DOCUMENT RESUME

ED 265 643 EA 018 132

AUTHOR Moore, Gwendolyn B.; Yin, Robert K.
TITLE Identifying Advanced Technologies for Education's Future.
INSTITUTION COSMOS Corp., Washington, DC.
SPONS AGENCY Special Education Programs (ED/OSERS), Washington, DC.
PUB DATE Apr 85
CONTRACT 300-84-0135
NOTE 19p.; Paper presented at the Annual Meeting of the American Educational Research Association (Chicago, IL, March 31-April 4, 1985).
PUB TYPE Speeches/Conference Papers (150) -- Reports - Research/Technical (143)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Artificial Intelligence; *Educational Technology; Educational Trends; Elementary Secondary Education; Futures (of Society); Special Education; *Technological Advancement; *Technology Transfer

ABSTRACT

A study to determine how three advanced technologies might be applied to the needs of special education students helped inspire the development of a new method for identifying such applications. This new method, named the "Hybrid Approach," combines features of the two traditional methods: technology-push and demand-pull. Technology-push involves creating new technologies before markets are identified; demand-pull strategies focus on identifying user needs and developing technologies to meet them. The hybrid approach identifies existing applications of technology in one field and forecasts their future applicability to situations in another field. Five steps are involved: (1) defining the technology, (2) identifying current uses of the technology, (3) obtaining specialists' views of the potential applicability of the current uses to new settings, (4) rating the scenarios developed in the previous step according to their chances for success, and (5) disseminating information about the potential uses found. A modified Delphi technique was used for the hybrid approach in the study. This paper draws on one aspect of the study (concerning applications of artificial intelligence technology to special education) as an illustration of the workings of the process. (PGD)

IDENTIFYING ADVANCED TECHNOLOGIES FOR EDUCATION'S FUTURE

Gwendolyn B. Moore
Robert K. Yin

Presentation at the annual meeting of the American Educational Research Association

April 1985

COSMOS CORPORATION

1735 Eye Street, N.W. • Suite 613 • Washington, D.C. 20006 • (202) 728-3939

CONTENTS

TABLES

IDENTIFYING ADVANCED TECHNOLOGIES FOR EDUCATION'S FUTURE

Introduction

This paper presents a new approach for identifying how advanced technologies, from a variety of fields, can be projected for their possible future applicability in educational settings. The paper reviews two processes that have been traditionally used for identifying the new applications of existing technologies (i.e., "technology-push" and "demand-pull"), and illustrates the new approach with an example of one specific advanced technology, artificial intelligence.

The paper is drawn from a study that examined how three advanced technologies--robotics, artificial intelligence, and computer simulation--might be usefully applied to the needs of special education students in the future. The 15-month study, conducted by COSMOS Corporation in Washington, D.C., has been sponsored by the U.S. Department of Education's Office of Special Education Programs.[1]

The study is based on the recognition that: 1) technologies have played and will continue to play an important part in special education, but 2) the most beneficial technologies have been transferred from other fields rather than having been invented within education itself. Thus, the goal of the study was to identify how technologies might be applied to educational needs in the future. (For information on technology in special education, see: Brown and Redden, 1979; Proceedings of the IEEE Computer Society, 1980; Zucker, 1981-1982; Office of Technology Assessment, 1982; Blaschke, 1984; Cain, 1984; Pollard, 1984; and Yin and White, 1984.)

This paper derives solely from the methodological aspects of the study; the substantive findings will be published in a forthcoming report, that will serve several purposes. First, it will summarize the definitions of the three technologies and the current "state-of-the-art" of each one. It will also identify current applications of the technologies and present hypothesized future uses of the technologies. Finally, it will describe possible actions--on the part of policymakers at the federal and state levels, as well as university, educational, and industrial groups--to facilitate the rapid, efficient, and equitable use of the three technologies by special education populations. (Copies of the report will be available through ERIC.)

Getting Technologies Into Practice

Traditionally, two processes have been followed to identify new applications of existing technologies: technology-push and demand-pull strategies. In technology-push strategies, new technologies are developed in the absence of pre-identified commercial outlets. In demand-pull strategies, the needs of a user population are established, and then technologies are developed to meet those needs.

A rich and diverse literature has analyzed these strategies and the processes by which technologies are put into practice in education and other public settings (e.g., see Berman and McLaughlin, 1974; House, 1974; Pincus, 1974; Radnor, 1975; Feller and Menzel, 1976; Nelson and Sieber, 1976; Yin, 1976; von Hippel, 1978; and Roessner, 1979b). In this literature, the supply of technology (equated with technology-push) and the demand for technology (equated with demand-pull) are examined for their effectiveness in meeting the needs of "users" (e.g., school or municipal service officials).

Technology-Push. Technology-push is the process whereby research and development (R&D) organizations create new technologies without the knowledge of a specific user audience or commercial market. An assumption behind the technology-push process is that innovations possess some type of inherent "good," and that they will thereby attract a sufficient market to justify the expenditure of development costs. For example, technology-push has been the motive behind a number of federally sponsored technology transfer efforts promoted nearly a decade ago, including a major one by the National Aeronautics and Space Administration (for examples of these programs, see U.S. Department of Transportation, 1976; and Executive Office of the President, 1977).

More recently, however, technology-push has been directly challenged for its failure to recognize the economic realities of modern-day society (Mowery and Rosenberg, 1979). These analysts argue (pp. 229-230) that "in a capitalist economy, where decision-makers operate on the basis of expectations of future profit, no substantial innovation activity will be undertaken unless there is some reasonable expectation that there exists a market demand sufficiently large to justify [the development expenditures]." Thus, while technological opportunity may be a necessary condition, it does not appear to be sufficient for projecting the applicability of technologies to future situations.

Demand-Pull. Demand-pull is where a demand for a new technology is said to induce its development (Yin, 1979). With this process, the needs of potential users are identified,[2] and existing technologies are applied to meet those needs. However, a number of studies have shown that identifying users' needs is not an easy process (e.g., Feller et al., 1975; and Eckfield et al., 1978). This is complicated further by the ambiguity of the concept of "user," and that, even if defined, users are much more diverse and fragmented than is often anticipated (Yin, 1978).

The primary assumption underlying "demand-pull" is that R&D organizations will muster their resources to develop technologies if a sufficient demand (i.e., market) exists for them. Another assumption is that the needs of potential users are best met with technological solutions (e.g., see Szanton, 1981. pp. 34-38). The criticisms of Mowery and Rosenberg (1979) appear to challenge both of these assumptions. They are critical of demand-pull for its failure to recognize the distinction between the "systematic relationship between prices and quantities" (demand) and the "rather shapeless and elusive notion of 'needs'" (p. 229). Further, demand-pull also fails to recognize the influence of the variety of technological opportunities available to R&D organizations. Therefore, like "technology-push," demand-pull is seen as a necessary--but, again, not sufficient--process for identifying new uses of technologies.

A Hybrid Approach. In spite of the acknowledged limitations of both of these strategies (e.g., see Yin, 1978; Roessner, 1979a; and Rosenberg, 1983), the development of alternative strategies has remained an unfulfilled goal. However, one new strategy has been developed during the course of the present study and may be considered a hybrid of the technology-push and demand-pull processes. The hybrid approach identifies existing applications of technologies in one field (analogous to technology-push) and forecasts their future applicability to situations in another field (analogous to demand-pull). In the present study, the approach was used to identify how advanced technologies might be used in educational settings.

The approach involves five steps. These are: 1) define the technology of interest; 2) identify current uses of the technology; 3) obtain ratings, from knowledgeable specialists, of the potential applicability of the current uses to new settings, and develop "scenarios" about how those new uses might occur; 4) obtain further ratings of the scenarios for the likelihood that they will succeed in the new settings; and 5) disseminate information about the potential uses of the technology.

An Example of the Hybrid Approach: Applying Artificial Intelligence Technology to Education

The hybrid approach was used to examine how robotics, artificial intelligence, and computer simulation might be used in educational settings in the future. Each of the five steps was followed for each technology. However, only one--artificial intelligence (AI)--is used here to illustrate the process.

Define the Technology. Most technologies represent broad, diverse fields. Although the fields can often be distinguished by identifying industrial, research, and professional organizations devoted solely to a particular technology, the fields tend to overlap, especially at their most advanced edges (e.g., Kinnucan, 1981). Thus, an important first step in considering alternative applications of a technology is to define the technology clearly. This step is an essential precursor to identifying its current uses.

Artificial intelligence can be initially defined as:

> The use of the computer to conduct the types of problem solving and decisionmaking faced by human beings in dealing with the world (Gevarter, 1983).

However, this definition can--and often is--taken to include such related activities as computer programming and the development of the "fifth generation computer" (for an introduction to AI and some of these related issues, see McCorduck, 1979). Computer programming, of course, covers an extensive range of activities which were thought to be not relevant given the technology focus of the present effort.

Thus, AI programs were distinguished from computer programming, with AI programs being those which:

1. Involve the manipulation of <u>symbolic processes</u>, and not merely numerical processes;
2. Utilize <u>heuristic search processes</u> based on rules, rather than algorithmic processes based on formulas; and
3. Call on large <u>knowledge representation bases</u> containing information separate from the control languages used by the program itself.

Finally, current activities to develop an intelligent "fifth generation computer" may be said to be at the heart of AI. However, these activities are far from resulting in any uses in routine, practice settings. Therefore, an additional distinction was indicated and "fifth generation" activities were excluded from the working definition of AI.

<u>Identify Uses of the Technology</u>

Once a technology has been defined, the next step is identifying ways in which it is currently being used. The search for current uses, or "applications," reflects the view that the societal benefits from new technologies are embodied in their practical uses. These applications occur in routine settings, and have normal support systems devoted to them--e.g., supply, maintenance, and repair resources. Further, applications will be available through some commercial source, or be a working prototype supplied to the user as a prelude to full commercial development. These characteristics of an application help to avoid identifying ideas still in the R&D stage, and emphasizes the importance of user experiences in real-life settings. Applications can be found in industry, the home, the office, or other organizations such as hospitals.

A number of different approaches may be used for identifying applications. The two most expedient approaches are interviewing knowledgeable individuals (e.g., association executives, researchers, industrial leaders) and searching trade and technical literature. The former is best accomplished through a "snowballing" technique, where one individual identifies applications as well as other knowledgeable individuals; the latter can benefit from a search of the materials in any good technical library. An essential part of this step is to confirm, through another round of interviews, that the named applications actually do operate in a practical setting. Often--especially with advanced technologies that are rapidly changing--the applications that are named may represent only partially functional prototypes that operate in laboratory settings.

A search of the type just described yielded 20 applications of AI technology. These applications reflected five different types of AI programs: expert, sensory information processing, natural language processing, speech synthesis, and planning systems (see Table 1). Taken together, these applications can be said to represent the "state-of-the-art" in AI, and they provided the basis from which future applications in educational settings might be identified.

From these 20, four AI applications were selected for more detailed examination. The four--expert, sensory information processing, natural language, and planning systems--were chosen to represent the range of possible AI applications. These four AI applications were examined in detail, and in-depth descriptions were prepared of the operational characteristics of each one, including its

Table 1

SUMMARY OF ARTIFICIAL INTELLIGENCE APPLICATIONS

Name	Type of Program and Function
ACRONYM	A vision system that produces a three-dimensional understanding of situations (e.g, aerial images of runways)
BUGGY	An expert system that helps to determine a student's arithmetic misconceptions or "bugs"
DELTA/CATS	An expert system that diagnoses problems in locomotives
DENDRAL	An expert system that determines the molecular structure of unknown chemical compounds
DEVISER	A general-purpose planning system that can account for time and schedule the appropriate sequencing of actions in complex situations (e.g., on-board spacecraft functions)
EMYCIN	An expert system that is used to construct other expert systems (it is the MYCIN expert system minus the medical knowledge)
EXPERT	An expert system that is a generalized scheme for building other expert reasoning models
HASP/SIAP	A sensory information processing system that uses diverse information (e.g., sonar signals and information about shipping lanes) to interpret the presence of certain kinds of ships
HEARSAY, HARPY	A speech recognition system that responds to human speech and can translate speech into written form
INTELLECT	A natural language processing system that queries a database by translating English commands into a database query language
MYCIN	An expert system that diagnoses particular types of bacterial infections

(continued on next page)

Table 1, Page Two

ONCOCIN	An expert system that assists physicians in the treatment of cancer patients by making therapy recommendations
PROSPECTOR	An expert system that analyzes geological formations related to 20 classes of minerals
PUFF/ MICROPUFF	An expert system that analyzes the pulmonary functioning of humans
"RTC Project"	A sensory information processing radar target classification system that uses rules to distinguish among different types of objects (e.g., aircraft carriers and destroyers)
SAVVY	A natural language processing system used for database management that can respond to poorly specified ("fuzzy") ideas
SCHOLAR	An expert system used for instructional tutoring that diagnoses learning misconceptions and displays material that reflects a student's errors
SOPHIE	An expert system that provides practice troubleshooting problems on electronic circuits
TAXMAN I, II	An expert system used to construct computer models of corporate tax cases and facts of the IRS to analyze the tax consequences of certain transactions
VISIONS	A sensory information processing system used to test various image understanding approaches and scene situations, such as houses and roads

costs, technology components, special support requirements, etc. (see Table 2 for an example of one of these descriptions). These descriptions were used as the stimulus materials for the third step.

Rate Applications and Develop Scenarios. The third step, in projecting the applicability of technologies to new settings, is to rate the current applications and to develop "scenarios" of new applications. The ratings are made by a panel of experts, consisting of individuals who are knowledgeable both about the technology and about the target setting (in this case, special education). The panel makes judgments about the settings, costs, benefits, and barriers likely to be related to the alternative uses of the current applications.

The rating step employs a "peer judgment with feedback" process, which is similar in some ways to the Delphi method.[3] This process requires that the panelists be provided with three sets of information: 1) a set of assumptions about the social, political, and environmental contexts for the future uses; 2) the definitions of the technologies; and 3) the in-depth descriptions of the applications that had been developed in step two.

On the basis of this information, each panelist "rates" the application along several dimensions, including the most relevant target population, time period when the new application may be realized, costs required to transfer the application, and activities that need to occur to facilitate the transfer. In addition, the panelists prepare scenarios that describe hypothetical, new uses of the current applications in the target setting.

Rate the Scenarios. In this fourth step, the "new" applications (as represented by the scenarios) are rated by using the same process as in the preceding step. During this fourth step, a number of iterations of ratings and feedback may occur, in an effort to move the panelists toward the type of consensus of opinion of the type sought during a Delphi study (e.g., Dalkey, 1969; nd Helmer, 1983).

The outcome of this iterative process is the development of conclusions, specific to each of the new applications. These deal with the specific population which might most benefit from the application,

Table 2

EXAMPLE OF IN-DEPTH SUMMARY
OF AN ARTIFICIAL INTELLIGENCE APPLICATION

INTELLECT, Artificial Intelligence

INTELLECT is an artificial intelligence, natural language processing system, that is used by staff in a large corporation to query a personnel database. The system allows operators to make requests, using common English sentences (e.g., "How many employees were hired in 1981?" or "How many employees have advanced college degrees?"). The system is used primarily for answering non-routine questions related to personnel, such as those which may arise during labor negotiations. Approximately 100 queries a week are put to the system, by the ten people who have access to it.

The INTELLECT system eliminates the need for extremely time-consuming manual searches of personnel records or the need for computer specialists to interface with users. Users are able to obtain information from the database without having to learn the complex control languages and request sequences normally associated with the use of computers. It also provides immediate responses to questions, and allows a user to feel free to ask as many questions as might be of interest. Finally, the system allows top-level managers to evaluate sensitive questions confidentially (e.g., "How many people would lose health insurance benefits if the policy were changed?"), because they can seek the necessary data themselves without the services of technical personnel.

The INTELLECT software is written in the PL-1 language, and is designed to resolve the ambiguity of questions put to it by analyzing the context of the questions. The system does this by using data from its lexicon and from the database itself. For example, take the question "Are there any bakers below 42nd Street in New York?" Two items are ambiguous in this question: is "baker" a person's name or a profession, and is "New York" the city or the state. Because "street" is a jurisdiction-specific concept, the system would "assume" that "New York" was the city. Further, if the particular database contained both "baker" as a name and "baker" as a profession, then the system would ask the user which "baker" was desired. If the database only contained one "type" of baker, the system would provide the answer. The ability of the program to resolve ambiguities makes it an advanced artificial intelligence system, and reflects the linguistic system and the basic elements of language structure contained in the program.

The INTELLECT program was developed by a commercial firm, and a full, life-time license to use it--which includes annual updates as the program is revised and refined--costs $50,000. The program can run on any mainframe computer.

the costs associated with it, the year it is likely to be available, and judgments about the technological and organizational changes that need to occur to facilitate the transfer process.

Comparing the ratings of the original AI applications with the ratings of the scenarios shows some interesting but subtle changes between the sets of ratings. For example, the beneficiary populations shift from mild and moderately handicapped to communication disordered and multiply handicapped, although the activities of students which would be aided by the technology remain essentially the same. In moving from applications to scenarios, however, the projected costs of developing the new applications become significantly greater, and in addition to technical and cost constraints, a third barrier--training--was identified. (The third round of ratings had not been completed by the time this paper was prepared.)

Disseminate Information about New Uses. The final step is to inform technology developers and funders (e.g., industrial and university research organizations, federal government agencies and foundations) about the directions for developing and marketing a new technology, and to inform potential users (e.g., teachers and other educators) about the possible benefits to be derived from the technology.

This step requires the identification of specific dissemination targets, and the active involvement of researchers, policymakers, and special educators. The overall goal of the dissemination activity is twofold: 1) to make relevant individuals aware of the study and its findings, and 2) to provide information about specific ways in which the three technologies might be used to help special education populations. It is hoped that such dissemination activities will stimulate the future development and use of specific technologies.

Importance of the Hybrid Approach

A new approach to identifying possible future uses of technologies has been described here. The approach helps to overcome some of the shortcomings of the "technology-push" and "demand-pull" approaches which have traditionally been used for this purpose. The approach is currently being used in a study of three advanced technologies--robotics, artificial intelligence, and computer simulation. The study is exploring how those technologies might be used to helpful to special education students in the future.

NOTES

[1] This paper is based on research supported by the U.S. Department of Education's Office of Special Education Programs under Contract No. 300-84-0135. Any findings, opinions, conclusions, or recommendations expressed in this paper are those of the authors and do not necessarily reflect the views of the Department. Further, the authors wish to express appreciation to COSMOS Corporation, which provided the actual support for developing and presenting this paper.

[2] A number of different methods have been used to identify the needs of future users. These have included needs assessments, technology assessments, and Delphi studies. As with "demand-pull" itself, these methods each present their own unique advantages and disadvantages.

[3] The method used in the present study was a modified Delphi study, consisting of three rounds. In round one, ten experts were used to rate the current applications of the three technologies and to develop scenarios about how those applications might be used in special education settings in the future. In the second round, five of the first ten experts rated the scenarios on a number of dimensions related to their possible future usefulness. During the third round, the same five experts were provided summary ratings from the second round, and were asked to reevaluate their second-round ratings of the scenarios. The data from all three rounds, together with other information collected during the project, will be the basis for the project's final report.

REFERENCES

Berman, Paul, and Milbrey W. McLaughlin, Federal Programs Supporting Educational Change, The Rand Corporation, Santa Monica, Calif., 1974.

Blaschke, Charles L., "Technology Trends in Special Education," paper presented at the CAESD Conference, Los Angeles, Calif., April 12, 1984.

Brown, J.W., and M.R. Redden, A Research Agenda on Science and Technology for the Handicapped, American Association for the Advancement of Science, Washington, D.C., January 1979.

Cain, Edward J., Jr., "The Challenge of Technology: Educating the Exceptional Child for the World Tomorrow," Teaching Exceptional Children, Summer 1984, 16(4):238-241.

Dalkey, Norman C., The Delphi Method: An Experimental Study of Group Opinion, The Rand Corporation, Santa Monica, Calif., June 1969.

Eckfield, Richard E., et al., Factors Involved in the Use of University Research by State and Local Officials, SRI International, Menlo Park, Calif., April 1978.

Executive Office of the President, Directory of Federal Technology Transfer, Washington, D.C., June 1977.

Feller, Irwin, et al., Sources and Uses of Scientific and Technological Information in State Legislatures, Institute for Research on Human Resources, Pennsylvania State University, University Park, Pa., June 1975.

_______, and Donald Menzel, "Diffusion of Innovations in Municipal Government," Center for the Study of Science Policy, Pennsylvania State University, University Park, Pa., 1976.

Gevarter, William B., An Overview of Artificial Intelligence and Robotics: Vol. I--Artificial Intelligence, Part A--The Core Ingredients, National Aeronautics and Space Administration, Washington, D.C., January 1983.

Helmer, Olaf, Looking Forward: A Guide to Futures Research, Sage Publications, Beverly Hills, Calif., 1983.

House, Ernest R., The Politics of Educational Innovation, McCutchan Publishing Company, Berkeley, Calif., 1974.

Kinnucan, Paul, "How Smart Robots are Becoming Smarter," High Technology, Sept./Oct. 1981, 1(1):32-40.

McCorduck, Pamela, Machines Who Think, W.H. Freeman and Company, New York, 1979.

Mowery, David C., and Nathan Rosenberg, "The Influence of Market Demand upon Innovation: A Critical Review of Some Recent Empirical Studies," Policy Research, April 1979, 8:103-153.

Nelson, Margaret, and Sam Sieber, "Innovations in Urban Secondary Schools," School Review, February 1976, 84:213-231.

Office of Technology Assessment, Technology and Handicapped People, Washington, D.C, May 1982.

Pincus, John, "Incentives of Innovation in Public Schools," Review of Educational Research, Winter 1974, 44:113-144.

Pollard, James P., "Understanding Technology: Adaptive Devices for Special Education," Electronic Learning, 1984, 3(5):44,46.

Proceedings of the IEEE Computer Society Workshop on the Application of Personal Computing to Aid the Handicapped, IEEE Computer Society, Laurel, Md., April 1980.

Roessner, J. David, "Federal Technology Policy: Innovation and Problem Solving in State and Local Governments," Policy Analysis, 1979a, pp. 181-200.

_______, "The Local Government Market as a Stimulus to Industrial Innovation," Policy Research, 1979b, 8:340-362.

Rosenberg, Nathan, Inside the Black Box: Technology and Economics, Cambridge University Press, Cambridge, 1983.

Szanton, Peter, Not Well Advised, Russell Sage Foundation, New York, 1981.

U.S. Department of Transportation, Technology Sharing: A Guide to Assistance in Obtaining and Using Research, Washington, D.C., 1976.

von Hippel, Eric, "Users as Innovators," Technology Review, January 1978, 80:31-39.

Yin, Robert K., "Contemporary Issues in Domestic Technology Transfer," in Subcommittee on Science, Research, and Technology, U.S. House of Representatives, Domestic Technology Transfer: Issues and Options, Washington, D.C., November 1978.

_______, and ~. Lynne White, Microcomputer Implementation in Schools, COSMOS Corporation, Washington, D.C., March 1984.

_______, et al., A Review of Case Studies of Technological Innovations in State and Local Services, Rand Corporation, Santa Monica, Calif., 1976.

Zucker, A., "Support of Educational Technology for the U.S. Department of Education: 1971-1980," Journal of Educational Technology Systems, 1981-1982, 10:303-320.