-cost microprocessors and new videodisc technology. both of which are predicted to bring about a fundamental alteration in instruction and the way that it is presented.

Practically every commercial breakthrough in communication. data processing. graphic reproduction. or video technology has met with attempts to find educational uses. Available as a result of decades of development is an impressive array of technological devices and software. from cable TV and digital telephone networks to simple reproduction techniques. electronic blackboards. audiotapes. and improved overhead projectors.

However. the actual application of educational technology of all kinds has been less than expected. and achievement has been modest. Teaching machines have failed to make a lasting impact. due mainly to clumsy hardware and ineffective software. The major survivor has been a systematic approach to instructional design carried over from programmed learning. Instructional television has been disappointing. and the large computers of the 1970s were simply too costly. Even widely used media. such as audiocassettes. LP records. filmstrips. films. and laboratory kits, although they certainly enhance instruction. have yet to show that they can significantly alter instructional results (Campeau 1974: Pitts and Schneider 1981; Schramm 1977). Educational technology has not produced dramatic developments in the cost of instruction. in its quality. or in its system of delivery. As Curtis and Biedenbach (1979) observe. "Education is the only major American industry which does not yet make intensive use of modern technologies to reduce its costs and to increase the scope of its services" (p. 3).

Although it is unrealistic to think that recent developments in educational technology will not eventually have a considerable impact on education, it is less certain that the full effects of the developments now occurring will be felt during the decade of the 1980s. Public education faces complex problems in the use of educational technology: some problems are economic. some concern the resistance to change. and some relate to the traditional role of the teacher; others are administrative and organizational or encompass the very character of the technology and the way that it is applied to teaching. The penetration of educational technology into public education simply has not been substantial and has certainly fallen short of the expectations of its more ardent proponents (Anandam and Kelly 1981: Koerner 1977: Pitts and Schneider 1981: and Popham 1980).

A prodigious amount of work in educational technology is nevertheless underway throughout the country. Stimulated in part by the desire to open new markets for informational technology, and made increasingly possible through dramatic cost reductions, this work has already produced a range of instructional devices and programs for application in just about all subject areas and grade levels. At the same time, concern over the rising cost of education and reluctance to increase public investment, when combined with heightened criticism over the quality of public education (Boyer 1983), has led to a search for more effective ways to provide services. Educational technology is a focus of interest (U.S. Congress 1981, 1983; U.S. Office of Technology Assessment 1982).

Purpose

The federal government has taken an active, but sporadic, interest in educational technology. Recently, Congress held a series of hearings to examine the potential of educational technology (U.S. Congress 1981, 1983). Although facing funding cuts, the U.S. Department of Education is grappling with a policy position to balance its strong interest in educational technology with the reduced federal role in education envisioned by the current administration (Zucker 1982).

The purpose of this policy paper is to explore some of the recent developments in educational technology and their potential applications to vocational training and retraining. The report is written for use by policymakers and program planners in the U.S. Department of Education and is intended to assist them in making more informed decisions about the federal role in the use of educational technology for vocational training and retraining. The report is also meant to be useful to state departments of education personnel, administrators of school districts, and specialists and administrators of other educational institutions, such as technical schools, community colleges, and universities, who have an interest in vocational education policy planning.

Source of Data

This study is based primarily on secondary sources of information. These include research literature, congressional reports, conference proceedings, studies by the U.S. Department of Education and the U.S. Office of Technology Assessment, information from repositories, and various trade and professional journals. No comprehensive review of federal activities is included because the information is scattered throughout different departments within agencies and between agencies. Existing summaries are used. Interviews were also conducted with individuals in the U.S. Department of Education, the U.S. Office of Technology Assessment, the National Institute of Education, the U.S. Department of Defense, and the American Society for Training and Development.

The report examines the application of educational technology to vocational education within the larger context of education in general. A paucity of good information on educational technology and vocational education severely restricts a reasonable overview. Perhaps more important, all of the problems facing other applications of educational technology also confront vocational education. The effective use of educational technology for vocational training and retraining depends upon the successful resolution of these larger issues.

Although there is considerable literature relating to educational technology, a great deal of it must be interpreted with caution. Trade and professional journals, in particular, tend to be uncritical advocates of educational technology, lauding potential applications while ignoring present problems. Many accounts lack rigorous standards and present unsupported conclusions. Knowledge about the use and effectiveness of educational technology is uneven, with considerably more known about some aspects and substantially less about others. It is also necessary to cull conclusions from many diverse sources, reconciling inconsistencies and filling gaps.

Educational technology is an immature field. As Koerner (1977) observes:

> [Educational technology] can be called a "field" only as a term of convenience. It still lacks a central body of theory and a corpus of recognized knowledge. It still lacks well-developed techniques of investigation. It still lacks career scholars. . . . (p. 5)

Objectives and Scope

It would be assuring to be able to turn to a well-worn formula or a simple procedure to evaluate and select educational technology, and it would be convenient to be able to say that one policy alternative is ideal for one situation, but that another is definitely better in another context. No such easy choices exist. There are not even reliable guidelines available to use in media evaluation. As Anandam and Kelly (1981) conclude, "There are probably few, if any, assignments more difficult or evasive than evaluating the use of technology in education" (p. 126).

Lacking a systematic body of evidence, it is difficult to formulate a cohesive policy. Removed from the local context, decisions are general, so caution must be used in extending conclusions to specific applications of educational technology. Also, judgments do not extend equally across all uses of technology. There are, nevertheless, basic questions that may be addressed and that form the backdrop from which policy alternatives may emerge. The following basic policy questions are examined in this report:

- **What is the role of different stakeholders and what is federal policy?**

  There are a number of groups that have a stake in educational technology: those who underwrite its cost, use its products, make a profit from its application, and have an interest in its success. The active role played by these groups, their use of technology, reasons for support, and the constraints they face have implications for the formulation of policy. Similarly, federal policy has shaped and guided the growth of the educational technology industry, and although much of the federal policy is in response to a variety of influences, a federal posture has evolved that will directly or indirectly shape future policy.

- **What is the cost of educational technology? Can it be expected in the long term to increase productivity?**

  Cost is a primary consideration in policy formulation. In a period of tight budgets and dwindling resources, cost may assume even greater importance.

- **How effective is educational technology?**

  The effectiveness of any educational practice relates to how widely it is to be adopted. To the extent that educational technology can produce acceptable instructional results, it will contribute to extending vocational opportunities, providing alternative ways of instructing, and serving different client populations.

- **How is educational technology used within the instructional context?**

  Teachers use educational technology because of perceived benefits. But other effects are less easily perceived or anticipated, and some are perhaps even negligible in the long term. Both the anticipated and unanticipated consequences of the application of educational technology ultimately have an impact on policy formulation.

- **What are the instructional capabilities of different technologies?**

  The instructional characteristics of different technologies suggest, in part, their potential application to vocational education.

Definitions

Any discussion of educational technology must immediately confront the issue of terminology. The term *educational technology* is elusive and is used in many different ways. In the more restricted, conventional sense, the term refers to the hardware and software of instruction—the devices and media used by the instructor, whether they are filmstrips, computers, videodiscs, or chalkboards (Knapper 1980). These are the electronic and mechanical gadgets and their accompanying materials that often adorn advertisements and dominate the focus of attention because they are obvious, attractive, and perhaps entertaining. In the broader and more current sense, educational technology refers to the systematic design, implementation, and management of the total instructional process (U.S. Congress 1981).

The Association for Educational Communications and Technology (1979), for example, identifies three "domains" of educational technology: educational management functions, educational development functions, and learning resources (p. 11). Eurat (see Armsey and Dahl 1973) suggests four common conceptions of educational technology: (1) the use of machines and devices in education, (2) a technology of instructional design, (3) curriculum development, and (4) the management of education (p. 2). The White House Conference on Children (1970) defines educational technology as a process that involves the following activities:

- Identifies the needs of learners, individually and collectively
- Determines what must be done to meet those needs and considers alternative solutions and options
- Involves the individual learner in determining the best way to meet his [sic] needs
- Designs and implements the selected strategies and tools
- Continually evaluates their effectiveness
- Revises when necessary (p. 150)

These broad concepts of educational technology recognize that the focus of activity extends considerably beyond hardware and media to encompass the instructional design process and the way that educational technology may enhance instruction. The hardware of technology is merely the mechanism through which instruction is delivered. Human and nonhuman resources are combined in instructional and evaluation functions.

The term *instructional technology* is often used interchangeably with educational technology. The Association for Educational Communications and Technology (1979), however, considers instructional technology to be a subset of educational technology, including instructional management functions, instructional development functions, and instructional system components. Knapper (1982c) defines instructional technology as "the systematic design and implementation of technological devices that supplant or supplement the human instructor" (pp. 41-42). Recent references are frequently made to the term *information technology*. Although this term is most commonly associated with business, it may be thought of as a type of educational technology incorporating computer and electronic communication for instructional purposes (ibid., p. 41).

The definition of the term *hardware* obviously refers to the electronic and electromechanical devices used in instruction, such as the audiocassette recorder, film projector, or television monitor. Less obvious, however, is the term *software*. Audiovisual specialists in education refer to software as the instructional materials used with the hardware, such as slides, film, and tapes. Computer specialists, on the other hand, use the term software to refer to the programs that control the hardware—the tapes, cards, and disks that give commands. Actual instructional materials are called *courseware* (Bunderson 1981). Due to the substantial popularity and use of small desktop computers, the term courseware will probably come into wide use in the near future among educators to denote the materials of instruction.

Finally, there is a difference between the use of telecommunication, video, and information-processing devices as instructional tools and as objects of study. As study tools, they are used to deliver instruction; as objects of study, they are the subjects—the vocational skills—to be learned.

The potential of educational technology currently exceeds the ability of education to make effective use of it. The purpose of this study is to explore the application of educational technology to vocational education and to provide policymakers with sufficient information to enable them to address its application in the vocational setting—in other words, to take a step toward closing the gap between potential and use.

CHAPTER 2

SURVEYING THE SCENE

Education is big business, and the potential market for educational technology is large. The National Center for Education Statistics (Grant and Eiden 1982), for example, estimates that one out of every four citizens directly participates in education. Of 234 million Americans, 56.7 million enrolled in school in the fall of 1983. There are over 3.3 million teachers and 300,000 administrators employed. Over $230 billion will be spent on education during the 1983-1984 school year. Education is the third largest industry in America, exceeded only by petroleum and retailing.

The educational technology market, however, is highly diversified and fluid. It is made up of many users requiring different product specifications. It is difficult to estimate the total size of the market or its needs, in large part because change is occurring rapidly, as a result of dramatic breakthroughs in engineering and product development. There is not a good understanding of how educational technology is used in public and private training, or of the extent of its use.

The following section briefly reviews the users of educational technology, the reasons why they use it, and the problems and constraints they face. Another section examines the producers of educational technology. The chapter concludes with an outline of federal policy regarding educational technology, with special attention given to vocational education.

Public Education

Public education is potentially the largest market for educational technology, but it is also the most elusive. Practically every classroom makes some use of educational technology, but overall use is limited. The general outlay for educational technology of all kinds is modest. Anandam and Kelly (1981) report that expenditures in the late 1970s "for technology constituted 0.3 - 0.5 percent of total expenditures at the elementary and high schools, 0.2 - 0.4 percent in vocational education and 2-year colleges, and 0.5 - 1.11 percent in 4-year colleges and universities" (p. 28). These are not relatively large amounts. Ahl (1977) suggests that monetary outlays for educational technology actually have been declining during the past decade. Public education continues to be a highly labor-intensive industry.

To be sure, schools are presently purchasing microcomputers in increasing numbers, but instructional use still remains limited. Boyer (1983) reports that "hardware manufacturers view schools as a small portion of the total computer market" (p. 192). Zucker (1982) estimates that school computer use will be only 3 percent of the total market by 1985. The U.S. Office of Technology Assessment (1982) states that, in 1981, there were a total of 145,000 personal computers installed at all grade levels, kindergarten through graduate school. This contrasts with the nearly 2 million used in homes and business, and it is projected that schools will not reach the 2 million mark until around 1992; at this time the total market will constitute approximately 22 million (see appendix A).

Secondary Education

There is considerable pressure on secondary schools to include computer use in instruction. This stems in part from parental concern over the need for computer literacy and from the perception that computer training provides a road to advanced schooling and better jobs. Some schools also view computers as a way to cope with sho. . .ges of math and science teachers, increased instructional loads, or the poor quality of instruction. These reasons probably extend to the use of educational technology in general (Sheingold 1981; U.S. Office of Technology Assessment 1982, appendix A; Zucker 1982).

Zucker (1982) reports that although roughly one in four public schools has available at least one computer terminal, approximately half of all secondary schools have this capacity, with microcomputer use expanding at a fast rate. This currently amounts to a ratio of 370 secondary students per terminal. However, with reduced federal and state funds, computer acquisition and use are placing a severe strain on school budgets. In some cases, schools cannot afford the required companion software or support services to implement an instructional system fully. Budgets for all types of educational technology are generally restricted. It is not uncommon, however, for parent groups to lead fund raising drives to purchase school computers or for schools to solicit assistance from local technology companies (U.S. Office of Technology Assessment 1982, appendix A).

With all of the interest surrounding school computer use, it is important not to lose sight of the difference between learning computer skills and using the computer as an instructional tool. The former is easier to provide. Parents, moreover, are probably interested in students' learning computer skills. Also, as computer use expands, resources will no doubt be drained away from other educational technologies.

There is some evidence to suggest that educational hardware is purchased without a clear prior perce.ption of what to use it for or of the extent of the long-term financial commitment required. The use of technology should follow from clear instructional requirements and not the other way around.

Vocational Training and Retraining

The extent to which educational technology is used in vocational education is unknown. There is, however, a flourishing industry supplying a wide range of instructional materials to vocational educators. Most are print materials, or a combination of print and simple media, such as filmstrips and loops, slides, cassettes, and workbooks. Few require sophisticated hardware. This extensive collection varies in quality and content, training format, specificity, intended training population, and required support hardware (Osborne 1982). These are developed and marketed by (1) well-known commercial publishers' specialty companies catering to a select market, (2) producers of hardware also marketing companion software, and (3) trade associations and unions.

The U.S. Office of Technology Assessment (1982) estimates that, for computers alone, there are one thousand active firms marketing programs, but few of them are for vocational instructional purposes. The market for vocational education is relatively small, compared to the potential market for general education subjects at the elementary and secondary levels. On the other hand, vocational education benefits from products of all kinds developed for business and industrial application in general, although there are few instructional areas where comprehensive coverage may be expected.

During the past decade, a considerable number of curriculum development activities have been supported through federal and state vocational education funds. As a result, many states have curriculum centers, often associated with major universities. Three regional centers produce materials for participating states. These are the Mid-American Vocational Curriculum Consortium (MAVCC), the Vocational-Technical Education Consortium of States (V-TECS), and the American Association for Vocational Materials (AACM). Various networks are another rich source of instructional materials. These include the state instructional laboratories found in forty-two states, the National Network for Curriculum Coordination in Vocational and Technical Education (NNCVTE), and the Educational Resources Information Center (ERIC). These networks basically disseminate curricula and instructional materials and contain a great amount of materials in their collections.

Federal funding has been an essential stimulus for all of these activities, because costs have been considerable. In general, the materials produced have been very uneven in quality, and use among local instructors probably has been less than desired. Centers have also tended to become repositories of large amounts of outdated and little-used materials. Surprisingly, practically all of the materials produced have been in print form, and no significant effort has been made to merge instructional development with educational technology, even in its simpler forms.

Currently, the only direct federal funding from the U.S. Office of Occupational and Adult Education in curriculum and instructional development includes funding for the National Network for Curriculum Coordination in Vocational and Technical Education, amounting to $785,000. A software evaluation project is supported through the National Center for Research in Vocational Education. Various states also conduct scattered development efforts, but the level of activity is probably diminishing due to lack of funds and other priorities.

The present policy position of the U.S. Department of Education, however, is to deemphasize direct federal involvement in curriculum and instructional development and to transfer responsibility to the state and local levels (Zucker 1982).

All along, states have been using federal vocational funding, combined with state and local money, to support development activities in curriculum and instruction. Prior to the 1976 Education Amendments (PL. 94-482), these activities were categorically funded. With the advent of block funding, however, the bulk of funds now goes to support instructional and administrative salaries and facilities. The Vocational Education Study (National Institute of Education 1981) states, for example, that "relatively few vocational education dollars are going to update curriculum and improve programs" (p. III-28), including, of course, uses of educational technology. This trend will probably continue. Faced with strict budget limits, vocational funds will continue to support program maintenance rather than improvement; educational technology will compete with other, more commanding demands for restricted state and local resources; and federal funds will be restricted from use for hardware purchase, discouraging investment in educational technology (ibid. 1981).

Community College

Community colleges are potentially fertile ground for educational technology. They have a history of providing nontraditional services to a range of client groups. Community colleges have exhibited willingness and flexibility to address different instructional needs, and program requirements suggest the effective use of educational technology. Open admission policy, flexible scheduling, the use of nonacademic and part-time faculty, short-term instruction, off-campus programs, and direct links to community business and industry all suggest innovative uses of educational technology. The conditions surrounding the use of educational technology at the community college level are more similar to those found in business and industrial applications than in secondary school use (U.S. Office of Technology Assessment 1982).

The Private Sector

The private sector plays an influential role in both the production and use of educational technology products, piloting development and aggressively pursuing markets while at the same time applying educational technology to its own training tasks. Recent developments in microprocessing and communication technology, for example, have stimulated commercial markets, with an increasingly wide range of products available to the educational public. In many cases, however, school use of technology is an offshoot of commercial products designed for other uses. Seeking to expand markets, manufacturers of hardware adapt products intended for business and office functions to instructional purposes. Public education thus largely constitutes a secondary, rather than a primary market for products (Pitts and Schneider 1981). This is mainly due to the fact that producers "cannot define the real potential of the school market either in its individual segments or in its aggregate form" (U.S. Office of Technology Assessment 1982, p. 145). Educational needs as well as the capacity to use technology vary greatly from district to district and school to school.

Marketing Technology

The current movement for educational technology is being driven by the producers of technology—a fact that few realize. The marketing strategy is on two fronts. First, after addressing the home and entertainment markets, producers have deftly turned to education, capitalizing on parental concern for educational quality and opportunity, building from public familiarity, and extending a helping hand to local communities. At the same time, producers have taken lobbying initiatives, and government at all levels has been "bombarded with the virtues of the machine" (Pitts and Schneider 1981, p. 2).

The educational technology industry, then, is a potent and viable force influencing the content of instruction, defining in part the limits of what is taught, and determining the technology used. "Pressure" for the schools to adopt educational technology stems in part from the industry that has a stake in its use and that, to a considerable extent, generates a "need" for educational technology.

Application to Training

The potential application of educational technology to industrial and business training is considerable. The American Society for Training and Development (U.S. Office of Technology Assessment 1981) estimates that industry spends approximately $30 billion annually for training, with roughly seventy-five thousand individuals engaged in full-time training and another seventy-five thousand in part-time training. Exactly how much industry spends for hardware and software is unknown.

Corporate training is becoming more decentralized, with considerable instructional activity carried out at the plant or division level (Brown 1981a, 1981b). The portability of educational technology, its effectiveness for short-term, small group training, and its ability to convey specific instructional content contribute to its attractiveness as an instructional medium. Instruction can be centrally developed and distributed to training sites, ensuring standardization of quality and content, providing instructional flexibility, and making possible employee participation regardless of schedule or location of work.

The use of expensive, advanced forms of educational technology by business and industry tends to be moderate. Companies are reluctant to phase out older, simpler technology that is working until the newer technology proves its cost-effectiveness. Simpler technology often proves to be more flexible, and it is easier and less costly to produce software for short-term use. Companies also value the ability to use a mix of media and human interaction to address a particular training problem, and they are reluctant to become "locked into" fixed hardware (Brown 1981a, 1981b).

As with the public sector, moreover, cost is a deterrent to use of educational technology in business and industry. The lack of hardware and software compatibility and the low quality of software are problems. Also, educational technology is considered less useful for some types of training, such as skill development. The U.S. Office of Technology Assessment (1982), however, suggests that "all the signs point to increased involvement of industry and labor in training and education" (p. 100).

In addition, cooperation among public institutions, such as vocational and technical schools and community colleges, is increasingly viewed as an effective way for companies to train staff. Currently, however, the private sector tends to collaborate with proprietary institutions and community colleges rather than with public secondary schools (Brown 1981a). Public programs that have close ties with the private sector tend to have higher-quality instruction (Sherman 1983).

Proprietary Education

Given the characteristics of proprietary education, educational technology could contribute to instruction. Training is short-term, its instruction is very specific and limited in scope, relatively large numbers of students follow the same course of study, and instructors may not have well-developed teaching skills. The use of educational technology in this area, however, is modest and mixed.

Trade, technical, and occupational schools make little or no use of educational technology. Instruction tends to be largely teacher directed and hands-on. For profit reasons, there is generally a low investment in educational hardware and instructional materials of all kinds. Business schools, on the other hand, tend to make considerable use of videotape, closed-circuit television and computer-managed instruction. The relationship between the technology and the learning task and work activity appears closer. Although home study courses tend to rely heavily on printed materials, greater use of educational technology is being advocated to regenerate the industry (U.S. Office of Technology Assessment 1982).

Military Use

The military has been a heavy purchaser of educational technology and has supported considerable research and development, particularly in the "high technologies," such as computer-based instruction. Given current funding difficulties, the U.S. Office of Technology Assessment (1982) observes that the U.S. Department of Defense (DOD) "will likely be the only federal agency to make major investments in R&D projects with educational applications" (p. 245). In addition, as the largest training institution in the country, with an annual educational budget of $10.5 billion, the military provides the major stimulation to a flourishing commercial educational technology market. Products developed, tested, and applied to military use spill over into industrial and school markets. Much of the state-of-the-art educational technology now available may be attributed to the influence of military investments in R&D (see appendix B).

Research and development in the area of basic skills that is conducted by the military may have considerable transfer potential. Faced with recruits characterized by low aptitude and achievement levels, and anticipating the operating requirements of sophisticated military technology, the armed services have invested heavily in basic skills training, the outcome of which may have considerable potential application to civilian training (Sticht 1981). Again, technical skills training may be another area of training technology transferable to civilian sector vocational education. Both are concerned with psychomotor skill development.

On the other hand, there are marked distinctions between military and civilian training that tend to reduce transferability. Perhaps most fundamental is the reason for using educational technology: to reduce training time and increase operational assignment time. Military personnel have limited enlistments and are paid during training, so programs are standardized from location to location and place a premium on time economy. Educational technology is considered successful if it reduces training time while leading to satisfactory performance levels—levels that may, however, be below those achieved through conventional teaching methods. This is in direct contrast to the civilian use of educational technology, which emphasizes achievement gains over conventional instruction (U.S. Office of Technology Assessment 1982).

The Federal Role

The federal government is an important actor in the educational technology scene. In 1982, a total of $273,915,000 in federal funds were invested in educational technology research and development (see appendix B). Such funds are used to stimulate new developments, to encourage local and state support, and to bring about change. Funding priorities constitute a critical focal point for federal policy.

Research and Development Priorities

By far the largest amount of federal support for educational technology goes to the U.S. Department of Defense: $256 million in 1982, in contrast to $13.4 million to the U.S. Department of Education and $4.5 million to the National Science Foundation. Of the amount spent by the U.S. Department of Education, the largest percentage goes to support computer research and development in science, math, reading, and written communication. Instructional television receives support, as do activities in videodisc technology, teleconferencing, and educational technology applied to the education of the handicapped (U.S. Office of Technology Assessment 1982). Apparently no federal research and development money was earmarked in fiscal year 1982 for educational technology applied to vocational education (see appendix C).

The National Science Foundation obviously supports activities in mathematics, engineering, and the physical and applied sciences. The bulk of funding goes to the areas of computer use in education and educational broadcasting (U.S. Office of Technology Assessment, 1982).

For the past decade, the U.S. Department of Education has tended to support the more popular, new, and expensive technologies, funnelling money into instructional television and mainframe computer application, for example. Television programming has received substantial amounts of support (Kincaid, McEachron, and McKinney 1974; Pitts and Schneider 1981; U.S. Department of Education 1982; U.S. Office of Technology Assessment 1982). On the other hand, substantial federal funds have been made available to school districts through formula or block grant funds to purchase hardware, library, and instructional materials. In other words, the federal government has played an active role in stimulating sales of technology. Probably lacking, however, has been basic research designed to solve many of the developmental and application problems surrounding educational technology, particularly in the case of the more simple technologies.

Substantial reductions are being made in research and development funds within the U.S. Department of Education, forcing cuts in educational technology research. Educational research accounts for 4 percent of all federal funding, but projections are that educational research will constitute 13 percent of total spending reductions. By 1984, it is projected that funds will fall by as much as 53 percent below actual 1980 levels (U.S. Office of Technology Assessment 1982).

Federal Policy

Current federal policy on education is inconsistent. Education for "new technologies" is considered a priority, yet reductions in federal funding rule out any substantive initiative. Some programs are cut, whereas other activities continue on at a reduced scale. Educational television still receives the bulk of funding, although at a reduced amount. The U.S. Department of Education now faces the task of reconciling a recognized need with the reality of diminished support (Zucker 1982).

One result is a lack of coherence. Support for using information technology in mathematics education has been discontinued, for example, while at the same time schools have been provided marketing and evaluation information to assist in the purchase of technology. Long-range planning has been curtailed by uncertainty, and there is no central goal on which to focus acquisition. Any new initiative, moreover, threatens to take funds from other activities.

Block grants also compound the difficulty of establishing consistent policy. It is difficult to stimulate support for specific purposes, such as educational technology. As previously suggested, federal expenditures for vocational education under the 1976 amendments, for example, are intended to bring about change, but they are mainly used for program maintenance even though they are meant for program improvement purposes (National Institute of Education 1981). Many states face funding cutbacks in education and will be increasingly reluctant to use block grant money for anything other than program maintenance, particularly if additional state funds are required, and certainly if educational technology does not prove its worth.

Congress has for some time expressed an interest in educational technology. Numerous hearings have been held over the years, but presently there is no action, even though Congress recognizes that a more cohesive federal posture should be developed (U.S. Congress 1981, 1983).

It is not surprising that the U.S. Office of Vocational and Adult Education reflects the ambivalence toward educational technology that characterizes federal policy in general. Faced with a reduced role, little more may be expected.

A close look at the total use of educational technology in primary, secondary, and adult public and private schools, and in government, industry, and military training reveals an industry of considerable diversity and proportion. An examination of federal policy, however, reveals uncertainty and the need to clarify a changing role with visible objectives. It is the educational sectors that are primarily outside the domain of public education that have probably been the greatest stimulus to growth in the maturing educational technology industry.

CHAPTER 3

COST AND PRODUCTIVITY

The high cost of education is a major public concern. "Real" costs continue to escalate. For example, as Curtis and Blatecky (1977) report:

> In dollars adjusted to reflect true buying power, the average per-pupil cost of America's public school system in 1947 was $406; in 1957-58, $733; in 1973-74, $1,364. In brief, America's per-pupil cost has been doubling (in adjusted dollars) every ten years, and it is still spiraling. (p. 35)

At the same time, public education has come under increased criticism. A skeptical public is reluctant to increase investments in education (Boyer 1983). As a result, financial problems plague many school districts, shortages of textbooks, materials, and supplies hamper instructional programs, and teachers face real losses in income.

It is not surprising that educational technology is considered by some as a potential way to reduce educational costs through increased productivity (Dede 1980; U.S. Congress 1981). But, to what extent is this a realistic expectation, and what are the cost determinants of educational technology? This chapter briefly examines these questions.

Barriers to Cost-Effectiveness

One source of the financial dilution facing schools is the failure to achieve a comparable increase in productivity relative to increased costs. Increases in class size are resisted. But there are also real upper limits on the number of students that a teacher can handle at one time, particularly in vocational laboratories. It is thus difficult to achieve productivity gains through increased enrollment. Furthermore, as long as instruction is organized in set time blocks, productivity gains also cannot be realized by those students progressing faster than others; they remain in the course until the term is completed, regardless of their progress. And real gains in learning are seldom counted as productivity gains.

Technology can result in productivity improvement. The way that this is done in every economic sector is to increase output relative to cost. However, this is difficult to achieve through the application of educational technology, and there are few, if any, examples where cost reduction can be cited as a major result (Hershfield 1982; Jamison, Suppes, and Wells 1974; Wagner 1982).

In the first place, educational technology tends to be "added on" to conventional instruction. The technology is used to supplement or enhance instruction, and not to increase the educational output of the teacher. As Knapper (1982b) observes, "it has taken two decades of experience with various instructional technologies to realize that most uses of technology do not supplant the human instructor, and often result in additional costs, even though they may well improve the quality of the learning experience for the student" (p. 57). Hence, there are generally actual cost increases associated with the use of the technology. To achieve greater productivity and cost savings, teachers must serve a greater number of students within a given period of time. Ultimately, this will probably require not only a changed perception of the teaching role, but altered scheduling and staffing patterns as well (Dobrov 1979; Lipson 1981).

When making cost estimates, the tendency is to ignore the contribution of the mainline instructional costs, leading to low and erroneous cost estimates for the technology. The technology is treated as if it is not an added-on cost. In fact, when claims are made for cost-savings through the use of educational technology, this is often the case. Even with a rapid reduction in cost, such as that anticipated with microcomputers, the addition of the technology still represents added-on cost and no saving unless other educational expenses are reduced or the number of students served is increased by the use of the technology.

If it is assumed that educational technology will replace other instructional costs, the potential savings are still relatively modest (Hershfield 1982; Stakenas and Kaufman 1977; Wagner 1982). Kincaid, McEachron and McKinney (1974), for example, estimated the upper limit of potential cost-savings that could be realized through the use of educational technology as a substitute for conventional classroom instruction. Assuming zero cost for the technology by disregarding the cost of the technology itself and the personnel required during its use, they found that the use of educational technology will only result in a 4.5 to 11 percent savings in the total costs of instruction. In the words of the researchers:

> We conclude that even by the most optimistic estimates cost savings from the use of technology would not be more than 1 percent of the total cost of elementary and secondary education, using any technology now envisaged and the highest levels of use that have been sustained in practice . . . . While not negligible, these savings do not represent the kinds of radical cost reductions that technology has attained in industrial applications. (Ibid., p. 26)

Equal and perhaps greater savings may be achieved through alternative means to reduce costs: eliminating low-priority activities, increasing the pupil-teacher ratio, reducing media use, controlling supplies and materials, and using differentiated staffing. The use of educational technology to reduce instructional costs is "simply not as attractive as other, more immediate and less capital-intensive means of reducing costs, no matter how inexpensive the technology may be" (Kincaid, McEachron, and McKinney 1974, p. 27).

It is difficult to achieve cost savings through educational technology simply because it is underused. There is a marked difference between *potential* and *actual* use. The technology may have considerable potential capacity, but actual use may be limited because of scheduling problems, unavailable software, a small number of potential users, maintenance problems, and the like. Or, the teacher may prefer only to use the technology in a limited way, combining it with other teaching methods. Obviously, then, high levels of use over an extended time may make even an initially expensive system relatively cost-effective, but in a real sense the capacity of the technology often exceeds the ability of the users to apply the system fully. This is generally true, regardless of the type of technology or the investment involved. Even the unit cost of a film projector is high if it is seldom used.

Two examples are instructive. The cost of the PLATO system far exceeds the original estimate of $5 per terminal hour, which was based on four thousand time-shared terminals. About one-thousand terminals were actually in use in 1977, at an average cost of $10,000 per terminal, or $15 per terminal hour (Koerner 1977; Wagner 1982). Despite extensive effort, it has been extremely difficult to expand system use to reach the theoretical, cost-effective upper limit. It is easy, Koerner (1977) observes, to be mislead by "the ease with which cost reduction can be 'proved' on paper and the enormous difficulty with which it is achieved in practice" (p. 27).

Similarly, an analysis of the costs over an eighteen-year operating period of the Hagerstown, Maryland, instructional television (ITV) system, which has the longest continuous operating history of any ITV project in the United States, showed that it would be cost-effective to replace the systems with teachers and additional classrooms (Jamison, Klees, and Wells 1978). This is mainly due to the relatively small numbers of students served and the high cost of programming. With an instructional broadcast capacity of 7,560 hours per week, only between 1,400 to 1,900 hours are actually used, despite efforts to expand system use beyond the twenty-two thousand students served by the Washington County School District. Perhaps a little late, it is now generally recognized that ITV requires a viewing audience numbering in the hundreds of thousands to benefit fully from economies of scale (Jamison 1977; Jamison, Klees, and Wells 1978; Schramm 1977).

In the case of vocational education, low use levels of technology are a real problem. The total student population served is often small, at least when compared to the population served through general education courses. Instructional materials are usually specific to a single technical area or level of training, further restricting use. In addition, instructional materials often become rapidly outdated, leading to high software replacement costs. The reasonable life expectancy of locally produced courseware is three years; commercially produced materials may be expected to remain current and usable for five years (Kincaid, McEachron, and McKinney 1974).

Finally, a course structured around the substantial use of hands-on skill training may leave little room for the full use of educational technology. The result may be a measured discrepancy between potential capacity and actual use—an overestimation of the extent of use and an underestimation of cost.

Cost Factors to Consider

Although it is tempting to turn to educational technology as a way of improving teacher productivity and reducing instructional cost, rarely is this goal achieved. Educational technology will probably cost more than conventional instruction, and a greater investment in time and money will be required prior to any educational output. Development adds rather than reduces costs, so start-up costs may be expected to be high. The proportion of fixed cost is greater, with conventional instruction having a lower ratio of fixed to variable cost. As suggested, the unit cost of educational technology is highly dependent on utilization rates. And, once expenditures are made, cost cannot be recovered if the investment is a poor one (Jamison, Klees, and Wells 1978; Wagner 1982).

However, because of lower variable costs, once an educational technology system is in place, the cost comes closer to conventional instruction if high rates of use are achieved. The marginal cost of serving additional students is usually low, and it is this capacity to extend instruction at a low cost beyond the number of students normally served by one teacher that is the unrealized promise of educational technology.

It is commonly assumed that technological innovation results in decreased user cost. Microprocessing technology is an example: hardware costs have plunged as a result of prodigious advances in microchip manufacturing. As Whitney (1977) observes, we are "facing the 1980s with $10 buying all of the processing electronics for a medium scale computer." (p. 44). Moreover, cost decreases have been achieved while performance capability has been improved. The result, however, is not necessarily overall cost-savings for users. Only about one-fourth (and not more than one-third) of costs are currently due to hardware (Zucker 1982). Manufacturing cost-savings, moreover, tend to reappear in system use and maintenance cost (Whitney 1977). This is especially true as the technology itself becomes more sophisticated (see appendix D). Ironically, the decreases in hardware component cost, such as those realized through the microchip, are what stimulate sophisticated advances.

The use and maintenance costs, then, "will become the dominant consideration in the purchase and use" of the more advanced electronic technology (Whitney 1977, p. 45). This includes software purchase and development, maintenance, expendable supplies, replacements, and training expenses. To keep these costs reasonable, functionally simple systems are desirable.

It is also necessary for educational technology to be amortized over a relatively long period of time to approach cost-effectiveness (Grayson 1976). In the case of ITV, for example, this may be as much as twenty years (Jamison 1977). For major hardware, such as computers, production equipment, and video recorders, this may be at least ten years (Kincaid, McEachron and McKinney 1974; Stakenas and Kaufman 1977). At the same time, however, educational technology is in a period of rapid change. The large investments of today in the state-of-the-art technology may well be the obsolete classroom liabilities of tomorrow. Poor educational decisions will not be easily reversed, and for this reason investments in the latest new technology should probably be modest until the technology itself becomes stabilized and users can be sure of relatively long-term use.

Software—Future Cost Determinant

Perhaps the most important cost consideration in the near future will be software. Software is expensive to buy and even more expensive to develop. Course development is a labor-intensive process, and software development itself requires a number of skills that the typical teacher does not possess. Initial development costs may be ten times or more than the annual salary of a teacher for a single, technology-based course. It is probably not unrealistic to expect costs in the order of two thousand to six thousand dollars per viewing minute for quality video, film, and other media-based instructional materials. Cost estimates for sophisticated computer programs using artificial intellegence techniques range from fifty thousand to three hundred thousand dollars for each hour of instruction (Grayson 1976; Hershfield 1982; Wagner 1982). The cost for an entire computer-assisted course may exceed $1 million (Zucker 1982).

An important distinction should be made between "big media," such as computers and instructional television, and "little media," such as slides, filmstrips, or instructional aids (Schramm 1977). Cost differences are striking. Schramm found that big media cost between three to fifteen times more than little media. Not only is it possible to purchase a greater range of different educational technology for the cost of a single big-media device, but little-media software may often be discarded with less loss when it becomes outdated, which may be in a relatively short time with vocational instruction. These materials, moreover, are within the range of what is normally appropriated for instructional support materials.

When technology systems are initially purchased, software costs tend to be consistently misjudged. In the case of vocational education, to provide sufficiently comprehensive instructional coverage in a single occupational area would be expensive. To address technology-based instruction in a large number of occupational areas is probably beyond the means of most institutions. But to purchase educational hardware and not provide ample software instructional capability only results in substantial underutilization of costly hardware capacity.

The foregoing review suggests that educational technology, as currently used, is not a viable way to reduce educational costs. Educational technology does not now result in higher teacher productivity and cost savings, and it is uncertain whether it ever will. One of the more pressing policy problems, however, is finding out whether educational technology can be cost-effective. Although "it seems almost inevitable that productivity improvements in the schools, if they are to occur, will require the use of technology" (Jamison, Suppes, and Wells 1974, p. 58), it is surely as inevitable that technology must first prove its worth, relative to cost.

CHAPTER 4

INSTRUCTIONAL EFFECTIVENESS

The nation's schools have not been doing very well. Declining test scores, high levels of functional illiteracy, and diluted curricula are the more obvious symptoms of deep-rooted problems with the quality of instruction. Copperman (National Commission on Excellence in Education 1983) contends that "for the first time in the history of our country, the educational skills of one generation will not surpass, will not equal, will not even approach, those of their parents" (p. 11).

Can educational technology lead to substantial improvement in the quality of instruction? Can new instructional tools be put in the hands of teachers, enabling them to reach further? If the use of educational technology can contribute to improving the quality of instruction, then it probably is a good educational investment, even though it may cost more. Current evidence, however, may suggest otherwise.

Research Results

There has been considerable research on the effectiveness of educational technology, but no definitive conclusions can be reached (Campeau 1974; Jamison, Klees, and Wells 1978; Jamison, Suppes, and Wells 1974; Kulik, Kulik, and Cohen 1980; Schramm, 1977; Wells 1976). Although technology is found to be more effective in some situations, conventional instruction is more effective in others. No consistent pattern of results emerges from the studies, few studies are easily replicated, and most lack rigor.

In general, students appear to learn from all instructional technology, but no research exists that suggests that educational technology is superior to conventional instruction or that one technology is superior to another (Campeau 1974; Jamison, Suppes, and Wells 1974; Pitts and Schneider 1981; Schramm 1977). Students, for example, learn just as effectively through the use of filmstrips or textbooks as they do through computer-assisted instruction, television, or the classroom teacher. There is no evidence to suggest that more sophisticated technology is more effective (Kincaid, McEachron, and McKinney 1974). To be sure, some technologies show superior results for individual instructional tasks, but as Gagne (1965) suggests, "no single medium is likely to have properties that make it best for all purposes" (p. 363). In addition, contrary to what is popularly believed, little evidence suggests that one particular medium is "differentially effective for different people" (Gagne 1965, p. 364).

Campeau's (1974) observation is probably correct in stating that it is by "user preference, not on evidence of instructional effectiveness" that the decision is made as to which technology "to purchase, install and use . . ." (p. 37). There is little in the way of practical research results that may be used to guide decision making. More support may be found to use educational technology because it is thought to enrich instruction than because it actually leads to more effective learning.

Research, however, probably has been misfocused. The least important virtue of educational technology is the actual delivery device, whether it is a computer, TV monitor, or slide projector. Some devices have greater instructional capability and versatility, such as storage capacity, visual format, and audio quality, but this can usually be duplicated by other technologies or combinations. Although the glamour of the computer, for example, is attractive, its instructional value is a result of the content of the lessons and the manner in which it is conveyed. There is no reason to think that computer-assisted instruction should yield superior instructional results when the content of its lesson may be inferior or its presentation awkward. Research tends to focus on gross comparisons between different technological devices and not on the interactions between instructional design, the learning task, and learners (Jamison, Suppes, and Wells, 1974; Salomon and Clark 1977; White 1982)

Faulty Comparisons

One reason for these gross comparisons is that research designs have imposed such rigid controls that any potential advantage of one medium over another may not have been taken into account. As Salomon and Clark (1977) explain:

> Methodologically, a comparison between two media calls for a well-controlled experiment in which all variables, except a media variable, are held constant. The content, mode of presentation, structure, didactics, situation, and the like need to be equalized between the experimental conditions. (p. 101)

The obvious result is no significant difference, and if differences are found, they are rare.

A technological device may be used in any number of ways, but there may not be a good understanding of the best way to use it. If it were possible to "successfully match student characteristics, characteristics of the subject to learn, and attributes of media," as Kincaid, McEachron, and McKinney (1974) suggest, "the media might be found to be consistently more effective" (p. 9). What is needed is a clear conception of the consistent pattern of instructional inputs provided by the technology that has primary influence on instructional effectiveness. In fact, to date, the variable that apparently has the strongest positive correlation with student learning is teacher verbal ability (Jamison, Suppes, and Wells 1974). Variables need to be isolated that are unique to the technology and that allow selection, organization, and transmittal of learning in a way that is superior to other technologies or the conventional teacher. Until we have a good understanding of these variables, we will not have a good understanding of how to evaluate and select educational technology.

Kincaid, McEachron, and McKinney (1974) observe that, of the studies conducted:

> the things that have made the use of the technology more effective are the same things that make conventional instruction more effective: good organization of material, a practical delivery, strong student motivation, integration of knowledge of the effects of the instruction into the teaching, rest pauses at appropriate times, and cues that direct pupils to those points essential to learn. (p. 8).

These variables are hardly unique to any one technology or mode of delivery.

The Software Problem

The single most important problem in the application of educational technology is that of software. Instructional effectiveness is directly tied to instructional delivery—the software.

Software development, however, is plagued with difficulties. For one thing, software development tends to be organized around a process that reflects more the use of a systematic approach to instructional design than it does a full consideration of the ways people learn or that subject matter is organized. Models of the instructional design process, for example, are helpful in clarifying the interaction of the design components as they relate to the achievement of learning outcomes (Andrew and Goodson 1980; Melton 1980), but they are less useful in dealing with the psychological processes involved in learning, such as the probability of eliciting a certain response, and the perceptual, attentional, and decoding power of the presentation (Gropper 1976; Salomon and Clark 1977; White 1982). Gagne (1980) suggests, for example, that "in developing programs of instruction, one must solve the problems of lesson design and media selection by reference to mental states and mental processes, rather than simply in terms of behavioral outcomes" (p. 7). As suggested, probably least understood and least considered in software design are the ways individual learners interact with the media and the learning task (Allen 1975; Snow 1977).

One result is that technology-based instructional systems are largely designed so that the learner interacts with the machine, and not the other way around. That is, as advanced as information processing is, it still does not duplicate human learning; yet the learner must follow the sequence of the machine and respond to the query of the program, even though this may be at odds with the more subjective and creative—but less structured and ordered—ways that individuals learn. "This is the essence of the problem of creating a 'transparent' or 'friendly' interface between the machine and its user," Resnikoff (1982, p. 7) observes. There is a basic incompatibility between the human mind and the digital sequence: one is rooted in the sensory system, the other in the microchip. Although systems of "artificial intelligence" now under development hold promise of more closely approximating human interaction (Smith 1980; Kearsley 1982), it is uncertain whether the man-machine mismatch can be lessened to where it ceases to be important. Presently, it manifests itself in several ways.

In the first place, the technology tends to dominate the learning process. There is a certain artificiality, for example, in the inordinate time and effort spent in merely manipulating the gadgets of the technology, the keyboards, command signals, and programs used to present information and guide learning. The complexity of the manipulations often outweighs the import of the lessons presented. Although it is true that the student is learning to operate the technology, it is also true that the principal reason for using the technology is to teach the student "to come to grips with thoughts, not with keyboards" (Resnikoff 1982, p. 7).

There is also the risk of distorting the learning process; the presentation is shaped by the idiosyncratic characteristics of the technology. On the one hand, there are functional limitations to what the technology can best teach, so what is chosen for instruction is what can be best accommodated within those limits. Procedural tasks, for example, may be chosen because they can be proceduralized, and not because they are the best candidates for learning. On the other hand, the way that the learning task is presented through the technology may be altered—oversimplified, for example—because of the design process used. Although instructional design may be accomplished through carefully formulated processes, there is, nevertheless, "a simplification of belief which assumes the instructional process, when reshaped into an efficient, well-formed procedure, remains otherwise unchanged in character" (Ellis 1974, p. 58).

Finally the hardware capacity is generally greater than the capability of the software to make full use of the hardware. The power and speed of the computer, for example, is hardly touched by the relatively simple tutorial and drill and practice programs characterizing much of the available software (Megarry 1983). And the instructional ramifications of such relatively simple devices as audio recorders have not been fully explored.

These problems reflect the relative "youth" of the field as well as the enormous difficulties encountered in interfacing learning with the machine. "The effort required to produce materials that will stand alone with learners working on their own is a very different matter than the development of materials of instruction to be used within the conventional classroom and integrated into a teaching framework provided by a human teacher" (Bunderson, 1981, pp. 92-93).

Production and Distribution Problems

A different set of problems revolve around the production and distribution of software. For a number of reasons, software does not get the kind of well-financed, careful, and extended development required to produce quality. Development is a labor-intensive, protracted, and expensive process. To produce quality software takes time—perhaps as much as ten years to conduct a major project from the concept stage through development, testing, revision, and marketing. Surely as many as three to five years are needed for a modest effort (Koerner 1977). However, because they are unsure of elusive markets, commercial producers of software are reluctant to invest substantial amounts in products with unknown, and possibly short, life-time use (U.S. Congress 1983). "Oft-revised instructional materials cost more than never-revised instructional materials," Popham (1980, p. 20) observes. In the long term, development costs are kept as low as possible, and limited numbers of products are placed on the market.

It is also uncommon to find project investigators and developers in universities and foundations committed to long-range efforts. They face the substantial difficulties of maintaining support and countering the lack of immediate, concrete results. The result is that what should be a carefully planned, measured, and extended process becomes a reaction to market forces, a process characterized by short-term development, or by products based on rather isolated research interests.

Ironically, dramatic design advances, which act to stimulate hardware sales, function to retard quality software development because of the increased reluctance to invest resources in products that will probably be outdated soon by the hardware. Software producers want to see the newest technological breakthroughs before investing resources. "Put very simply, technology changes so quickly that it is becoming increasingly more difficult to design instruction for existing hardware," observes Caldwell (1983, p. 264). On the other hand, disappointment with software ultimately has an adverse effect on hardware acceptance because of the inability to show good instructional results.

There is certainly quality software on the market available to the discriminating buyer. But the overall quality is not high, with substantial amounts of marginal material available (Megarry 1983; U.S. Congress 1981, 1983). Furthermore, there has been a proliferation of software producers trying to capitalize on computer and videodisc technology, all touting their own products, few of which have had the extensive, controlled field testing, revision, and retesting necessary to ensure instructional quality. Although a natural winnowing will occur (and probably soon), this may not happen soon enough to offset the inevitable disenchantment that results from unfulfilled promises. The proliferation of material development threatens the very credibility on which acceptance is based.

Perhaps because they are distracted by the captivating appeal of the hardware, potential users do not always give software the attention that it merits. In purchasing educational technology, a strong case may be made for basing decisions on software quality and availability, and not on hardware appeal. Users should not be misled by uncritical enthusiasm for the gadgetry of educational technology to accept the programs, packages, and messages without question or examination.

Incompatibility between Systems

Yet another confounding problem is that of incompatible hardware systems. Software is not interchangeable between different hardware devices because of the lack of standardization. One result is limited markets that do not provide enough financial return to support quality software development. Another is limits on the range of software available for particular hardware devices. Some producers of software are attempting to develop materials adaptable to different hardware, but the result is usually higher costs in support peripheries, lack of instructional quality, and reduced programming capability (Caldwell 1983).

The Human Factor

Interest in the quality of software must also extend to concern about the preparation of instructional design specialists. Individuals who can create innovative, functional, and effective materials are in short supply. Not surprisingly, commercial producers tend to use programmers to create software, even though they usually do not have the experience or knowledge of instructional design procedures or of the subject field (Pitts and Schneider 1981; U.S. Congress 1981). The result may be less than satisfactory. Instructional design requires a range of skills from the artistic and creative to knowledge of the subject field, hardware capability, programming characteristics, and learning theory and its application (Bunderson 1981). Although the industry has had difficulty securing a supply of qualified individuals, public schools, with considerably less monetary benefits, may be expected to have even more difficulty if greater need arises. The authoring systems currently under development, which allow individuals to generate their own software, will require greater, not less, sophistication of instructional design procedures among users (Kearsley 1982). Poorly designed instructional materials lack quality, regardless of the hardware used.

Software is expensive, and the proportion of resources absorbed by software will become greater as hardware costs drop and expanded systems use requires increased software capability. The single most important investment in educational technology in the near future may be in software. But software quality and availability are also the most irresolvable problems facing the educational use of technology and may define the real limits of use in the school. Much software is found lacking in quality and in its ability to use hardware to full capacity (Anandam and Kelly 1981; Koerner 1977; U.S. Congress 1981). An obvious result is overinvestment in hardware potential, less than effective use of the technology, and less than adequate gains in learning. The considerable promise of educational technology is severely restrained by the expense, quality, and availability of software.

Instructional effectiveness is a major concern to anyone seeking qualitative improvements in education. But until we know better how a particular technology functions to promote learning and the way that the instructional sequence itself may be best structured, comparisons of the effectiveness of instructional technologies will continue to be disappointing. Gross comparisons are inadequate; questions need to be answered about the effects of specific instructional inputs, and how these inputs, when mediated through the technology, act on the learner and the content being learned. Determining instructional effectiveness, in this sense, ought to be a primary policy concern, for it is necessary, as Koerner (1977) observes, to determine whether educational technology "can be used effectively at any price" (p. 28).

CHAPTER 5

THE INSTRUCTIONAL CONTEXT

If it is difficult to show any cost advantage, and if instructional effectiveness is largely promise, then why use educational technology? Is there an instructional benefit to vocational education worth incurring extra expense?

Educational technology, even in its current state of uncertain effectiveness, may add other instructional dimensions. For one thing, it may provide technical content not obtained through existing instruction. Occupations are in a continuous state of change, and although some areas are changing more slowly than other areas, few vocational teachers are spared the need to update their curriculum (Evans 1971). The obsolescence of both instructional content and instructor may be offset in part by the use of educational technology to introduce new technical content. Relatively inexpensive instructional devices and software, such as film loops, videocassettes, and slides, may be used.

Similarly, through the use of educational technology it is possible to provide learning experiences not otherwise attained through regular instruction. The simulation of complex production processes, the graphic illustration of microscopic organisms, accounts of actual working conditions, and displays of new technology are but a few ways that regular instruction may be enhanced and extended. These are experiences that could not normally be included because of cost, safety, or physical location; but through the camera, recorder, or computer they can be made part of instruction. Although additional cost is incurred, it is a cost thought necessary because students need to be informed. These are largely "value-added" benefits, that is, positive effects on student performance that are difficult to achieve through conventional instruction. It is not easy to estimate the cost of these benefits, but they may well be justified, even if not on economic grounds.

New Roles for Technology

Perhaps one of the more important future uses of educational technology will be to extend learning opportunities to individuals and groups not now adequately served. Within conventional instructional laboratories and classrooms, for example, educational technology may be used to provide remedial or adapted instruction to special populations (Lally and Macleod 1983) or to small groups of students. This probably will be less costly than the addition of support personnel. When instruction is limited to a small number of individuals, then the cost advantage of the conventional teacher and group instruction disappears, and it is more cost-effective to use technology.

But educational technology may also be used to address the instructional needs of individuals not presently served by traditional classroom instruction. This may include, for example, retraining programs for displaced workers, small rural programs, or evening programs run by community organizations. Unfettered by a set location, educational technology can distribute instruction in alternative ways not possible through conventional instruction (Curtis and Biedenbach 1979). Educational technology may also be used to substitute for the lack of qualified staff, to provide instruction to individuals or small groups, or to supplement other forms of instruction, such as on-the-job training.

The experience of business and industry offers examples of successful practice. Self-contained, multiple media packages are designed for use with small groups of individuals as a way to introduce and market new product lines, train salespeople, or instruct production and maintenance personnel. Training is short-term, is provided in different geographic locations, uses existing facilities, and has modest staff requirements. Cost may be kept low by using combinations of media and teacher-directed instruction.

An important asset of educational technology is its physical portability—the ability to be used in just about any place at any time. Educational technologies, in other words, "enable educators, for the first time, to deliver education where and when the consumers, not the manufacturers, of education want to buy and use it" (Curtis and Biedenbach 1979, p. 5).

Teachers and Technology

Many teachers, of course, use educational technology and will continue to do so as more effective and creative devices become available and software problems are solved. Hardly a classroom is without an overhead or film projector, and considerable numbers have low-cost desktop computers. Teachers use educational technology to perform routine, distasteful, or boring tasks, and they use educational technology when they feel that it can contribute something to instruction that they cannot provide.

Ask teachers why they use instructional media, and many will reply that it offers a way to change the pace of instruction, to motivate students, to interject something new, and to capture the attention of the students who respond better to a mix of instructional modes (Tyler 1980). They reflect a long-held "gut feeling" among teachers that providing a number of ways to learn is better than providing only one. Research generally supports the use of multimodal instruction: greater learning apparently occurs when the student can interact with the instructional content in more than one way (Cronbach and Snow 1977; Schramm 1977; Snow 1977). Combinations of media with print and teacher interaction provide a versatility of presentation that is considered desirable.

Technology, however, is generally embraced with caution. "Teachers do not believe," Tyler (1980) notes, "that most children learn what the schools seek to teach without the help of teachers" (p. 12). Similarly, Hoyle (1983) observes that teachers "do not wish to individualize instruction as much as to personalize instruction" (p. 60). Although educational technology is used, it is probably accepted with much less ardor than its strongest supporters desire, as evidenced by its relatively infrequent use. In some cases, educational technology is resisted, even if covertly (Hoyle 1983).

The reluctance to embrace educational technology with open arms stems from several sources. For one thing, if teachers are not replaced by educational technology in the search for cost-effectiveness, they will at least be required to perform new instructional tasks in the attempt to show instructional effectiveness. New skills will have to be learned, comfortable instructional practices altered, and additional preparation given to material development. Teachers will have to devote many after-school and summers hours to learning how to use the technology (Lidtke 1981). And all of the "normal" problems and frustrations of equipment shortage, breakdown, and maintenance may be expected as systems are developed.

Perhaps more ominous, there is a real threat of deprofessionalization, the replacement of teacher initiative and innovation by the black box and preprogrammed cassette. In addition, an environment that requires coordination and collaboration, working in teams, and reacting to the schedule of the machine leads to a loss of autonomy (Hoyle 1983). Given that educational technology is applied on a wide scale, the successful application itself poses problems. The extensive use of technology in a local school involves a significant shift from secondary to first-line use; that is, rather than function as a complement to teacher-directed instruction, educational technology largely replaces teacher interactions and provides the content and instructional sequence. In the process, however, the individual teacher and local school relinquish control over what is taught to the producers of software, a control that may be difficult to check. Although textbooks, for example, may be easily adapted or supplemented by the teacher, educational technology is less amenable to alteration. Such a set instructional sequence contains an even more threatening factor: it may entirely replace the teacher.

Benefits to Instruction

Technology, on the other hand, may have a net benefit on classroom instruction, bringing the individual teacher out of isolation and opening up the instructional process. Traditionally, the teacher is in complete charge of the classroom. But educational technology can open the door of the classroom to wider exposure. The full implementation of educational technology requires coordinated team effort. As suggested, individual teachers become increasingly dependent upon support systems that require a team rather than an individual approach to solving instructional problems. Teachers will not be able to follow their strengths or interests, but rather must cover the planned activities of the computer or the structured lesson of the videodisc. Instructional results will be out in the open for all team members to view. These and other factors suggest that educational technology may indeed threaten the teachers, but they also suggest that, in the long run, educational technology can bring continuity and substance into the classroom.

Teacher acceptance, however, is critical for the successful application of educational technology. It is at the classroom level that educational technology will either succeed or fail. How can teacher acceptance be gained?

Teacher Training

Teacher training in advanced technologies is certainly one need. Technology brings to mind lessons on how to push the right buttons, insert disks, and tell when the equipment is malfunctioning. But these may be the easiest of the training tasks. As seen from the flood of educational software on the market, users will need to learn how to identify and select quality instructional materials, and to base judgments on discriminations that go beyond attractive packaging and convincing sales talk. If teachers are to produce materials, they will have to acquire the skills of the programmer and instructional designer to avoid limiting their use of the technology and becoming captive to the market. In short, a rather sophisticated set of skills will be needed, at least by some teachers. Finally, new instructional management techniques will be required if the technology is to be used in an open, flexible, resource-based learning system.

Teacher preparation institutions have been slow in responding to technology. "There is little evidence that most of the teacher training colleges in the United States are providing adequate instruction to new teachers in the use of information technology," concludes a report of recent hearings before the House Committee on Education and Labor (U.S. Congress 1983, p. 19).

Zucker (1982) reports that only one out of three teacher training programs in the United States offers even one computer course. Perhaps hoping that educational technology will quietly go away, most teacher preparation programs continue to expose novices to rather conventional teaching skills. The impact of the substantial use of educational technology will be just as pervasive for teacher training programs as for its application in the public schools.

Control Questions

"Unless the teacher is thoroughly convinced that this is worthwhile for students," observes Lidtke (1981), "the teacher will not be motivated to expend time and/or effort in preparing for the use of educational technology" (p. 82). The participation of teachers in the decision to purchase and use technology and in its planning and implementation is probably essential to the acceptance of educational technology. Decisions "imposed" from the top down usually do not invoke enthusiastic conviction; mutual participation may.

The isolation of the teacher from decision making and control, in fact, may prove to be one of the more controversial dimensions of educational technology. One obvious impact of informational technology, Carlson (1979) observes, is the centralization of authority. Data gathering and analysis, for example, are increasingly centralized, which in turn leads to centralized decision making. This occurs in business and government, and similar changes are taking place in education. Teachers may have less control over what is taught, and choices may increasingly be made by administrators, curriculum coordinators, and purchasing agents removed from the actual instructional process (Grayson 1976).

The School Setting

Typically, educational technology is used in a teacher-led class. It is the teacher-led class, as the basic instructional unit in the school, that largely determines the instructional role that the technology will play, as well as its effectiveness. However, when educational technology is considered little more than an adjunct to conventional teaching, it is unlikly to be used in a way that will fully capitalize on its instructional strengths or compensate for its inherent weaknesses.

In the first place, educational technology is probably a poor substitute, in most situations, for conventional instruction. It is costly and not any more effective. On the other hand, as previously suggested, the most potent use of educational technology may be to lead the way to new models of instruction (Hershfield 1982). Educational technologies may give rise to instructional applications that extend beyond conventional teacher interaction. It is this use of educational technology that is promising, because it may add new capabilities to an educational system that appears to be floundering.

The organizational and administrative structure of the school also imposes constraints on the use of educational technology. Schools are organized and administered to support the standard instructional role of the classroom teacher. If educational technology has had a less than significant impact on instruction, it is due at least in part to the fact that budgeting practices, student schedules, administrative regulations, staffing patterns, and teaching loads are organized around the traditional work unit of the school (Dobrov 1979; Lipson 1981).

A few illustrations are instructive. Hershfield (1982) suggests, for example, that "current administrative practices make it impossible to consider funding course development in the high technology mode" (p. 7). Funds are allocated across departments, with the major portion used for salaries. Educational technology, in contrast, is capital-intensive, requires considerable start-up expenditures, involves an extended period of development, and uses staff members in different roles. Sheehan (1982) believes that, as a consequence of the introduction of the personal computer in the school, "the relationship of students to the library, the classroom, and the laboratory will change in ways that are hard to predict but that will affect the infrastructure of the institution fundamentally" (p. 108).

One practical barrier is easy access and use. Anyone who has had experience with the use of educational technology in schools knows the frustrations encountered through lost, broken, or malfunctioning equipment and materials. The collection, distribution, and maintenance of educational technology must be centralized in some way to facilitate easy and reliable use, while at the same time not presenting cumbersome and time-consuming barriers. Again, the technology should not require extensive additional planning or preparation, or instructors will not use it. Ideally, the technology should be in a form that will allow the average teacher to use it with a maximum of fifteen to twenty minutes of preparation. And, the technology must be either designed for easy instructional use, or else sufficient support must be available to facilitate use. These may be mundane considerations, but they are essential considerations in gaining teacher acceptance, and they further suggest the need to develop effective patterns of organizing and administering the use of educational technology.

Presently, the organizational and administrative structures of the school combine to limit the effective role that educational technology can play. In a real sense, new technology requires new ways of conducting the work of the school—a conception of instruction that transcends conventional practice.

The Impact on Students

In all of the talk surrounding educational technology, little attention is given to the student. It is commonly assumed that the use of technology will be perceived as a positive thing. Anyone who has had more than a passing acquaintance with school laboratories, however, knows the destruction that occurs as a result of negligence, but more often of intended vandalism. Perhaps they are expressing hostility toward school, or reacting to the wealth, order, and efficiency represented by the machine that is so lacking in their own lives, but each year students willfully destroy school property worth considerable sums of money. If educational technology is placed in schools on a large scale, how much destruction should be anticipated?

Perhaps a more portentous problem is unequal opportunity. For some students, perhaps many, the technology will be as alien to them as their home and community environment is to the world of high technology. Many students from poorer environments simply do not have the opportunity to become acquainted with computers, for example, nor can they afford to purchase one. There is also less likelihood that the schools attended by low-income students will be able to afford large investments in the latest educational technology. School computer sales seem to confirm this: it is the large, wealthy school districts that are investing in computers (U.S. Office of Technology Assessment 1982). "For low income, low achieving children," Zucker (1982) reports, "the result may be a whole new set of disadvantages more severe and even more difficult to remedy than those they already face" (p. 406). Although there are serious problems with achievement levels in reading and math, now will be added the "computer literacy gap." Students from poor homes, Boyer (1983) contends, "will fall further behind in the struggle for equal opportunity" (p. 89).

The wide application of educational technology will require a rethinking of the ways that vocational education is delivered to students, and a new commitment to serve other client populations. The challenges facing vocational education in the 1980s certainly call for creative and innovative ways of addressing vocational education. Although solutions may be less obvious than needs, educational technology offers much promise.

CHAPTER 6

AN OVERVIEW OF EDUCATIONAL TECHNOLOGIES

Educational technology has evolved from blackboards and simple filmstrip projectors and tape recorders to an array of technically complex and powerful information-processing, communication, and video devices. And these developments are probably just the beginning, a hint of what is to come. With inexpensive microcomputers, video devices, and transmission technology (e.g., cable, lasers, optical fibers, and satellite broadcast), classrooms and homes may be transformed into resource centers, supplying on-demand tutoring and linking learners to extensive information networks. Speech interface with the computer, for example, is probably not more than five years away; the portable electric display "carrel," providing immediate access to worldwide information storage, is in the near future; and low-power broadcast, limited to a range of ten to fifteen miles and requiring a capital investment of only five thousand dollars, may extend cost-effective instruction to low-population-density areas.

The potential of educational technology, however, has always exceeded the human and institutional capacity to make full use of it (Anandam and Kelly 1981). But it is clear that the inevitable development of educational technology will demand a serious reexamination of the ways in which technology may be effectively used. Learning how to use current technology better, however, is a commanding challenge. There is marked disparity between use and potential, and actual application and future vision.

Little Media

Of all instructional materials used in the school, print is the most widely used, accounting for about 54 percent of all educational media purchased. Filmstrips account for about 16 percent and film for 6 percent. All other media comprise the remaining 24 percent (Woodbury 1980). What Schramm (1977) calls "little media" comprises the bulk of school purchases. These include filmloops, transparencies, tapes, and other simple instructional devices and materials used every day by the teacher to complement verbal or written instruction.

In the recent enthusiasm for the more sophisticated educational technologies, such as microcomputers and videodiscs, sight should not be lost of the use and effectiveness of little media. In general, they are relatively low cost, portable, and flexible in use. They can be used easily by the teacher, with little prior training required. Storage and handling procedures are simple, and increasingly more software is becoming available at low costs (Osborne 1982; Woodbury 1980).

But little media are primarily an adjunct to (rather than a replacement for) conventional instruction. Combinations of little media may be used along with teacher-led instruction to enhance learning. Given the ease of use, flexibility, cost, and availability of software, coupled with the fact that specialized vocational instruction represents a relatively restricted market, little media continue to be important. Moreover, little media appear to produce instructional results as effectively as does instruction delivered through computers, TV, films, and other "big media" (Campeau 1974; Schramm 1977). Finally, many of the instructional design problems that plague software development may be worked out as easily and at less cost using little media, so a better research and development investment may be to focus efforts on little media, and then transfer findings to more expensive technology.

Print materials, including textbooks, manuals, programmed materials, teacher and student guides, and worksheets, remain the most cost-effective instructional material (Neumann 1980). Ironically, producers of software tend to take existing print material and program it for computerized use. Print material is also widely used to supplement much of the instruction delivered through the "higher" technologies, compensating for inherent weaknesses.

The Computer

The computer, nevertheless, is the technology currently on center stage. Stimulated by the mass market generated for business, industrial, and home use and made increasingly available by dramatic price decreases, the small desk-top computer has stimulated considerable excitement. There actually have been three stages in the development and use of computer-assisted instruction (CAI), each accompanied by predictions of significant educational application.

Large mainframe computers dominated the field in the 1960s and early 1970s. Expensive and bulky, they require large operating and maintenance staffs, continuous rental and system operating costs, and extensive use in order to realize the benefits of the power and capacity of such systems. PLATO, for example—the best known and most extensive computer-based instructional system—consists of a large central computer connected to many terminals by long-distance telephone lines or satellite. Perhaps it is significant that the Control Data Corporation, owner of the marketing rights to PLATO, is moving rapidly to link software and computer use to microcomputers.

Minicomputers came into wide use during the early 1970s. Less expensive and bulky, they may be used easily by a single school or department. Their widest use, however, is in school accounting and management functions, particularly at the university level.

The microcomputer has captured recent attention, characterized by some as a "technological explosion" that will have an impact upon all levels of education, public and private. Hardware costs have plummeted, making computer technology available to schools and individuals at reasonable costs. Low-cost, small-size models with modest space requirements, ease of use, and adequate capacity make the microcomputer a flexible instructional tool within easy reach of most classrooms (Edwards 1978; Hall 1982). "The state of the art in computer-based instruction may still be rudimentary in relation to its potential," Koerner (1977) observes, "but the speed with which this specialty has developed in little more than a decade suggests the even greater speed with which it will grow in the future" (p. 11).

Instructional Uses

The most widely used instructional strategy in computer-based instruction has been drill and practice, mainly due to the relative ease of programming. Capitalizing on the ability of the computer to present endless exercise variations, instruction is presented to the learner, feedback is provided, and the flow and sequence of instruction is altered according to the response. Mainly used for basic skill development where memorization is employed, computerized drill and practice exercises provide one-to-one interaction and the opportunity for unrestricted review (Bunderson 1981; Knapper 1982a).

The tutorial system is the oldest strategy used. Microcomputers present the material sequentially, provide frequent response opportunities and checks, make branching options available, and present new content. Both drill and practice and tutorial strategies have common characteristics: (1) they basically emulate the teacher, (2) instruction is limited to less difficult levels of learning, and (3) instruction is interactive.

Simulation is becoming a widespread, rather powerful use of the computer. Problems are presented to the learner that require the ability to analyze, rate, and apply basic knowledge. Simulation may substitute for experiences unavailable through regular classroom instruction because of cost, unavailable equipment, danger, or physical impossibilities. The student can readily explore the effects of alternative solutions, while at the same time receiving corrective feedback.

Other Computer Uses

Computer-managed instruction (CMI) is advanced as a way to integrate, coordinate, and guide student learning. Extending its uses beyond mere instruction, the computer assesses the current knowledge level of the student, diagnoses difficulties, prescribes instruction, schedules resources, monitors progress, and reports. The system frees the teacher, in part, from record keeping, and at the same time supplies a greater range of information than would be normally available (Baker 1981). CMI systems, however, have not been widely implemented. Cost, the extensive time involved to design and implement a system, and lack of flexibility are major problems. "One great advantage of the human instructor," Knapper (1982a) observes, "is flexibility to cope with a wide range of learner and situational demands, and it may well be counterproductive to spend long hours trying to replicate this ability in a computer program, instead of using the computer for what it does best" (p. 48).

And what does the computer do best? The computer is an extremely powerful and efficient machine for manipulating and transmitting information. Its storage capacity is vast and the processing speed remarkable. The computer, however, is a poor communication device. As Knapper (1982a) observes, "its capacity to manipulate has always outstripped its ability to present the results of these manipulations" (p. 48). One outcome is that when the computer is used for simple drill and practice, for example, its capacity is severely underused; but because of poor communication properties, it is difficult to apply computer technology successfully to complex teaching tasks. "Neither the simplest tasks nor complex ones," Resnikoff (1982) observes, "normally justify the other complicated and idiosyncratic interface presented to the user; and the most complex and interesting tasks require cognitive algorithms that remain outside our grasp" (p. 6). Only recently have major efforts been made to combine the data processing power of the computer with the communication capacity of video technology, thus overcoming major shortcomings of traditional CAI.

Research Results

The most evident research conclusion that may be drawn about computer-based instruction (CBI) is that it can reduce instructional time in comparison with conventional instruction. This is a major reason why CBI is so attractive to the military. Students need less time to reach similar performance levels, perhaps as much as one-third less (Hall 1982; Kulik, Kulik, and Cohen 1980; O'Neil 1981; Schramm 1977; Thomas 1979). However, it is harder to show that CBI has a superior educational advantage over other instructional methods. Students apparently do not learn any better through CBI. With the exception of elementary-level instruction, there are no overall significant gains in learning when CBI is used either as a supplement or as the major instructional mode (Jamison, Suppes, and Wells 1974; Kulik, Kulik, and Cohen 1980; Schramm 1977).

Kulik, Kulik, and Cohen (1980) are probably right in that the instructional accomplishments of CBI must be considered modest, and that its results are not as impressive as the results of the application of other instructional technology. But CBI does have an overall positive effect on student attitude toward learning: it is interesting, stimulating, and motivational (Hall 1982; O'Neil 1981; Thomas 1979). On the other hand, studies of the PLATO and Time-Shared Interactive Computer Controlled Information Television (TICCIT) systems by the Educational Testing Service (Alderman 1978; Murphy and Apple 1977) found that there were increased course withdrawal rates and neutral-to-negative student attitudes with CBI.

One group in particular that may benefit from CBI is special needs learners. The ability of CBI to deliver special remediation, individual attention, and variable time makes it possible to provide a degree of individualized instruction unavailable through conventional teaching. Periodic programmed review may help in the maintenance of skills. Control and enhancement devices (e.g., special graphics, sound, and color; and light, sound and touch controls) make it possible to adapt instruction and hardware to a range of needs (Morgan 1981).

The adult learner, in particular, may profit from CBI. Adults generally have specific training needs, and there are greater restrictions on available time. With CBI, less direct supervision is probably required, and instruction may be provided at a number of locations, whether at work sites, extension programs, or in homes.

Constraints

The lack of high-quality software and courseware may prove to be the most difficult obstacle for CBI to surmount. Hardware, as previously suggested, is only the vehicle by which instruction is delivered, and it has relatively little direct impact on learning. Software and courseware provide the substance of what is learned—the instructional interactions—and are generally costly and difficult to develop.

Although the computer has considerable potential, its capability as an instructional tool has not been fully exploited by the simple drill-and-practice and tutorial courseware widely used. Techniques and applications that are now in the development stage probably will have the greatest transforming potential. Linking CBI with other instructional technology, in fact, may prove to be the most potent learning mode (Knapper 1982b).

There is also a significant difference between computers in the school and computers used for instruction. Put another way, there are a number of school uses of computers, one of which is providing instruction. As everywhere else, computers are used to perform routine and administrative and management functions, such as financial accounting, planning, and student record keeping. Considerable numbers are probably used in this way. Computers are also used to teach about computers, that is, programming as a skill to be learned. This is an essential purpose in many vocational programs; such as in business, data processing, retail selling, machining, and increasingly in other areas. Science and math, however, have probably taken the lead in teaching computer use to all students.

Computer skills will no doubt grow in importance as we move into the age of "information technology" and "high technology." Boyer (1983), however, cautions that computers will become so easy to use for the nonspecialist that the more important educational function will be to use the computer as "an object of study," a means "to put the technological revolution in perspective" (p. 195).

Video Technology

Videotapes, videocassettes, and more recently, videodiscs, have attracted considerable attention, and eventually they may largely replace instructional television and strongly challenge instructional film. They are flexible media, and when linked with other instructional technologies, provide a versatility not available from any single technology. Furthermore, considerable research and development is underway, promising improvement and new products.

The Videodisc

Particularly promising is the videodisc, a device that stores television programming on a disk. "Many informed people," Koerner (1977) suggests, "believe that the videodisc, combined with the free-standing computer, will be a genuinely far-reaching development in education" (p. 17). The relative cost will be low compared to other technologies. A remarkable amount of information can be stored on a simple half-hour disc (about fifty-four thousand frames). The system is extremely adaptable, supplying image banks for still and motion sequences and linking slides, sound, or computers to provide interactive, learner-controlled applications of all sorts. Separate tracks allow separate audio or visual information; frames may be stopped, slowed, reversed, or rerun; and both linear and nonlinear visuals may be provided (Grayson 1982; Koerner 1977; Schneider 1977; U.S. Congress 1981). Heuston (U.S. Congress 1981) observes that the videodisc is capable of combining (1) the inexpensive, portable, available, and highly replicable character of a book with (2) the sound, color, and motion of ITV and (3) the calculation, storage, and information accessibility of a computer. Particularly relevant to vocational instruction is the potential to present "different views of the same process on adjacent videodisc tracks and to switch from one viewpoint to another by pressing buttons on an external keyboard" (Schneider 1977, p. 319).

Videodiscs, however, are not highly durable. Dust, in particular is bothersome, and disc wear should be expected. Video equipment in any form is vulnerable to physical and environmental conditions. As with other instructional technology, videodiscs suffer from poor quality and ineffective software. Surprisingly, moreover, private sector training has embraced videodisc technology with caution. Advantages do not warrant discarding technology already in use. And the cost of providing master copies is not justified by use (Brown 1981a; U.S. Office of Technology Assessment 1982).

Instructional Television

Instructional television (ITV) takes a number of forms: cable, closed-circuit transmission, open-circuit transmission, microwave transmission, and satellite transmission, among others. However, although instructional television is widely used, it is used "very much as an adjunct to the teacher's normal work, or as an interlude, rather than in any way which could be construed as constituting a radical shift in the nature of teaching and learning" (Hoyle 1983, p. 57). Instructional television, then, is basically an added-on cost, complementing rather than replacing the classroom teacher.

Extensive research shows no significant difference in learning when comparing ITV and conventional classroom instruction (Campeau 1974; Jamison, Suppes, and Wells 1974; Schramm 1977). Students probably learn no more or no less through ITV. Surprisingly, when two-way learning is provided through "talkback" ITV, inferior results are achieved.

One apparent advantage of ITV is that it can provide instruction not available through other means. Particularly useful for vocational and technical instructional purposes is the use of ITV to simulate learning experience, to provide career information, to depict the use of machinery not available in the instructional laboratory, or to guide students through complicated (and perhaps hazardous) operations. Instruction, however, is passive and one-way, with the student having no control over learning. ITV is a poor substitute for the lecture, and broadcast ITV is inflexible.

Films

Films and ITV are considered to be quite similar in presentation format, and both are used to provide instruction in knowledge and skill acquisition, to motivate individuals, or to effect changes in attitude or personal values. Not surprisingly, research results show that use of film has no pattern of instructional superiority. Students learn from film, but probably no better than from other media (Campeau 1974; Schramm 1977). Interestingly, Marchant (1977) found that the conditions under which film is used in the classroom has a relatively direct impact on instructional effectiveness. Perhaps "more consideration needs to be given to the type of learning that is to take place and arrange for the presentation to facilitate such learning" (ibid., p. 73).

The use of instructional film has been declining (Koerner 1977). Cost is one factor; film is an expensive media, and is seldom cost-efficient in educational settings. Film is also inconvenient to use. Videotape, for example, is more portable and is seriously challenging film as an instructional tool.

The use of filmloops, a "little media," is more economical than regular film. Filmloops are also very accessible to students, lend themselves to individualized instruction, and are highly portable and flexible. Considerable instructional material is available for vocational training in the form of filmloops.

Audio Technology

Audiocassettes and recorders are inexpensive. Recorders are simple to operate, small in size, portable, and relatively durable. Instructional materials are easy to develop. A major drawback, however, is that audio instruction only rarely is sufficient for teaching technical concepts and procedures. On the other hand, when combined with manuals, worksheets and visuals, audio instruction can be highly effective (Schramm 1977). In addition, audio is "literacy free", and recorders have a playback capability that enables the student to repeat at any point. Perhaps the best uses of audio recordings are to supplement other instruction, to provide review, or to give directions.

Sound is important in the performance of manual job tasks. A machinist, for example, can tell the correct cutting speed and feeds by sound; a skilled auto mechanic can detect engine problems by listening. In view of the use of audio cues in work performance, greater research and development of audio teaching materials seem highly desirable and would help to advance the understanding of this generally overlooked, but nevertheless essential, dimension of task performance.

System Use

There is a tendency to consider individual technologies in isolation, when, in fact, a particular technology or combination may be used best as part of a total instructional system. Emphasis is shifted from finding the single best technology to a consideration of instructional requirements, followed by the selection of an available combination of teacher-led and technology-based system, such as have been used by the Open University in England and by the audio tutorial (AT) method of Samuel Postlethwait of Purdue University (Knapper 1980). In these approaches, educational technology is properly placed within the context of the total instructional system.

Perhaps the single most obvious difference between private and public sector use of educational technology is that the former tends to place the use of educational technology within the context of instructional systems design. Technology use follows from a careful needs assessment and, if it is used, it is usually in conjunction with other methodologies and because it provides a cost-effective alternative. With a few notable exceptions, public education, in contrast, tends to focus on the technology itself, with a search for effective use following acquisition.

The previously reviewed definitions of technology offered by the White House Conference on Children (1970) and the Association for Educational Communications and Technology (1979) suggest a comprehensive concept of educational technology encompassing needs assessment, design strategies, and human and nonhuman resource use. Such a concept of educational technology is probably essential if educational technology is to help facilitate effective learning.

Similarly, in regard to vocational instruction, one of the more pressing development activities may be to interface educational technology with the competency-based instructional paradigm that has achieved such widespread attention. It is within the total instructional context that educational technology will ultimately have to prove its worth.

On the other hand, perhaps the greatest strength of the newer technologies is that they may lead to truly new uses of the technology—ways to use technology on its own terms. If instructional technology has been less than fully successful, it may be because it has been used to imitate the human teacher within the conventional instruction context, rather than contribute innovative and new instructional capabilities. A "factor that limits our vision is our tendency to be trapped in images from the past. New technologies initially imitate old technologies" (U.S. Congress 1981, pp. 42-43), when what may be needed is to seize the opportunity to transform the instructional task itself.

CHAPTER 7

SUMMARY AND POLICY ALTERNATIVES

Are we poised on the edge of truly remarkable changes in education, led by advances in microelectronics and telecommunications coupled with improved software? Or will the application of educational technology be a disappointment, a failure to capitalize on the considerable potential to extend educational opportunity and to improve instructional effectiveness?

The past use of educational technology has not been encouraging. The heralding of great promise often has been followed by muted acknowledgement of less than adequate results. Many of the problems surrounding the use of educational technology need to be addressed before wide application is attempted. "If the gadgets fail to achieve their purpose, which certainly seems likely at this stage in their development," Pitts and Schneider (1981) caution, "then they will soon be stored away in closets and labeled another 'innovative failure'" (p. 3).

Given the policy position of the current administration toward the role of the federal government in education, and accepting the fact of real budget limitations, any policy initiative intended to stimulate the development and application of educational technology for vocational training and retraining must be modest. In addition, given the limitations and uncertainties surrounding the effective use of educational technology, a modest policy may be prudent.

Educational technology cannot now meet the considerable expectations placed on it: cost reductions and increased teacher productivity are not forthcoming; qualitative improvements in instruction are not achieved through educational technology alone; and educational technology is an uneasy addition to the teacher-led classroom and organizational structure of the public school. Educational technology is most widely used to complement or supplement instruction. And the software sequence is not a complete substitute for human interaction.

On the other hand, the application of educational technology to vocational education should be pursued, even if on a modest scale, if for no other reason than to provide educational credibility. Technology in general is rapidly transforming the way that we work, think, and live, and is penetrating the home, factory, office, and playfield. Education simply cannot ignore these changes without exacerbating the already serious discrepancies between the instructional world of the classroom and the realities of daily life. The student in the laboratory or classroom must experience the tools of technology found in the accounting office or plant. Simply to ignore these changes will lead to an educational system that will become so outdated and dysfunctional that it will incite its own demise.

Education in general is already under sustained attack (Boyer 1983; National Commission on Excellence 1983). The very structure of public education and its ability to address the educational needs of contemporary society has been called into question. Educational technology, however, can stimulate new and better ways to promote learning. Experimentation and application must proceed. As Hershfield (1982) warns, "if educators do not reorient themselves quickly to take advantage of this technology, private industry and new types of nonprofit educational organizations will do so" (p. 15).

Perhaps the most important benefit now achieved through educational technology is the "value added" to instruction. Through it, a better instructional mix can be achieved, teacher-led instruction can be augmented, and the context and quality of presentation can be enhanced. The obsolescence of instructors and content may be partly offset through the use of educational technology. Those outcomes, however, may be achieved through little media as well as big media.

Policy Recommendations

The problems facing the development and application of educational technology are not unsurmountable. Faced with real budget limitations on policy initiatives, there is room, nevertheless, for a cohesive policy to set the tone of discussion, guide inquiry, and stimulate future action. It is recommended that the U.S. Department of Education consider the following policy positions:

- Claims about the efficacy of educational technology should be moderate. It appears that the educational public is again searching for simple answers to complex problems, and educational technology is currently a prime candidate. Federal policy probably should not stress cost-savings, even though this is an attractive assertion, given the financial climate surrounding public education. Claims for learning effectiveness should be tempered, if they are made at all. Credibility is at stake.

  Many states, moreover, already face severe funding cutbacks, and the increased burden of costly technology will only add to their difficulties, especially if cost-savings or instructional results are not forthcoming. Although it is perhaps tempting to ride the tide of unqualified enthusiasm for educational technology, qualified caution is probably a more prudent long-term policy.

- Potentially the most viable use of educational technology at this time may be to extend instruction to nonconventional client populations through combinations of teacher-directed instruction and low-cost educational technology.

  Educational technology is often conceived as a substitute or complement to conventional teacher-led classroom instruction; when, in fact, its most satisfactory use may be to develop an alternative delivery system. Educational technology, for example, is used by the military to reduce training time; private industry benefits from the portability of technology, the ability to ensure standard quality, less need for formally trained instructional staff, and centralized instructional development. Similar applications, building from the strength of technology, need to be explored for vocational education in the public sector.

  The examination of potential alternative uses of educational technology should be encouraged, focusing on such activities as: adult vocational literacy, basic skills development, the retraining of displaced workers, instruction for the handicapped, and instruction in new technologies.

- Currently, the capacity of educational technology probably exceeds the ability of most teachers to use the technology fully. Preservice teacher training activities should be encouraged to prepare the next generation to make good use of educational technology. In-service training is needed to accompany current applications.

  To apply educational technology widely before teachers are adequately trained may be "putting the cart before the horse." Better-trained teachers will probably ensure better future uses of educational technology.

Since teacher education is primarily a function of state colleges and universities, little direct federal investment may be required once the training need is widely acknowledged.

- Technology in general is creating new requirements for education. Both the industrial and service sectors will require individuals who have new skills and the ability to be retrained, which may require a high degree of technological literacy. The introduction of computers as an object of study, a skill to be learned, is necessary in many vocational programs.

  For some applications of technology, coupling instructional uses of the computer with skill training may be one way to approach cost-effective use of educational technology. This is an area that should probably be explored.

  It may be prudent policy, however, to keep a distance between the two uses of technology. Parents certainly confuse the two, and it is probably to the benefit of producers of technology to blur distinctions. The revision of vocational curricula to reflect business and industrial application of technology must go on, regardless of the success of educational technology; the application of educational technology, on the other hand, poses different problems from those accompanying the skill training uses of technology.

To the extent that funds can be made available, modest initiatives in the following areas appear reasonable:

- Explore the research and development results of other federal agencies for relevant application to vocational education. For the past decade, federal initiatives in educational technology have largely taken place outside of the U.S. Office of Occupational and Adult Education, but those outside accomplishments may be able to provide a foundation on which more specific application to vocational training and retraining may be structured.

- Support a modest research effort in software development. Considerably more research is needed to identify the critical variables in the interaction between instructional design, the learning task, and learners. Until such a research base is established, software development will probably continue to flounder in the pool of gross comparisons characterizing current research.

  Although there is not a good understanding of important learning variables, there is probably less understanding of how to enhance vocational instruction. Research has tended to focus on cognitive tasks, when more attention needs to be directed to how students acquire job performance skills through the use of educational technology.

  Producers of educational hardware and software simply do not support sustained research efforts, and their main focus of interest is on the marketing of products.

- A clear priority is the pursuit of cost-saving uses of educational technology. Until it can be demonstrated that technology is cost-effective, use will continue to be restricted in the long term. A clear demonstration that cost can be reduced, however, "would facilitate a sharp evaluation of success and probably increase the probability of success" (Jamison, Suppes, and Wells 1974, p. 58).

A more comprehensive policy will have to await the resolution of issues surrounding the reduced federal role in education. States, and certainly individual local districts, are highly unlikely to support the necessary sustained research and development activities to ensure the successful classroom application of educational technology. They do not have the resources or inclination. Teaching students is their main order of business. And block grant funding makes it difficult to sustain efforts to apply technology.

Whether or not the public will support higher levels of funding for education is another outcome on which the future application of educational technology hinges. The proper role of vocational education is being seriously debated for the first time in two decades, and the relationship between schools and the workplace may significantly alter in the near future (Evans 1982; Sherman 1983). The educational technology field itself must mature and become something more than "a variegated, nationwide collection of projects frequently isolated from and unrelated to one another" (Koerner 1977, p. 5)

The five questions that this report set out to address do, nevertheless, provide a backdrop from which a comprehensive policy may eventually emerge. The findings suggest directions that policy can take to help ensure the successful application of educational technology to vocational instruction. The following are general observations and recommendations:

1. **What is the role of different stakeholders in educational technology and what is federal policy in this area?**

   - Public interest in educational technology is being stimulated, in a large part, by the producers of hardware and software seeking to expand markets for information technology. It is also a result of public concern over the high cost of education and the lack of instructional quality. In the long-term, educational technology probably cannot ameliorate these concerns.

   - The use of educational technology at the community college level probably merits greater attention. Conditions are favorable in community colleges for more nearly achieving cost-effective uses of technology.

   - The private sector's approach to educational technology is cautious, and use of high technology is limited.

   - It is poor policy to rely solely on the private sector to produce and market educational technology. The producers of hardware and software are, in a real sense, captive to their own profit-and-loss sheets, and it is the market forces that determine what is produced and hence, what students learn. Educational products will be developed because of market size and profit margins, and not necessarily because they lead to superior learning or address vital learning tasks.

   - Federal funding has been highly important for past developmental efforts in curriculum and instructional development. Block grant funding will continue to be a problem, and will probably retard efforts to use educational technology at the local level.

   - Networking may constitute an attractive alternative for the regional use of educational technology. However, there is some question whether or not the benefits to local users offset the costs involved. Results of the curriculum networks and centers established during the 1970s were mixed.

   - There needs to be greater support for basic research on software development, instructional interactions, and "mixes" of low- and moderately priced technology.

There probably needs to be less emphasis on large projects involving high technology, such as computer-assisted instruction and instructional television. Federal funds should not be used for "marketing" educational technology.

2. **What is the cost of educational technology? May it be expected to increase productivity?**

   - Cost-savings should not be expected from the use of educational technology, at least in the near future. Increases in teacher productivity are simply not forthcoming.

   - Cost-effectiveness will require structural changes in the way that instruction is organized and administered. It will require changes in the traditional teaching role, so that technology can function as more than an added-on cost.

   - Software will continue to be an important cost factor. After the initial purchase of hardware, software becomes the major determiner of cost.

   - Hardware development and application probably do not need to be supported. Hardware capacity consistently exceeds the capability of the software to use the hardware. Furthermore, if schools can not afford hardware, they certainly cannot afford the additional capital and recurrent expenses associated with the instructional use of technology.

   - The rapid advances in microprocessing electronics alone suggest that it is unwise to make large commitments to hardware purchases when costs are falling and the technology is changing. The inability to make cost-effective use of technology, the software problems, and the lack of appreciable gains in learning effectiveness also suggest that the application of educational technology should be modest: enough to encourage experimentation with classroom applications, but not enough to convert teacher-led classrooms into man-machine systems of learning.

3. **How effective is educational technology?**

   - Since presently there appears to be little difference in the instructional effectiveness of one technology compared to another, selection factors at the local level (other than instructional effectiveness), such as cost, ease of use, and availability of software may be the more important determinants of technology use.

   - Software development will continue to remain a priority, particularly in relation to high-cost, sophisticated technology. The relatively small size of the vocational education market and the uncertainty of market conditions function to retard software development.

4. **How is educational technology used within the instructional context?**

   - Educational technology continues to be important because it enhances instruction and provides interactions not normally available through teacher-led instruction.

   - Educational technology may be used effectively to introduce new instructional content, particularly in the high technology areas. Its use may be cost-effective in relation to teacher retraining.

- The application of educational technology to special needs learners is an area meriting additional development. However, applications to vocational education probably need to be coordinated with other development efforts, in general.

- Ways of serving other client populations, particularly by linking public and private sector training, need to be explored.

- The need to provide aid to poorer school districts to purchase computer and information technology will probably become a pressing issue. Schools attended by low-income students will need access to technology.

- Attention should be directed toward identifying organizational and administrative changes that must be effected in response to the application of educational technology. The existing organizational structure of schools has developed in response to the classroom teachers and the subject-based departments. The successful application of educational technology, however, probably requires new organizational and delivery structures.

5. **What are the instructional capabilities of different technologies?**

   - Functionally simple systems, using "little media," are probably preferable to more expensive and complex technologies within conventional vocational instructional settings. Not only are costs generally lower, but greater instructional flexibility is achieved.

   - Enthusiasm for the more complex technologies should not lead to less support for "little media" that have largely proven their usefulness for vocational instructional purposes.

   - Support for computer-assisted instruction (CAI) should be modest. CAI currently has limited application to vocational training and retraining. The past research and development in the field, moreover, has been extremely expensive, exceeding by far any reasonable effort that the U.S. Office of Vocational and Adult Education can mount. The best policy may be to build from the efforts of the U.S. Department of Defense, the National Science Foundation, and other projects within the U.S. Department of Education.

   - The integration of educational technology with instructional systems design needs to be explored. Past and current curriculum and instructional development projects provide for no interface with educational technology.

Another policy alternative, of course, is not to do anything, to let developments work their own way. This position, however, is an abdication of leadership. The problems of the time demand more. Certainly, to realize the expectation of improving instructional quality through the use of educational technology requires that a stand be taken to ensure the effective use of technology in our present and future educational systems.

APPENDICES

APPENDIX A
COMPUTER USE

U.S. INSTALLED BASE OF PERSONAL COMPUTERS BY MARKET SECTOR
(units in thousands)

	1982	1983	1984	1985	1986
Home/hobby	700	1,327	2,357	3,407	4,798
Business/professional . . .	1,236	2,345	3,975	6,025	8,428
Total	1,936	3,672	6,332	9,432	13,226

MICROS IN SCHOOLS (installed base)

Hardware	Purchased by school district for K-12	School Level			Total for 1981	Total Installed
		Grades K-8	Grades 9-12	College		
Totals	10,400	16,800	22,800	30,000	80,000	145,000

SOURCE: Office of Technology Assessment. *Information Technology and Its Impact on American Education.* The Office of Technology Assessment, 1982. p. 44.

APPENDIX B
EXPENDITURES FOR EDUCATIONAL TECHNOLOGY R & D, FISCAL YEAR 1982

Department of Education R&D Budget, Fiscal Year 1982 for Selected Program Areas

Program area	Approved R&D funding level (in millions)	Funds for education technology R&D (in millions)	Percent of program total
National Institute of Education	$ 53.4	$ 1.3 (est.)	2.4%
National Institute for Handicapped Research	$ 28.6	$ 0.2 (est.)	6.99%
Bilingual Education	$ 6.0	0	0
Handicapped Research Innovation & Development	$ 7.2	$ 0.9	12.5%
Vocational Educational Programs of National Significance	$ 5.5 (est.)	0	0
Educational Technology	$ 6.679	$ 6.679	100%
Special Education Resources	$	$ 1.8	
Fund for the Improvement of Postsecondary Education	$ 10.0	$ 2.5	40%
Total (all R&D within agency)	$107.4	$13.379	12.45%

Projected Federal Expenditures for Educational Technology R&D Fiscal Year 1982

Department	Projected expenditure educational technology—R&D	Total R&D budget (approved levels)
National Science Foundation	$ 4.536 million (est.)	$991 million
Department of Education	$ 13.379 million (est.)	$107.4 million
Department of Defense	$256 million (est.)	$ 19.9 billion
Total	$273.915 million (est.)	$ 20.99 billion

SOURCE: Office of Technology Assessment. *Information Technology and its Impact on American Education.* The Office of Technology Assessment 1982, p. 118.

APPENDIX C

CONTINUATION GRANTS FOR EDUCATION TECHNOLOGY FISCAL YEAR 1982

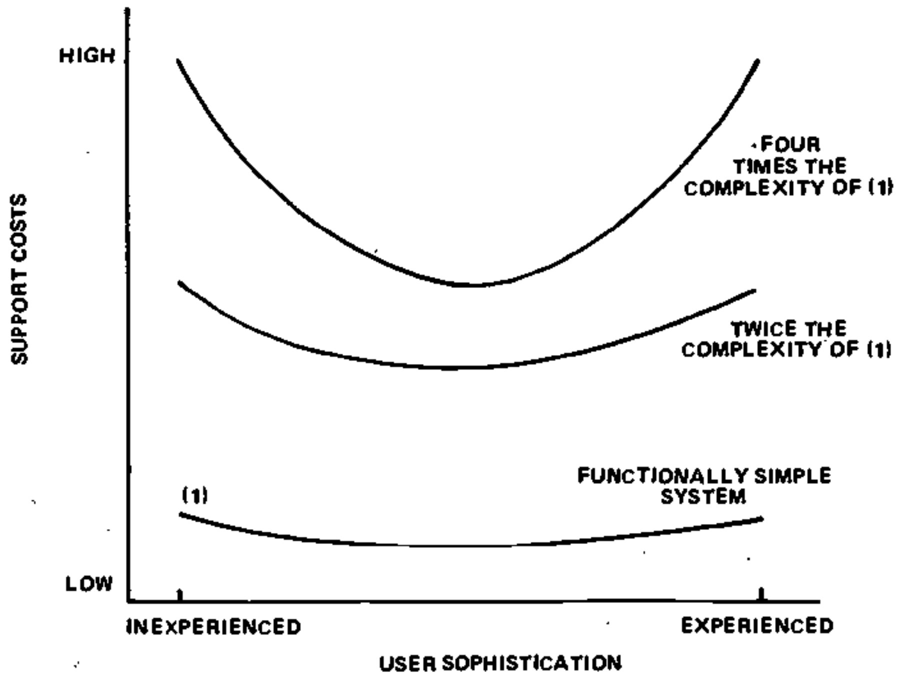
Program	Grant Description	Funding Level
DEPARTMENT OF EDUCATION		
Division of Educational Technology (Office of Educational Research and Improvement)	**Microcomputer Software**	$2 25 million
	Development: Elementary grades (3 yrs. funding at $150.000 per project)	
	Ohio State: mathematics: development and testing in 25 schools by fiscal year 1983	
	Wycatt reading: Bold, Beranek and Newman written composition	
	Video disk	
	University of Nebraska development of Spanish-English dictionary and microcomputer software.	$0.225 million
	American Institute of Research: video disk for music and math curricula for elementary grades: 45 site demonstrations and electronic mail component	
	Teleconferencing	
	"Project Best": assistance to officials in 45 States in understanding potential of technology: electronic mailbox component, 8 teleconferences	$0.250 million $1.1 million
	Television	
	Seven projects (selected grants highlighted)	
	"3-2-1 Contact": production funds to Children's Television Workshop ($1 million)	$16.175 million
	"Power House": health and nutrition—economically disadvantaged minority youth ($3.5 million).	
	"Kids": program for elementary grades on radio broadcasting ($1 million)	
National Institute for Handicapped Research	Adaptation of educational technology for use by handicapped	$0.2 million (est)
Special Education Resources	Deafnet Telecommunications Project—model dissemination ($0 3 million)	$1.8 million (est)
	Line 1 Caption Broadcasting Program ($1.5 million)	
Handicapped Research—Innovation Development	Technology Utilization Project	$0.9 million (est)

National Institute of Education	"Mathematics Education Using Information Technology": (until fiscal year 1982-83 jointly funded with NSF: $0 6 million). Computer courseware development "Calculator Information Center" ($0.1 million). "Computer Software Clearinghouse" ($0.2 million). Portion of Regional Educational Laboratories budget utilized for educational projects: courseware development: satellite telecommunications project (est. $0.4 million).	$1.3 million (est)
Fund for the Improvement of Postsecondary Education	Educational television. teleconferencing. computer-aided instruction. and video disk (local projects)	$1.5 million (est) $1.7 million (est)
NATIONAL SCIENCE FOUNDATION Office of Science and Engineering Education	Computer-based education. CAD/CAM education. and other projects currently up for review	
	Science Broadcasting	$2.336 million
	Prism Productions. Inc.. "How About": 90 second science series for commercial television (syndicated to 140 stations—jointly funded with General Motors Research Labs: NSF contribution: $0.208 million). Children's Television Workshop. "3-2-1 Contact": science programming: National Public Radio. "Science Information on Public Radio": establishment of science production capabilities and provision for science coverage for distribution to 227 public radio stations ($0.198 million).	
DEPARTMENT OF DEFENSE Army	See tables 18 and 19 for program elements and project topics	$73.5 million
Navy and Marine Corps	See tables 18 and 19 for program elements and Project topics	$131.7 million
Air Force	See tables 18 and 19 for program elements and project topics.	$49 4 million
Total		$284.336 million

SOURCE Office of Technology Assessment. *Information Technology and Its Impact on American Education*. The Office of Technology Assessment 1982. p. 120

APPENDIX D

COST AS A FUNCTION OF SYSTEM COMPLEXITY



SUPPORT COST ESCALATION WITH INCREASING FUNCTIONAL COMPLEXITY OF SYSTEMS

SOURCE: Whitney, T.M. "Compact Computers for the 1980s." In *Computers and Communication Implications for Education*, edited by R.J. Seidel and M. Rubin. New York: Academic Press 1977, p. 48.

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