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ABSTRACT

Concerns about the current educational technology movement are discussed in these four papers which were presented during a seminar of 20 representatives from 10 Council for Educational Development and Research (CEDaR) member institutions. The first by Marcella Pitts and E. Joseph Schneider provides an overview of the educational technology movement and discusses current use of and interest in technology in schools. The paper distinguishes differences between educational technology and technological gadgetry, cautioning against indiscriminate use of technological hardware without instructional expertise. The second paper by Alan M. Lesgold focuses on ways basic instructional principles derived from education and psychology can be applied to computer-based instruction. Three seminar themes are highlighted in the third paper by Richard E. Schutz: (1) the capability for CEDaR member institutions to advance educational technology and school improvement through programmatic research and development; (2) the possibility for CEDaR institutions to combine their expertise to explore instructional applications of technology; and (3) the problems of injudicious application of technology to educational problems. The final paper presents the views of a panel of experts, who comment on the services that research and development organizations can provide to schools and make specific recommendations about technology-related research issues. Each paper begins with a short summary, and references are listed for the first and third papers. (LMM)

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A Bright Promise But A Dim Future Researchers Examine Potential of Educational Technology

Proceedings of a Cooperative School Improvement Program Seminar June 1-3, 1981 Washington, DC

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Preface

Twenty representatives from ten CEDaR-member institutions attended a seminar, "Educational Technology: Bright Promise or Dim Future?", in Washington, D.C., June 1-3, 1981. The seminar was sponsored by CEDaR's Cooperative School Improvement (CSI) program. This volume is a report of that seminar—the papers presented, the issues discussed, and the cooperative steps the CEDaR-member institutions agreed to initiate in educational technology.

During the course of the seminar, participants raised several concerns about the current technology movement. First, school personnel are uncertain about how and when to use technology to improve instruction even though schools are purchasing technological hardware at an increasing rate. Second, the technological hardware is becoming more and more sophisticated but there are few high-quality programs available which utilize the technology. Third, the private, profit makers, a dominant presence in the technology movement, will continue to expand their investment in education. Industry specialists have a limited understanding of the instructional principles that should guide the development of technology-related materials. Fourth, school personnel, and perhaps the educational research and development community, will be blamed for the fact that technology has not made a remarkable difference in schools or in students' learning.

The institutions decided that they should come forward to assist school personnel in making informed decisions about technology and in making the best instructional use of technology. Consequently, they resolved to undertake a collaborative project and develop for the school-based community materials school personnel can use to guide their purchase of technology and its use in classroom instruction.

Introduction

In early June, representatives from the CEDaR-member institutions met in Washington, D.C. to discuss the promises and pitfalls of educational technology. The two-day seminar, "Educational Technology: Bright Promise or Dim Future?", was sponsored by CEDaR's Cooperative School Improvement program, an effort that encourages collaborative ventures among the institutions designed to improve educational practice. Educational technology was an area in which the CEDaR members felt they should consider initiating a cooperative school improvement project.

During the course of the session, participants examined technology's bright promise in relation to its current use in schools and the state-of-the-art of technology-related instruction. They discussed the federal government's and Congress' support of educational technology and the private, profitmaking sector's role in technology's entry into schools. Their conclusion: current trends in these areas preview a dim future for educational technology, if they are not challenged.

The institutions resolved that the role of research and development organizations committed to school improvement is to challenge these trends. Consequently, they agreed to develop, cooperatively, tools school personnel can use to face the challenges and address the problems technology's entrance into schools poses for them.

We are indebted to Robert G. Scanlon, Pennsylvania's Secretary of Education, who in his opening remarks set the charge for the meeting and stimulated the discussion that followed.

E. Joseph Schneider
Executive Director
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Development & Research

August 1981

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Marcella Pitts and E. Joseph Schneider
Council for Educational Development and Research

An Introduction to
"Educational Technology: Bright Promise or Dim Future?"

"Educational Technology: Bright Promise or Dim Future?", by Marcella Pitts and E. Joseph Schneider, provides an overview of the educational technology movement.

The authors examine schools' current use of technology, the private sector's activities in the education market and elsewhere, Congressional interest in educational technology, and the federal bureaucracy's current and future support for technology-related research and development.

The authors caution that the r&d community can ill afford to see technological hardware flood schools, have little effect on improving education, and be labelled a failure.

Basic to the paper is a distinction between educational technology and technological gadgetry. Educational technology has objectives based on research in human learning and communication and uses both human and non-human resources to bring about more effective learning. The indiscriminate use of technological hardware in the classroom, without blending the capability of the machines with instructional expertise to bring abo[illegible] more effective learning, is technological gadgetry. The CEDaR institutions' task, the authors conclude, is furthering educational technology to improve schools.

Educational Technology: Bright Promise or Dim Future?

Marcella R. Pitts and E. Joseph Schneider
Council for Educational Development and Research

A cynic might suggest that the current educational technology boom is to the 80s what the curriculum development movement was to the 60s. Their advocates certainly sound much alike. Every positive adjective except "panacea" is used to describe the impact technology will make on learning. Panacea isn't used because frankly not even a computer salesman thinks there's much hope for some schools and/or some children. But that doesn't prevent the hardware manufacturers and their customers in the superintendent's suite, or their colleagues in the research community and the publishing industry, from shouting to each other that they had better get on board or this parade will pass them by.

Beyond a doubt, education is being bombarded with the virtues of the machine. The times demand it. An important segment of the general public thinks schools are lousy and getting worse. The economics of education practically dictate that we find a way to educate children while lessening the enormous personnel costs associated with the task. And the gadgets promising to help cut costs exist in abundance right now, amazing kids and their parents both with their amusement and entertainment capability. Obviously, educational technology is more than a passing fad.

But where's the educational research and development community? Well, one thing is obvious: the educational research community isn't out in front on this movement. Educational technology is being driven by the hardware manufacturers, the machine salesmen, and their hired courseware developers.

Our paper, then, is written out of frustration. We worry that the contributions educational research can make to the educational technology movement are at best being ignored. The snub might be tolerable if it wasn't so painfully obvious that being ignored frequently means we're being rejected. And frankly, the research community can ill afford to sit by and watch electronic gadgets invade the public schools. If the gadgets fail to achieve their purposes, which certainly seems likely at this stage in their development, then they will soon be stored away in closets and labeled another "innovative failure." Such failures, we have learned from our earlier experiences with curriculum development, tend to haunt the research community even years later.

So our paper has two purposes. We want to share with the participants at the Cooperative School Improvement (CSI) seminar what we see going on in the educational technology movement. We'll take a look at the schools to see what use they currently make of the new wizardy. Then we'll spend a few pages exploring with you the commercial sector's dreams and marketing plans. Because we depend on them so much, we'll next visit with our friends in the federal bureaucracy to see how they are spreading their wealth to further the movement. No visit with the government would be complete without some cursory discussion of the visions being played out in the U.S. Congress.

We'll conclude the paper, then, with two scenerios. The first is negative. It's the path we're currently charting for ourselves, though. It's also the familiar path; we've gone down it before. The other scenerio is optimistic. It foresees a major role for the CEDaR-member institutions in this rush to introduce gadgets into the classroom. Unfortunately, this scenerio requires some changes in the way we do business and in the way we relate to the other actors in this drama. Whether or not we're capable of realizing the optimistic scenerio will be the basis for discussion at the seminar.

Educational Technology or Educational Gadgets?

Right up front we might just as well grapple with a little controversy. When we talk about educational technology, are we simply acknowledging the existence of just so many pieces of hardware and machinery? Educators have certainly learned the hard way that even the fanciest machines with the most impressive levers, buttons, and color-coded dials have an uncanny ability to first bore and eventually alienate their users. Of course there's more to educational technology than media and machines. But just how much more is questionable. So before we go on, let's define technology as we would like to think it exists. Here's a definition that suits our purposes:

> Educational technology goes beyond any particular medium or device. In this sense, educational technology is more than the sum of its parts. It is a systematic way of designing, carrying out, and evaluating the total process of learning and teaching in terms of specific objectives, based upon research in human learning and communication, and employing a combination of human and non-human resources to bring about more effective learning (1970 President's Commission on Instruction and Technology).

Not bad. It certainly reinforces our profession's legitimate involvement in the movement. In other words, this definition views educational technology as a process rather than merely the application of electronic gadgetry to education. And of some importance, we believe, the definition emphasizes the necessary interaction between humans and machines ". . . to bring about more effective learning."

From where we stand, we're going to insist that anything carrying the "educational technology" label live up to the lofty definition given us by the presidential commission. And we're going to be particularly concerned about the activity's ability to demonstrate that (1) its objectives are based upon research in human learning and communication; (2) it uses both human and non-human resources; and (3) it brings about more effective learning.

If the activity within the educational technology arena isn't of the blue-vein variety described above, we're going to label it for what it probably is: educational gadgetry having no more redeeming qualities than the fact its products might just entertain or amuse the user.

For the sake of discussion, we're going to go one step further. Let's just say that anything that results from educational technology is "good." And anything short of that, educational gadgetry, in other words, is "bad." Every resource used in a classroom should directly or indirectly result in increased achievement among pupils. If it doesn't, the "resource" becomes a detriment, robbing the student of valuable time and energy needed for meaningful instruction and learning.

Schools Slow To Embrace Educational Gadgetry

Without question, educational gadgetry is filtering into schools. Sales of classroom microcomputers and other audio-visual materials were up in 1980 and the increase is expected to continue. In fact, the National Audio-Visual Association anticipates an increase in sales even though federal funding patterns, inflation, and declining enrollments all work against long-term industry goals.

One of the older technological devices currently in use in schools is instructional television (ITV). Approximately 15 million children received a regular portion of their instruction from ITV, according to a 1977 National Center for Educational Statistics (NCES) survey.

The use of broadcast and cable television in classrooms will undoubtedly be affected by technological advances in satellite communications and emerging new hardware such as videodiscs. These advances should increase the range of programs available to schools and their applications in the classrooms. Furthermore, television and videodisc are beginning to link up with computers.

Nevertheless, education's interest in television as an instructional tool has shifted to computers, especially microcomputers. Proponents of technology predict a revolution in computer-based education in the next several years. If so, we'll see more computers and a wider application of them for instructional purposes.

The government's most recent statistics show that about half of the nation's school districts provide students with access to a microcomputer or at the very least, a computer terminal. That's about 52,000 computers.

When we begin to examine individual school building use, though, NCES tells us that one out of every four public schools in its sample had at least one microcomputer or computer. Half of the secondary schools have them compared to only 14 percent of the elementary schools.

The NCES study also shows that computer availability within school districts is limited. Students in about three-fourths of the districts with microcomputers have fewer than five available for their use. And in the majority of districts, only one school has access to the hardware.

Not surprising, then, instructional use of the computers is restricted. The primary use, reported by 85 percent of the districts surveyed, is in "computer literacy" courses. Other instructional applications are "to improve learning in selected subject areas (72 percent) and "to challenge high achievers" (64 percent). Fewer than half (45 percent) of the districts use computers for "remedial and compensatory instruction." This last statistic is interesting because schools were thought to use their computers for "drill and practice" application.

The survey suggests that school districts make the most efficient use of their limited number of computers by introducing students to the world of electronic gadgets through literacy courses; applying them in specific subject areas; and using them to motivate and reward bright students.

The government's surveyors did not gather data on administrative use of computers, an application which we suspect far outstrips instructional use. An earlier survey did reveal that administrative uses dominated instructional uses by a ratio of nearly three to one (Korotkin, 1970).

The relatively limited use of computers in schools is a sharp contrast to the predictions about the revolution in computer-based education. The technology revolution, in other words, has started. But it's moving slowly.

While technology's potential is attractive, certainly in the abstract, numerous obstacles exist to prevent it from becoming an integral part of schooling. These obstacles will not prevent the increased use of technological gadgetry, but they are substantial roadblocks to integrating the hardware into approaches that solve educational problems.

Historical Obstacles to Schools' Use of Technology

The use of technological gadgetry in education certainly isn't new. Educators have been adopting new technological devices, media, and systems for the past 60 years if we listen to Ralph Tyler (1980). Some gadgets, such as the overhead projector, caught on quickly and were widely adopted. Others, such as teaching machines, have had little impact.

The residue from the problems and failures associated with applying technology to schools over the past 20 years, while not insurmountable, will undoubtedly have an effect on the support educators find for their current enthuasiasm about the gadgets and their capabilities.

Instructional Obstacles to Schools' use of Technology

The use of technological hardware in instruction is in its infancy. More importantly, the hardware is beginning to outstrip the software and courseware. A proliferation of equipment is matched only by a dearth of good instructional programs. In fact, some courseware on the market is literally little more than computerized programmed-instruction texts. Consequently, the computer's diagnostic capability and its full interactive potential remains underutilized. The computer, in other words, exists as little more than an expensive toy.

Organizational Obstacles to Schools' Use of Technology

The lack of extensive adoption of technology in education has been attributed, at least in part, to fundamental incompatibilities between the educational system and most of the technology intended to perform educational functions (Luehrman, 1979).

Part of the problem lies in trying to implement a new technology in a system developed for an older technology (Chadwick, 1979, Hirshfield, 1981). That system, the traditional teaching-learning model, poses a challenge for the technologist. The model is teacher and textbook dominated. The teacher, aided by the textbook, is the basic source and interpreter of information. In addition, the teacher performs various roles, including diagnosing students' skills, providing almost all forms of instruction, managing the classroom, and evaluating the pupils' learning.

Technology, if adopted widely in schools, promises to change the role of both the teacher and the textbook. Neither is particularly comfortable with that notion.

At a purely practical level, the current fiscal crunch and declining enrollments, which threaten teachers' jobs, will also limit the application of technology in schools. Even then technology will come face to face with the fact "the social and organizational structure of schools has proven highly resistant to the replacement of the teacher by a machine" (Walling et al. 1981).

Economic Obstacles to Schools' Use of Technology

Despite proponents' arguments that the cost of technology is now within the grasp of school districts, education is undeniably entering a period of declining fiscal resources. It is also an era of declining enrollments and stable teaching populations, an inopportune time to introduce labor-saving devices into the classroom.

These factors will keep technology out of reach of many school districts, especially those in lower-income areas. Without subsidies or external support, schools simply won't be able to afford the new gadgets.

Marketplace Guides Private Enterprise

Despite what we may think of their utility for instruction, the private sector has done an impressive job of developing educational hardware and courseware. Some of the larger producers have made major commitments in education. Control Data, for example, has invested $750 million since 1962 in the design and production of computer-based instruction (New York Times, April 26, 1981). It's not a "get-rich-quick" enterprise, though. Only now does Control Data expect to begin making a profit from its long-term investment in PLATO. Other producers, like Atari and Tandi Corporation, are relative newcomers. In fact, not one of the leading microcomputer producers had any instructional products in the 1960s; why some of the companies did not even exist then. Nevertheless, companies such as these and others involved in various aspects of information technology, including Xerox, IBM, RCA, Texas Instruments, and even Exxon, are by many predictions destined to become the corporate giants of the future (Molitar, 1981).

Given the time and resources invested in hardware and courseware development, the private sector naturally seeks a mass market for its products. Elementary and secondary education simply isn't that kind of market. And the marketing strategies of the large companies demonstrate that fact. Although many have an investment in the education market, it is modest compared to their efforts in the industrial and home markets.

Systems such as PLATO and TICCIT, for example, sell well in industry and the military. Microcomputers, on the other hand, have gone over well in the home market (Molitor, 1981).

The private sector, nevertheless, undoubtedly will continue and possibly expand its investment in education. Following a long period of wait and see, for example, major educational publishers are investing in the development of courseware for computers and microcomputers. Scott Foresman, Houghton Mifflin, Science Research Associates, Random House, and Macmillan are all developing and marketing materials.

In addition, the publishers are beginning to combine their efforts with the microcomputer producers. Random House, for example, was recently named the authorized education market distributor of Radio Shack's TRS-80 computer products for classroom use. Scott Fores . an is selling products for Texas Instruments and SRA is selling Atari products (Educational Technology, March, 1981).

These partnerships meet the needs of both the producers and the publishers. They suit the computer makers because they do not have the expertise to deal with the special needs of the school market. The publishers have the expertise, but they had virtually withdrawn from the field prior to the microcomputer revolution. Consequently, they have nothing to offer schools clamoring for microcomputer hardware and courseware.

There is a growing concern, however, that the industry is guided only by the marketplace. Profit-making corporations, naturally, respond to private markets "in order of their comparative profitability, regardless of their relative social consequences" (Walling et al., 1981).

Federal Government Takes a Back Seat

Over the years several expert panels have made strong and specific recommendations for government support and coordination of educational technology. Since technology is moving rapidly, some observers urge federal policy makers to climb on board the technology train now or be run over by it. Unfortunately, it appears that the federal sector may have been left standing at the station. Currently, the federal government finds itself in the uncomfortable position of trying to integrate itself into something already happening under the auspices of the private sector.

Department of Education

The majority of the Department of Education's (DoED) technology funding supports telecommunications projects. Other areas are catching up, though. In FY 80 the department spent $40 million to support various technology efforts, including $19 million in telecommunications projects; $15 million on projects involving computers, calculators, and videodiscs; $5 million on projects using teaching machines; and $1 million on videotape projects.

Of the money spent supporting computer-related projects in FY 80, $11 million funded projects focusing on mainframe computers related to higher education. Another $2.5 million supported projects utilizing microcomputers and about $200,000 funded mini-computer projects.

The dollar signs don't tell the technology story, however. Impressive amounts of money were spent to purchase fancy gadgets, but only a minimal amount went to develop either courseware or hardware.

That is, the government's largest investment in technology is actually formula grant dollars awarded to school districts through Title IV-B. Districts can use these funds to purchase microcomputers as well as library and instructional materials. The library and gadget manufacturers maintain sizeable Washington lobbys to ensure that these funds continue to flow for this purpose.

The government's less-than-impressive investment in the future hasn't gone unnoticed, though. For example, Ernest Boyer, while Commissioner of Education, appointed a task force to advise him about education and technology. He accepted the recommendations, which would have resulted in a boon to instructional television had he stayed around to implement them. Alas, he didn't.

The technology initiative was revived, through, by Shirley Hufstedler, DoED's first Secretary. She put her own task force together. Alas, she, too, departed before any of its recommendations could be put into place.

Now we're up to Ted Bell, Hufstedler's replacement. He, too, has some ideas about the potential of educational technology. And he, too, has a task force looking at the issue. Many of Bell's task force members are veterans of earlier duty. In fact, so many of them served in a similar capacity earlier in their careers that we might wonder what new ideas they'll bring forward.

Old hands predict that Bell's task force will recommend a small departmental initiative in educational technology. Money is tight, you realize. Given the modest number of dollars it's willing to expend, the initiative will tend to be modest also. In fact, insiders predict that it will be nothing more grand than a few projects addressing several pressing needs. These probably will include the need for high-quality courseware; the need to provide school districts with marketing and evaluation information to use as they consider technological devices; the need to demonstrate the cost-effectiveness of technology for some educational activities; and the need to educate teachers to use the new technologies. The initiative, which will be lucky to get off the ground in a year, will undoubtedly support a few demonstration projects, a small dissemination effort, and some modest technical assistance programs.

National Science Foundation

The National Science Foundation's Education Directorate has been responsible for much of the federally sponsored research in technology as it relates to education, especially science education.

The Reagan administration, though, has proposed drastic cuts in the Foundation, particularly across its Science Education Directorate. The administration proposes phasing out the Directorate's contract and grant work in FY 82. The phase out will mean the elimination of programs that for years have funded the development of computer courseware, software, films and video modules.

National Institute of Education

Much of the National Institute of Education's support for technology research is through a joint program it sponsors with the National Science Foundation. This one-year-old program funds research on ways to improve mathematics instruction through technology, especially microcomputers. It currently supports nine projects. The joint program is funded at $750,000 and the same level of support has been requested for FY 82. The federal project officers envision their program supporting the development of several small-scale prototype programs this year and a smaller number of larger projects in FY 82.

The Institute's support of technology-related research and development totaled approximately $3.6 million in FY 80. Of this, $1.9 million supported telecommunication projects. The largest was the Appalachian Community Service Network at $1.2 million. The Institute also awarded half a million dollars to the Alaskan Educational Telecommunication project.

In addition, NIE invested about $850,000 in computer-related projects, of which half a million was used to help maintain the ERIC system's computer data bases.

Funding for micro-computer work totaled $760,000. Of this, about $200,000 supported the Northwest Regional Educational Laboratory's Computer Technology MicroSIFT Clearinghouse. The Institute also awarded $130,000 both to Advanced Learning Technology, Woodside, Calif., and San Francisco State University to develop microcomputer software and courseware in math.

Finally, NIE spent $90,000 on research and development related to the use of hand-held calculators. CEMREL of St. Louis received about $40,000 of the pot to experiment with calculator use in their major math effort. Another $50,000 went to Ohio State University to develop a calculator information center.

Overall, NIE's investment in technology has been modest: future involvement given the agency's funding blahs, will be even less impressive.

Department of Defense

The one agency relatively immune from budget cuts is the Department of Defense. Its investment in research and development in educational technology dwarves other agencies. For example, it currently spends $10 billion a year developing training courses for its personnel. Much of this is dependent on technology. The department has adopted technology to cope with high personnel turnover, to cut high personnel costs associated with training, and to provide the kind of training needed for its increasingly sophisticated weapons systems.

Most of the technology-related r&d supported by the military is directed toward developing a technology base for designing alternative, cost effective instructional delivery systems. The r&d focuses to a great extent on reducing training time through techniques that permit instruction to be individualized to a wide range of student aptitudes; reducing the demand for the involvement of personnel in the design, development, and operation of instructional systems through computer support: and providing realistic experiences by a variety of means, including computer-based systems and television.

Congress All But Ignores Educational Technology

The House of Representatives has expressed an interest in educational technology for some time. Over the years it has created commissions to study the field, mandated a major study, and held numerous hearings on science and information technology, the role of computers, and technology's applications to education. But as of yet, no congressional mandate has emerged that brings focus to the initiatives at the federal level.

The most recent congressional attempt to develop a more cohesive federal posture in technology is the Information Policy Science and Technology Act of 1981 (HR 3137) introduced by George Brown (D-Calif.) this past April.

Congressman Brown, former chairman of the House Subcommittee on Science, Research and Technology, has long demonstrated an interest in information technology and its implications for education.

Brown's current bill proposes to create an Institute for Information Policy and Research to address national policy issues in the technology area. The Institute would: 1) provide a forum in which industry, government, commerce, and education can formulate national information policy recommendations; and 2) provide a mechanism for planning and coordinating federal r&d in science and information technology.

The Institute would also develop channels for federal agencies to communicate with one another about their technology initiatives, coordinate federal research and development in this area, and develop more efficient processes for disseminating and utilizing scientific and technical information.

During its authorized 10-year lifetime, the Institute could conduct studies and make recommendations in several areas. These include the impact of regulatory, patent, and copyright policies on technological development; the role and acceptance of technology in schools, businesses, and the home; and the potential impact of technology on the work force's training needs. Studies supported by the Institute would range from an examination of international efforts in science and information technology to an assessment of how the federal government could use technology to improve its administrative effectiveness and productivity.

The Institute would be operated under the supervision and policy control of a 15-member National Information Science and Technology Board appointed by the President and run by a special assistant for science and information technology, also a presidential appointment. The authorized appropriation level for the Institute, $6 million in FY 83, would increase to $8 million in the following fiscal year, and $10 million in FY 85.

Brown's bill has been referred to the Committee of Science and Technology, chaired by Don Fuqua (D-Fla.). Hearings are expected in June or later. But even if this bill is reported out of committee, it still has a long road ahead of it before it becomes law.

Replacing Gadgetry with Technology

In our introduction, we argued that educational technology is "good" because it involves man and machine working in concert to apply validated social science research results to a learning situation. On the other hand, we threw a black hat on technological gadgetry. To our way of thinking, the schools can ill afford to purchase, let alone incorporate into the classroom, any gadget or process that doesn't have a significant payoff in terms of increased student achievement.

We went from our introduction into an admittedly capsulized description of what's going on now in the technology movement. We looked at it from several vantage points.

For example, we found that the gadgets are working their way into the schools. Trouble is, we also learned that the fancy hardware isn't really having much to do with the schools' instructional program. And when it does, the gadgets are being used for drill and practice or as a learning tool to make children computer literate.

We looked next at the private sector. And we learned, to nobody's surprise, that the profit-making companies are concerned about profits. Right now, industry and the home-entertainment markets are the profitable outlets for the electronic gadgetry. Schools do offer the hardware manufacturers a market for their products. But schools are fairly autonomous and their needs vary from district to district. Consequently, the manufacturers have a difficult time putting together a marketing scheme that will give superintendents the choice they expect at a price they can afford while also ensuring a suitable profit for the company's stockholders.

Other problems hound the technology movement. For example, SRI recently did a study and found that the new gadgets may have a negative impact on schools. Reasons SRI cite include the fact the hardware is designed for entertainment and communication purposes and thus little attention has been paid to determining its actual educational value. Second, the quality and effects of the courseware are extremely varied and largely unknown. Furthermore, the purchase is frequently based on cost and only simple notions of educational needs. Third, the hardware is peddled based on the customers' ability to pay rather than their actual needs. Fourth, the market is dominated now by industry specialists with little knowledge of the educational system.

A big problem facing the hardware developers, of course, is the quality of the courseware. Recently, the hardware producers and the textbook publishers have come to the realization that they can benefit each other. Whether or not the match-up benefits schools remains to be seen. But it does seem to us somewhat likely that the hardware manufacturers will simply program standard texts onto machines and in the process do little to improve the instructional offering.

The Department of Education, meanwhile, has all but chosen to sit out the technology movement. The little bit of money it does have to spend is spread widely among libraries, colleges, and the public media. Research dollars used to flow regularly from the Science Education Directorate of the National Science Foundation. But beginning next year that flaw will likely end.

The Department of Defense has money to spend on educational technology, though. Lots of money. In fact, the defense agency is concerned about the ability of the educational research community to spend its funds quickly or wisely enough. The military interests, of course, are not always seen as being compatible with educational interests. But they could be. The military needs to train its volunteers. Much of this training comes down to the basics: teaching 17 and 18-year men and women to read, write, and perform simple arithmetic problems. Those objectives certainly parallel the educational objectives of every school system in this country.

Regardless of which federal agency we consider, nearly all the research dollars in the educational technology field flow from Washington. Although the flow may appear to be insufficient, sufficient dollars are available to enable qualified researchers to advance the state of the art, to improve the courseware, and to assist schools in the difficult task of implementing the hardware in classrooms.

Trouble is, the field isn't about to wait for the r & d community to come forward with prototype courseware, research on the impact of machine use, or evidence of the effectiveness of one gadget over another. Frankly, the hardware manufacturers are way ahead of the research community. Consequently, they are not apt to slow down and wait for us.

So, playing out the negative scenerio, we suggest that the future for educational technology appears fairly dismal, particularly if student achievement is a concern.

- o The hardware is ready to go. Although developed for a non-school market, most of the gadgets can be viewed as having some educational purposes.

- Much of the courseware to accompany the hardware is untested and probably of little increased value to the classroom teacher or the pupils. Additional courseware will be developed by the manufacturer or its hired academic authors to be compatible with the hardware rather than to reflect advances made in our understanding of the teaching-learning process.

- The federal government will continue to support a modest research effort relating to technology. However, the effort will be so insignificant (i.e., non-programmatic) that it will have little impact on the hardware manufacturers, the courseware developers, and the adopting schools.

- Congress has never generated much interest in technology and this situation isn't about to change.

- The CEDaR-member institutions could perform a useful role given the above-described scenerio. That is, school districts will still seek outside guidance as they begin purchasing and using the electronic gadgetry. Some agencies or institutions will be asked, probably in the one-shot inservice workshop format, to help train teachers to use the new equipment in their instructional program. Other institutions will be able to conduct federally initiated small research projects won in competition. But overall, the impact of the member institutions' expertise will be negligible.

- Eventually the general public will realize that technology has made little difference in either the productivity of schools or the quality of their instructional programs. And public education will suffer still another series of chastisements. The research community won't escape without its share of the blame either.

The negative scenerio assumes status quo from the federal government, the U.S. Congress, the school community, the hardware and courseware developers, and the research community. A change in attitude on the part of one or more of these groups might be sufficient to alter the script.

A change in attitude isn't likely from either the Congress or the current administration. Both appear intent on reducing the federal government's involvement in local and state educational issues. The schools themselves are not likely to have either the time nor the inclination to exert some leadership for change. The hardware and the accompanying promises it brings just has too much to offer a beleagured school official.

For all kinds of logical reasons, neither the manufacturers nor their colleagues in the courseware development business have much incentive to alter the technology movement.

And that leaves the research community. That leaves us. The only way we see to develop an optimistic scenerio is for the CEDaR-member institutions to come forward and raise an alarm about the technology movement.

The membership has the skills to work with the manufacturers to develop validated instructional courseware. The member institutions know how to work with schools to ensure that the technology they purchase first addresses their individual needs and second does something about them.

The money to assume this leadership exists in the Pentagon, in the massive funds being awarded to contractors interested in helping the military improve its training programs with new technology.

A positive scenerio, in other words, would have these components:

- CEDaR-member institutions, building on their history of successes as well as failures in the curriculum development movement, have more to offer the field than any comparable set of institutions in existence.

- The membership knows how to develop courseware that's compatible with the hardware; as important, the CEDaR-member institutions know how to make those course offerings improve instruction and consequently performance in the classroom.

- The membership knows schools; the member institutions know schools' limitations as well as their potential. Consequently, the CEDaR institutions have much they can offer both the nation's schools and the hardware industry.

- The membership has the talent necessary to ensure that the technology movement is undergirded by a sound research foundation. It also has a strong track record which should help ensure its better researchers adequate funds from the Defense Department for technology-related inquiry.

- The CEDaR-member institutions know the business of programmatic r & d better than most. Consequently, they understand the interaction that must occur among the hardware manufacturers, the courseware developers, the schools, and the technical-assistance providers. This insight, we believe, will be absolutely necessary if the negative scenerio painted above is to be stopped.

Participating in this CSI seminar is but a first step. Others, hopefully, will be spelled out before its conclusion.

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2 "Instructional Principles for Computer-based Learning"

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An Introduction to
"Instructional Principles for Computer-Based Learning"

In his paper, "Instructional Principles for Computer-based Learning", Alan Lesgold reviews what the r&d community already knows about instruction and can apply to the technology arena as well as what it does not yet know and, consequently, needs to research.

Lesgold, a research associate at the Learning Research and Development Center, University of Pittsburgh, focuses his discussion on one kind of technology—computers. He conveys the picture of a new instructional medium that is both powerful and affordable. Further, the computer is a medium to which the r&d commnmunity can apply basic instructional principles derived from education and psychology in the development of computer-based learning environments. He reviews these in the paper and suggests ways to apply the principles to computer-based instruction.

The computer also challenges the instructional community to build upon its own base of expertise as it seeks to harness the computer's power for instruction. The author explores many of the problems in developing high-quality computer-based learning environments. The research questions surrounding these problem areas provide a future r&d agenda for the CEDaR-member institutions—an agenda Lesgold cautions, must be based on an understanding of current computer technology and the issues that drive it.

Instructional Principles for Computer-Based Learning

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In the last thirty years, we have seen the rapid development of a new technology that is completely reshaping the structure of our society—technology of automated information processing. Any such sweeping change is inherently destabilizing and iconoclastic. This is certainly the case with the computer revolution. Having the potential for solving substantial societal problems, the computer tends to be seen as both panacea to those troubled by these problems and enemy to those with sacerdotal functions based upon them. An enlightened priesthood such as our own will appropriately have mixed feelings about the innovations being offered from the outside. In this presentation, I would like to examine the current state of computer contributions to educational technology and to discuss the tools we have gained from outside our own field and the major tasks that remain for us to perform.

The Contributions from Outside of Education

I will begin by outlining some of the contributions that I think have come from outside of the psychological and educational research community.

For the most part, the contributions of the computer research and technology community to instruction have been to provide powerful hardware and to engineer solutions to problems that instructional developers have posed in the past. There has gradually developed a range of machines that are powerful enough to undertake serious educational tasks. Further, the cost of these devices has been plunging. Certain computer components now cost only one-eighth of what they did two years ago. At many levels, the impossible is being made possible faster than we can keep track of the change.

Since they are the producers of such change, many computer professionals have felt a strong obligation to explore the implications of new technology for doing what has heretofore been called impossible. In the case of education, this has resulted in the phenomenon that seemed under attack in the discussion paper for this seminar, that of computer scientists taking over the design of instructional technology. My reaction is quite different. The computer world is doing what it is obligated to do. It is making every effort to pound into our heads the full implications of technology changes and to develop new technologies, such as robotics, for which no established expertise exists. What we have to do is to critically evaluate what computer people have done and to build on their work using our own base of expertise. We can only do this if we are childlike enough to be amazed every now and then by the newest accomplishments and to explore playfully what uses we can make of them. At the same time, we must be professional enough to help society untangle which aspects of the impossible have been attained and which are only potentially attainable.

A third force in this situation is perhaps less helpful. This is the individual entrepreneurs trying to capture a piece of the school equipment market by quickly dashing off computer-based drill programs and games without understanding how these items can seriously improve instruction. It is quite possible for anyone with a desire to buy a personal computer instead of a color TV to become an instructional software developer and even to build software that improves instruction for some of the children some of the time. This third force is the largest in terms of its influence on schools. The microcomputer software used by school systems today consists largely of programs and instructional materials written by amateurs, much of which is of poor quality.

As centrally supported research centers, I think we need to stay away from most of this small scale market, even at the risk of missing the real educational breakthrough that in principle could occur in someone's garage. Rather, I think we need to attempt to understand the major new forces at our disposal and to examine their potential in light of the basic principles of learning that drive our field. We need to invest serious individual effort in analyzing the power and limitations of new hardware and software resources, and this analysis needs to be kept up to date. We should, I argue, get educated and re-educated regularly in what levels of technology are now feasible. We then need to consider those new resources in terms of basic learning principles, to which I now turn.

Learning from Basic Learning Principles

Implicit in my next remarks are several principles that I will first state explicitly:

- An instructional psychology of errors in performance needs to be further developed in order to exploit the ability of the computer to respond immediately to the quality of performance of the child.

- Such a theory, combined with behavioral principles of positive reinforcement of correct performance, should guide the interaction between man and machine.

- Reinforcements should not just be formal statements of good and bad. Rather, they should make the general act of learning and the correct performance of cognitive skills truly a pleasant and desired experience for the student.

- A deeper cognitive psychology of subject matter skills must continue to develop and must inform the design of computer-based learning systems.

- Practice in newly acquired cognitive skills is important. It is perhaps in this area that schools are least able to provide human resources with the potential of the computer. We should not belittle drill and practice as such, rather we should make it work well and know when it is needed.

Let me begin my discussion of these points by considering what we learned from behavioral theorists. It is fashionable these days to play down the importance of the behavioral principles that once drove our field. After all, we did not live happily ever after. Also, we have come to realize that our instructional goals are not generally behavioral goals that we can specify clearly and completely. Further, the recent exciting action in basic psychological research has been on the cognitive front. Nonetheless, I think there are important principles that need to be saved or modified from the behavioral work of the past.

The first of these principles is the principle of reinforcement. As behaviorists, we found the principle of reinforcement very straightforward. Whenever the student made a correct response, we provided a formal reinforcement. If we were using a teaching machine, it said "Good work!" or something else equally ineffectual. The principle was important for two reason. First, students need to be motivated to engage in learning exercises, and second, they need to have guidance about which of their performances are correct.

The problems are also two: first, formal reinforcement is not necessarily motivating for many students, and second, the mapping of behaviors onto underlying cognitive performance capabilities is not simple. But these are problems for us to try to solve. Nothing we have seen so far suggests that the basic principle of reinforcement was wrong. It remains as a goal for designing computer-based instructional systems. Such systems must help the student evaluate his performance and they must motivate him to continue learning.

A human teacher can, in many cases, make quick decisions about what the student needs to be taught to resolve his current misunderstandings. Unfortunately, few teachers have small enough classes and quick enough classes and quick enough analysis skills to be perfect tutors or drillmasters. They cannot intervene immediately whenever any child in the class displays evidence of fundamental misunderstanding, nor can they immediately reinforce those first few tentative responses a child makes when she finally understands a concept. At best, the workbooks of children can be taken home at night and can form the basis for somewhat individualized feedback and assignments the next day. We are now at the point, though, when a computer system might be able to provide realtime analysis and feedback. I envision intelligent computer systems which could continually monitor children's practice of basic skills and could intervene with feedback and conceptually driven instruction whenever fundamental misunderstandings were detected.

Audrey Champagne, Lauren Resnick, and I are starting to use a microcomputer to provide this sort of immediate intervention in arithmetic computation practice. Basically, whenever a child makes computational errors, the computer will offer him an alternative environment in which his numerical computations are mapped onto computer displays of Deines blocks. The child will be able to manipulate this environment in a manner that allows him to see both the blockworld and the numerical world results of specific computational actions. We make this instructional intervention extremely concrete by allowing children to do—on the graphics terminal—block movements, exchanges, numerical acts like crossing out numbers and replacing them, etc., just as they would with real blocks and pencil and paper. We hope that this system will be one of many that recognize and immediately respond to the child's need for specific informative feedback and instruction during the course of performing reading and arithmetic skills.

It is important to note that the Champagne and Resnick system is not just the application of new technology to an existing approach. Rather it is based upon detailed analysis and empirical exploration of the knowledge and performance capabilities that underlie arithmetic computation skill. The blockworld demonstrations are not chosen by any naive rational approach but rather are the result of a rich and deep theory of the semantics of arithmetic on which Resnick and Jim Greeno have been working for several years.

Most of the instructional software currently available falls short of meeting the need for immediately useful feedback in several ways. Essentially, it takes the behavioral technology of teaching machines and implements it more cheaply on microcomputers. Thus, the reinforcers for correct performance are better, but neither the sequencing of instruction nor the analysis of error patterns is any better than in the machines developed by Skinner a generation ago. Further, there remain serious problems of man-machine interaction which I will discuss in a few moments.

The extisting instructional software often makes use of very creative reinforcers that use improved graphics resources and color TV monitors. One very real problem is that the response to errors is sometimes fancier than that to correct performance. Consider the arithmetic work I just described. If making mistakes in subtraction will produce neat graphics displays while correct responses produce only more problems to solve, we can predict what will happen. Consequently, we are searching for artful ways to make successful performance gain just as much apparent attention from the computer and just as flashy a response.

Most of my attention thus far has been directed toward instruction that removes conceptual deficiencies and that develops accurate performance capabilities in cognitive skills. Once a skill is acquired, it needs to be practiced and refined. New skills build upon extisting ones, and this is not possible when existing skills are inefficient, weak, and demanding of too much conscious processing capacity. We need to better understand the kinds of practice that makes a skill efficient, strong, and automatic.

In the area of reading, for example, Charles Perfetti and I have spent some time exploring the role of word recognition efficiency in the development of higher level reading comprehension skills. While we have presented an informal theory of the effects of word processing slowness on comprehension, much more work is needed in this area. Nonetheless, it is already clear that progress through the early years of the reading curriculum is most successful in those children who develop speedy word recognition.

What remains to be understood is the extent to which children who are slow in the word processing aspects of reading can make up for it by developing richer comprehension-level skills. That is, we need to ask when and how practice makes perfect. Like sports coaches, we need to know when to give conceptual advice and when to demand intellectual wind sprints. I believe the key to answering this question lies in taking a more rigorous approach to cognitive theory development. Fortunately, this is starting to happen. Much of the new work is heavily dependent upon a rich understanding of earlier work in subject matter instruction and in cognitive psychology.

Problems for Computer-Based Learning

Having introduced several principles which I believe should guide the development of computer-based instruction, I now wish to look in detail at several aspects of computer usage in education and to comment on roles educational research and development facilities can play for each. The order in which I discuss these aspects is somewhat arbitrary.

Man-machine Interaction

I first turn to issues of human factors, the interaction of students, often young children, with computers. That is, in my opinion, the most serious area that I will address, at least from a practical standpoint.

Types of computers schools seem to be buying are those that take some advantage of the plunging costs of computer power, namely those that have made the same computer that used to cost tens or hundreds of thousands of dollars into a $1,500 to $2,500 item. Such systems have moderate memory, because we have learned to make memory cheap. They also have relatively standard 8-bit microprocessors and simple display controllers—all items that are old standards that have been miniaturized and put on a chip. If you look at current CAI programs sold in hobby stores and they remind you of work in the 1960s, don't be surprised—they are made for a smaller and much cheaper variant of the hardware and software systems of that era.

The problem is that such systems are very hard to talk to. The only input is a keyboard, and most children cannot type. The output is either low-grade printed text or a relatively coarse-grained video display. As I will discuss in a moment, the language conventions the user must follow to start a program or to write his own are complex, awkward, and not generative of useful attitudes about how to use computers. We, the more economically privileged educational researchers, have an obligation to study which aspects of the interface between person and machine need improvement and to evaluate improvements that are offered.

A number of improvements are on the way, and some are cheap enough that schools may be willing to buy them. These include devices for selecting a point on the display screen (touch-sensitive screens), voice output capabilities, graphics software and hardware, better programming languages, etc. Here we need to do research to evaluate the instructional value of these improvements.

A case in point is voice output. Voice output is now very cheap in some of its versions and at least reasonable in others. However, this economy is achieved at a cost of some loss of complete fidelity to human speech patterns. Both digitized and phonetically coded speech have limitations. Digitized speech is still costly enough that it is unlikely that systems introduced in the near future will offer correct intonational contours for sentences. Phonetically-coded synthesized speech affords the opportunity for cheaper realization of intonational contours within and between words, but the basic phonemes are not perfect. The question we need to address is whether this matters, and if so, to whom.

There is some evidence that young children who have trouble learning to read also are less capable in auditory discrimination tasks. Are such children more dependent on intonational contours for contextual cues in listening to spoken languages? We ought to find out. We also ought to try to discover which voice output capabilities are most usable by children with partial hearing impediments. It would be a shame if our talking systems were selectively biased against those who have trouble reading, and it would be relatively simple to find out the extent to which such a problem exists.

Work is also needed on graphics and their uses. The study of graph efficiency and readability has never attracted a force of talented researchers sufficient to the size of the problem. With the addition of animation, color, and flashing word capabilities, the problem of knowing how to use graphics becomes more severe. At another level, though, it becomes more solvable. Display terminals are good research tools, allowing detailed measurements of ". speed at which students respond and the accuracy of their performance when different types of displays are used. Thus, it should be possible to design principled studies of graphics effectiveness. Again, we want to make sure that we know which children can best be served by specific approaches and specific hardware. Both the faster and the slower learner need to be served, but it may be useful to know which is most likely to learn better or learn more as a result of a specific technological intervention.

Computer Literacy, Aesthetics and Integrity

Another issue I would like to address is that of the kinds of computer programming environments used by instructional system developers and also those made available to students. While I mean more than just the programming language being used, it is easier to restrict my brief remarks today to issues of language. We are told, by a number of the lesser sages of computer-based instruction, that BASIC is the standard language for CAI systems and also that it is the language that children should be taught. The reason given is that it is the standard language for home computers today, and these are the computers that schools have bought. I urge you strongly to question this point of view.

Computer languages evolve partly by accident and partly because of ... porary market factors. In fact, if you take into account the industrial use of microprocessors, the tide is turning fast away from BASIC, toward LOGO, PASCAL, C, LISP and similar languages. The reason is that these newer languages more directly convey central concepts of computer literacy, resulting in programs that are more accurate and more easily understood by others. BASIC itself gained recognition because it was better than its predecessors at focusing the programmer's attention on the flow of control in his program. However, it fails to make the structure of complex computation clear enough and places a heavy and unnecessary processing load on the programmer.

According to one of the best writers on programming style, Edsger Dijkstra, a good programming language should encourage the building of programs from compact routines, each of which is so small that its correctness is self-evident. Also, from my point of view, there should be no artificial syntactic barriers between commands (or procedure calls) designed by the programmer and commands built into the system. Indeed, I hypothesize that the best instructional environments on computers may present a common command structure to CAI programmers and developers, to CAI system student-users, and to students who happen to want to write their own systems instead of executing the developer's.

These are hypotheses, but reasonable ones. Certainly we instructional researchers need to be involved in testing their adequacy and, if appropriate, urging their adoption. You may think that the languages used by courseware developers will have no effect on the students who use their products, but I think they do. Languages impose tremendously on the nature of thinking and of the design process. Papert makes this point strongly in his book Mindstorms, but we see it all around us. For example, a local institution in Pittsburgh is offering programming courses to children. The first is called "Introduction to Computing" and teaches the syntax of BASIC and some simple programming techniques. A later course is called "Debugging." The unfortunate choice of computer language imposes such a mental load on the children that they cannot design working programs very readily. They need to spend considerable time learning how to find the errors that arise because of the overly cumbersome style BASIC forces them to use in designing their programs.

Compare that sort of introduction to the computer to the introduction a child receives if he starts in a LOGO environment and is able to build sophisticated programs that he understands the very first day. Not only the child but also the instructional developer can benefit from programming environments that encourage clean design and straight forward function. Too much of the argument against computer-based instruction is made by people who experienced the clumsy syntax and massive debugging effort required by BASIC and similar languages.

Instructional researchers should be central to efforts to provide computer literacy training in the schools. But, we have to learn enough about computers and about the software design process to be involved knowledgeably. That will take time, but it's time that some of us will have to invest if we don't want to yield this domain to engineers whose knowledge of instruction is bounded by common sense and some reading about behavioral objectives. The price of not being left out of the computer literacy boom is taking the time to go beyond corner newsstand books on BASIC to serious exercise of our scholarly skills and serious study of the current issues of language design and man-machine interaction that occupy the minds of our best computer scientists today. *

Motivation

If you didn't bite on that one, let me pose an entirely different role for educational developers and researchers in the design of computer-based instruction. This is the analysis and specification of motivating devices. It was suggested in the discussion paper that all technologies have a temporary ability to attract students' attention but this soon fades. The computer field has been able, in certain areas, to encourage involvement that goes beyond the point of initial novelty. Computer games are extremely addictive, and there are many instructional designers who feel that computer based instruction should be presented in the context of such games.

I feel that social psychologists, motivation researchers, and instructional developers have a major responsibility here. The best work of the computer industry on motivation has tended to conclude that fantasy games are the most motivating.** Most of those currently in existence are games of violence, in

* A similar issue arises at the level of operating systems. While systems derived from UNIX (a Bell Laboratories trademark) are starting to appear, the earlier and cheaper microcomputer operating systems are also unnecessarily clumsy and inconsistent in design.

** The work was done by Tom Malone of Xerox Palo Alto Research Center.

which klingons are zapped, the bad side of the Force is overcome, etc. Some are very innovative. For example, in one outstanding game developed in the PLATO group at Illinois by Sharon Dugdale, children attempt to destroy intruder space ships in a graphically defined space by writing functions for their missile's trajectory. Even the mathematically illiterate child often learns to graph parabolas if that is the only way to destroy three ships that aren't in a straight line. This is masterful work, better than almost all software that will enter schools in the next few years, and if there were better approaches to motivation known, I'm sure Dugdale would use them. I think some of us have to find them.

A motivational system that rests on the computer as a fantasy world controlled by violence is not the thing I desire most for my children. Yet, today's efforts in instructional game development are driven by the same understanding of motivation that drives television (parenthetically, there are games designers in computer companies who have already noticed that of the two classic motivators on TV, sex and violence, only one has been adequately exploited thus far. How to use the other is left as an exercise for those of you who want really original instructional programs).

I think we need to develop a cognitive theory of motivation. Indeed, perhaps we need to start thinking about the need to teach certain aspects of motivation as a skill. A useful long-term goal for computer-based system designers might be the design of a computer-based motivation curriculum. More generally, there is need for substantial research on issues of motivation. The marketing research of recent years has refined the art of getting someone to pay attention to a message for 5 to 60 seconds, but we haven't done as well in the longer time spans. This is a problem that we need to address if the full potential of computer-assisted instruction is to be realized.

In our everyday thinking, we behave as if motivational dispositions can be taught by a variety of mechanisms from piano lessons to conscription into the military. A longer-term goal for computer-based instruction is to attempt to develop systems that increase the mental discipline of students. Presumably, the lessons of the behavioral researchers are a useful starting point here, too. If we make certain types of practice experiences rewarding, through direct rewards or through enhanced probability of success, presumably that practice will occur more frequently in the future. The cognitive aspect of this is that students often need to be taught what success is in certain basic skill areas. A child cannot be motivated by success in writing essays unless he has an internal cognitive model of what a successful essay is. It is this sort of a model, not cute bells and whistles, that can survive the transition to a society in which the computer and its artifacts are no longer novel nor inherently rewarding.

Controlled Instruction Vs. Learning Environments

Another area in which we can make a contribution is in design decisions having to do with the extent to which we want to control the learner. At one extreme, we can envision practice systems in which the computer is almost completely in control of the child's destiny—where he can only choose between not interacting with the machine at all and interacting as instructed by it. Of course, drill need not be that way, and there are ways to provide choices even in the most constraining environments. One alternative is the LOGO environment and similar arrangements, in which the student programs his own demonstrations and exercises. When such an environment is well designed, whatever the student does is likely to be instructive. For example, Andrea DiSessa at MIT has designed a system called Dynaturtle, which is a LOGO environment in which there is an object and the ability to hit the object with a specified force from a specified direction. The object cannot be stopped, started, or moved except through exerting force impulses on it. By the time the student has played with this environment a while, he has learned a lot about mechanics. Another environment, in which there are a variety of specific tools the student can use, was demonstrated to you today by Audrey Champagne.

I suspect that instructional designers and researchers are in a good position to develop and apply principles for deciding when, how and why to constrain the choices that are open to a student in a computer-based learning environment. The issues here overlap those of motivation discussed above and also those of computer literarv that can be addressed bv competent instructional developers and researchers even if thev are not computer wizards. Thev are also traditional issues of education. Unless we do a better job, the software hacks out there are going to recommit the errors of the past. Just as we've had uniformed flipflopping from cubicles to open classrooms and back without reason, we'll see claims for letting the student do his own thing alternate with calls for keeping students from frittering awav their time in games that don't directlv teach, and these arguments will have the same level of reason behind them that thev have alwavs had. We can improve this state of affairs, and we should.

Evaluation

The final area I will mention, albeit brieflv, is evaluation. Computer-based instruction is inherentlv better evaluated, if we take advantage of the opportunities it presents. We see people like David Berliner having to spend hundreds of person-hours observing students to see if thev're on task or not. In computer environments, spving on the student is easv, and thus we have ample opportunitv to find out which svstems students use, how much, and, assuming curriculum-embedded testing, with what effect. Evaluation hooks should be an automatic part of everv computer-based instructional svstem, at least at the level of an option to record the transaction. We should be explaining to the world whv this is necessarv, and we have the expertise to help in taking advantage of the capabilitv once it is there. (Again a parenthetical note: a PASCAL, C, or LOGO program can have this capabilitv added in five minutes. For a BASIC program, it could take weeks.)

Summary

To summarize, I have explored the problems in developing high-qualitv computer-based learning environments, including motivation, analvsis of error patterns and providing on-the-spot conceptual assistance, man-machine interface issues, language issues, and environmental design issues. I have conveved a picture of a new medium that requires manv of the same sorts of research and expertise that all other instruction requires. I have suggested that we in the instructional community can provide this expertise and do the research but that in many cases it means that we must be scholars with enough integrity to wholly master a basic understanding of current computer technology and the issues that drive it.

Today, schools are often buying the wrong stuff. Some will experience failure in the computer medium faster than we can explain why they have failed, and they will tar us with a brush that a lot of untrained entreprenuers deserve instead. We cannot stop that completely. We can proceed at a substantive level to seriously attack this domain and understand it. There's an economic basis in military and industrial training needs to support much of this work, even if we can't get enough support from our traditional sources. The duty is to undertake the effort responsibly. If good computer-based instructional techniques are developed for training assemblyline workers, clerks, programmers, pilots, and cooks, society will see that the techniques are also used in schools. Our task, however we attack it, is to do our work with craftsmanship, integrity, and an eye toward generality.

3 "Programmatic R&D, Educational Technology, and Cooperative School Improvement"

Richard E. Schutz
SWRL Educational Research and Development

An Introduction to

"Programmatic R&D, Educational Technology, and Cooperative School Improvement"

Three seminar themes are highlighted in "Programmatic R&D, Educational Technology, and Cooperative School Improvement," by Richard Schutz, executive director of SWRL Educational Research and Development, Los Alamitos, Calif.

Through their programmatic r&d, the CEDaR-member institutions have developed the capability for forwarding educational technology and school improvement, if they choose to take on these tasks, according to Schutz.

He suggests the CEDaR-member institutions combine their expertise and explore the instructional applications of various kinds of technology. These, Schutz divides into three categories: low technology equipment, such as hand-held calculators; medium-technology equipment, including the microcomputer; and high-technology devices, such as communication satellites and cable television. The first category includes devices which are readily available and underutilized although they have great promise as instructional tools.

Schutz cautions, however, against the injudicious application of technological solutions to schools' instructional and administrative problems. These solutions may be expensive and constitute inappropriate uses of the technological devices.

Reinforcing comments raised in other seminar papers and by participants, Schutz cautions that technological devices have no justification apart from the specific purposes they serve, such as increasing students' learning and promoting school improvement.

Programmatic R&D, Educational Technology, and Cooperative Schoom Improvement

Richard E. Schutz

SWRL Educational Research and Development

My qualifications for speaking to this topic derive from experiences as a participant observer in the longitudinal ethnographic study called labs and centers. In this capacity I have had an opportunity to interact with various aspects of educational technology on a long-term, sustained basis. One of the features of a long-term ethnographic study is a feeling of deja vu, in situations that to others are exciting first time experiences. General interest in educational technology goes up and down like a roller coaster. The ride is now on the way up, and there are new passengers aboard the roller coaster. So first, I'll describe the frustrations and celebrations involved in riding the roller coaster of educational technology for at least one full ride. Second, I'll enumerate some reasons why the present time appears propitious for CEDaR institutions to become more strongly identified with educational technology matters. Third, I'll sketch some images of the kinds of contributions that CEDaR institutions are uniquely qualified to make relative to educational technology.

I've titled the presentation "Programmatic R&D, Educational Technology, and Cooperative School Improvement" for two reasons. First, this is a CEDaR seminar. CEDaR was established and functions to promote programmatic r&d: sequentially planned, sustained, and cumulative institutional-based r&d in education. The seminar is being held specifically to forward the CEDaR Cooperative School Improvement program, a CEDaR initiative to ensure that the benefits of programmatic r&d actually and really come to have an important impact on school practice (Schneider, 1979). I'm convinced that educational technology, programmatic r&d, and cooperative school improvement can and must interact symbiotically and that CEDaR provides the structural mechanism for nurturing the symbiosis. So the first reason for the title relates to CEDaR.

The second reason relates to me. I happen to have a real personal weakness for equipment. I excuse this pro-technology bias as a part of my American upbringing—society makes me do it. But for whatever reason, I tilt toward being a technology enthusiast. I like low-tech gadgets, intermediate-tech devices, high-tech systems, and all forms of equipment in between. To keep this built-in bias from running away, it helps to keep it in between the rock of programmatic r&d on one side and the hard place of cooperative school improvement on the other side. Considering educational technology as a means rather than an end—a verb rather that a noun—is healthy for everyone. From at least the time of Thomas Edison, each new configuration of information processing equipment has repeated the same education history. Still photography, motion pictures, radio, television, computers, and microelectronic equipment have all followed a common route. First, the equipment is hailed as having "vast potential" for education. The potential is so great that it will be a "technological revolution"—a new world of education is right around the corner. The press, the public, and the education profession enthusiastically look forward to the better educational world that is just ahead.

At the time the "technological revolution" is hailed (or re-hailed), it is recognized that some minor work has yet to be done to harness the potential of the equipment systems in education. That is, the equipment was not derived in an education environment. The origins of the equipment are always in a business, industry, home appliance, military, and/or amusement context—never in education. However, dog-and-pony demonstrations of the new equipment that look educational are easily contrived or imagined for initial marketing purposes. These demonstrations are enough for a sales force to begin selling. Concurrently, the dog and pony configurations are enough to permit the equipment to be tested seriously in a few school locations. Since the 1950's, it has been the practice of the federal government to take the initiative in planning, fielding, and financing the early testing of new equipment in education. The current request for proposals involving the videodisc illustrates the tradition:

o The development of the videodisc and its potential for interactive use with the microcomputer presents a new technology with vast implications for the improvement of teaching of basic skills at the elementary level.

- (The Department of Education) has acquired 46 videotapes in mathematics and music. Other discs are anticipated in the area of reading.

- ED anticipates awarding a 24-month contract for the coordination and evaluation of interactive videodisc and microcomputer technology for teaching basic skills.

The favorable publicity that surrounds such testing aids sales. All participants in the test have strong motivation to make the demonstration look good. No project officer or school superintendent can afford to admit to any deficiency—the repercussions that would come from admitting to foisting a dumb idea off on kids and teachers are too severe to permit anything but good news to surface. To keep up with this good news, school people totally removed from the "test" widely report that they are "using the technology" in their local situation. Which school officials want to admit that they and their colleagues are professionally and technologically backward, particularly since the equipment at issue is galloping along with clear benefits in non-education sectors.

The demonstration test ends without fanfare. (By this time the attention of the "revolution" has moved to another new configuration with "vast potential.") Schools proceed to integrate the equipment into their operations as feasible and reasonable, but this is not "news." The "news" at any subsequent time deals not with the equipment system but with the failure of schools. Extra! Extra! Teachers and principals are resistant to change. Extra! Extra! Equipment with vast potential sits on the shelf much of the time. Extra! Extra! Schools are decades behind the technology of other sectors, due to the inexcusable deficiencies of school officials. In short, the school community is regularly abused by a technological revolution that is always about to happen but that never does happen.

In any sector of human life other than education this series of events would be viewed as a hoax. If such it is, certainly the school community least deserves condemnation for perpetrating the scam. However, so long as the cycle is repeated, the school community specifically and education interests generally will lose every time.

John Gardner has stated the point more broadly:

> "The roller coaster of aspiration and disillusionment is amusing to the extreme conservative who thought the aspirations were silly in the first place. It gives satisfaction to the left-wing nihilist, who thinks the whole system should be brought down. It is a gold mine for mountebanks willing to promise anything and exploit any emotion. But it is a devastating whipsaw for serious and responsible leaders" (p.4).

Gardner wrote this in 1968. In the subsequent years the extreme conservatives, the left-wing nihilists, and the unscrupulous mountebanks have all made notable advances in the educational technology revolution. But these are the bad guys in the educational technology revolution. I'm with the good guys.

Is there a better way for the good guys? One would be hard pressed to find a worse way, but indeed there is a better way. It begins in programmatic r&d and it leads to cooperative school improvement. Just as some people are surprised to learn that they speak prose, some CEDaR institutions may be surprised to learn that they are key elements in the technological revolution in education. Yet our institutions have been, are now, and I hope in the future will be, just that.

This aspect of CEDaR has received little publicity. But educational technology has been alive and well and living in labs and centers throughout our history. Not every CEDaR institution has shared the concern to the same degree—we minimize overlap and duplication. And the emphasis in each of our institutions has shifted with the times—we keep at the forefront as it advances. This is not the place for a general history of the educational technology efforts of CEDaR institutions. It will be sufficient for my purpose to carve out a very narrow slice of that history as retrospective for the prospective view of the seminar.

Although it is common in education parlance to equate technology with devices, this usage is a corruption that forwards the interests of the bad guys rather than the good guys. Standard scholarship considers the term technology as "a set of techniques that will generally lead to a predictable outcome under specified circumstances" (Nelson, Peck, and Kalachek, 1967). These techniques will often include devices to good effect, but the point is that devices have no justification apart from the specific purposes they serve. Technology is not a device looking for a justification. It serves us; not vice versa.

O.K. Let's go back to 1966. Then, as now, regional labs were to meet regional r&d needs using regional resources. A SWRL regional needs survey indicates a good match: teachers need accurate information about the instructional status of their students. Call it computer-managed instruction. It's not clear to me whether LRDC or SWRL should be credited for coining the slogan, "computer-managed instruction." I think we did, but I'd be happy to give Pitt the credit. Either way, it was a lab-center invention that moved beyond the computer-assisted instruction that relied on Skinner's "teaching machine" logic.

Supplying teachers with accurate information about the instructional status of their students was imbalanced. It left out school administrators. What do school administrators find most important? Their budgets. Fine. What do they need help with? Budget planning. Great. We'll do that too—computer-assisted budgeting. (You can thank SWRL for both inventing and killing that slogan.) So these two simple technological initiatives were put together to form one—of four--SWRL program priorities.

Priorities are one thing. Doing something about them is another thing. Where to start? Then as now, the military was in the vanguard of electronic information processing. System Development Corporation, a regional resource, had led the way in this advance. SDC will work with SWRL to adapt their technology for purposes of computer-managed instruction and computer-assisted budgeting. SWRL will then proceed to make the technology available to schools generally, first within the SWRL region and then through other laboratories in other regions nationally.

How do we make regular information available to teachers about the instructional status of their students? Well, the computer can store and report this information without difficulty. The trick is how to get the source data into the computer. O.K., we'll put a teletype machine and an operator in a classroom in each of two schools. This will permit us to give a few teachers virtually immediate turn-around information and other teachers the same kind of information on an over-night or weekly basis. We will work at a single grade but in two subjects, math and reading.

What did we find out? Well, no matter how fast the turn-around, the reaction from the teachers was the same: "I already knew that." Observational data indicated that this was not really so—the teachers didn't know, but that was irrelevant. The reaction to the information we were giving them was much the same as that to the answers in a self-instructional text. When you see the answer, there is a strong tendency to believe that you already knew the information irrespective of whether or not you actually did.

We learned in about 15 days what others have failed to learn in 15 years. The aspiration of focusing the aim of computer-managed instruction to assist teachers is misguided. Teachers do know how their students are doing; what they lack is a means of communicating their information to others in a credible and creditable form. We could help them do that (we and our computers), but there was still the "simple" matter of how to get the source data from the schools into the computer.

Well, the teletype was a more complex data entry device than was required. A simple scanner was all we really needed—something that would feed one sheet of 8-1/2" x 11" paper through a device to be read optically and transferred by telephone to the computer. We designed the simple machine, put the specs out to bid and found a qualified firm willing to build 30 of the machines at $500 each—$15,000; a nominal expenditure. We had the money in our budget, but the boilerplate provisions of our contract required subcontract approval from OE. Here we got a lesson in the sociology and politics of educational technology. In the course of obtaining subcontract approval, a junior OE bureaucrat made a policy decision for the federal government: Educational labs should not be involved with hardware—hardware is for engineers, not educators. By the time we got the subcontract untangled a year later the price had gone from $500 to $750 each, so the deal fell through. However, we had found another firm that was willing to do the construction with their money rather than ours. That was the good news. The bad news was that this increased the price to $1,000 and took two years.

We got two or three devices that allowed us to pursue our investigation but quite naturally, the firm that we were working with also wanted a market—which we were in no position to deliver. Scanners weren't a big seller in education at the time. So they put a few more bells and whistles on their machine, turned it into a hard-wire rather than telephone-remote device, and sold a number of the devices to a large Japanese industrial firm for $3,500 each. The price and function of the machine were both now out-of-range for us, and we had inadvertently helped American industry help Japanese industry rather than providing any immediate help to American education.

By this time, we were up to 1972 and had established communication with the top management of a large firm in connection with their publishing some of the instructional products that we had developed. From 1972-1975 this firm had a team of 5-10 engineers and support staff working at SWRL and at other locations specifically on our interpretation of computer-managed instruction $300-500K of their money anually. They found that their copier could, with slight adaptation, also perform a scanning function, but there remained the little problem of how to enter the coded identification of individual students, teachers, schools, and districts in machine-readable form. That sounds simple until you try to do it. We tried everything from credit card devices to drill presses and never really worked out the problem between 1972 and 1975. Then the financial bottom fell out from under the firm in a downturn of their industry, and they abruptly—at least for us it was abrupt—abandoned the activity with us.

In the interim, however, our Japanese-supplier firm had been overtaken and purchased by a firm called National Computer Systems. NCS equipment in the late 197''s became the standard in the kind of scanning we were interested in. NCS installed their equipment widely enough around the country so that source data entry was no longer a technical obstacle.

Back at the SWRL ranch, while all of this device-centered activity was going on we had concurrently been working steadily over the years on the form and substance of information that teachers, students, parents, principals, and district administrators would all find useable and useful. That also sounds easy until you try to do it. Because the story is a good deal more complicated than the equipment story, I won't even get into it here beyond saying that we did it.

Fifteen years from the time we started we had the technology well in hand to provide credible and creditable information about the instructional accomplishments of students and schools. When you get the technology worked out, it's simple and cheap—from $.50 to $2 per student per year from economy to deluxe. Both the computer and management receded to the background as the technology evolved. But without the configuration known as the computer and the construct known as management, the technology would not have been realized.

The CEDaR Cooperative School Improvement program is currently implementing the technology I've described in several locations; including all elementary students in two great-urban-city school districts. The technological accomplishment is not simply an R&D stunt. It provides the professional foundation for making quality education in American elementary schools an operational reality rather than a rhetorical aspiration. The slogan "computer-managed instruction" was lost in the process. (It was succeeded by the descriptor "instructional accomplishment information", IAI). But the point was always to promote education, not a slogan.

What happened to computer-assisted budgeting? It was a good slogan, but it was a bad idea, and we aborted it as quickly as we could do so without embarrassment. It took us only a couple of years to learn that although school districts give a good deal of prominence to their budget, school superintendents can, if necessary, keep track of their budget on the back of an envelope. The budget is just as important to the chief executive officers of a school district as the budget is to the chief executive officers of a corporation; and the dollars involved are often just as large—$1.8 billion for a district like Los Angeles. But in any school district, large or small, the budget is a forum for the resolution of political and social matters that are far removed from computer assistance. The complications are political and social not financial. We learned a lot about the enterprise of schooling and about how r&d can assist and abuse school administrators. But we found that computer-assisted budgeting was an expendable technology despite its initial promise.

Misanthropes, mountebanks, and nihilists will find it easy to dismiss these experiences with the computer in instruction and administration. Efforts to diminish, victimize, and destroy public education move along with or without technology. But the concern of the opponents of public education is not school improvement. Ours is.

I can generalize the conclusions that are supported by the particulars I've been describing by referring to a book that was important in halting the excesses of enthusiasm for computers that built up in the 1960's (Oettinger, 1969). This book derived from the Harvard Program on Technology and Society, a multi-disciplinary effort conducted from 1964-1969 under a large grant from IBM. The publications associated with this effort are all well worth reading. They give credence to my rule of thumb: Never trust writing on educational technology under ten years old. Much of Oettinger's perspective was then and is now faulty, but some parts were then and are now altogether sound.

In the final chapter Oettinger asks the question, "How are the necessary resources to be allocated for economically efficient progress" in education? His answer is in five points:

1. If we want efficiency, we must support promising ideas longer than either private or government programs now permit.

   Developing new processes and devices from prototype to production model is both time-consuming and risky.

2. If we want efficiency, we must support risk-taking and cushion failure:

   The road to wisdom?—Well, it's plain and simple to express:

   Err
   and err
   and err again
   but less
   and less
   and less.

3. If we want efficiency, then risks, resources, and responsibilities, the 3 R's of educational technology, must be shared by all partners in the educational enterprise.

   We have seen how hopeless advance by one partner is without advance by others.

4. If we want efficiency, we must chart our course by human judgment, not exclusively by formula.

   Forcing scientific technique beyond its limits is scientism, not science; obscurantism, not rationality.

5. If we want efficiency, we must follow in depth with a small number of diverse alternatives.

   The present shotgun approach has been exhausted; it has few achievements to its credit.

Those five points are a good part of the foundational principles of programmatic r&d. Oettinger didn't really follow his own counsel, and it was generally ignored by others. However, it was then and is now sound counsel.

So much for the past. Let's move on to the present. What is there about the present situation to make this a propitious time for CEDaR to give greater concern to matters of educational technology? Most people would say that it's the present state of the art of information processing equipment. I believe this is a very faulty perspective. With a few notable exceptions which I'll get to later, none of the present equipment systems has any merits that are not now being well-exploited by schools. Additional CEDaR effort to promote the purchase of this equipment now or in the immediate future would be doing schools a disservice rather than assisting them. Throwing devices at schools is no more justified than throwing dollars or scholars at them. Devices, like dollars and scholars, have a necessary and justifiable role in education; but as means rather than ends for education improvement.

The advocacy of an educational technology initiative at this time can reasonably rely on systematic conditions now prevailing in the educational system, in the general public mood, and in CEDaR insitutions. Let's briefly consider each of these conditions.

Tom Green (1980) has given us the information necessary to counter those who contend that the educational system is either an unfounded fiction or an unfathomable endeavor—anything but a predictable phenomenon. Green's book warrants more attention than I can give it here. However, a point that Green makes in passing is highly germane to our seminar. Green notes that the motives or incentives related to technology operate differently in education than in other sectors. The education system is not the industrial system. Efforts to treat the education system as if it were an industrial system are popular, but they have no more chance of success than the less popular efforts to treat industry as if it were education.

In education, as in industry, growth and success are key considerations. However, in the education system, there are several routes to growth and success. The increase in efficiency associated with technology does not have the dominance it enjoys in the industrial system. Green identifies several other modes of growth of the educational system (p.10).

1. Increasing the grades in the system or the number of students in the grades (e.g., "Education for All American Youth").

2. Increasing the rate of attendance and survival (e.g., reducing the "dropout problem").

3. Adding levels at the top or bottom (e.g., preschool, life-long learning).

4. Horizontal expansion by picking up new functions (e.g., school lunch program, guidance and counseling, career education).

5. Differentiation of programs or institutions (e.g., individualization, magnet schools, aptitude-treatment interaction).

6. Extending the school year or school day (e.g., year-round schools, day care programs).

7. Increasing staff independently of anything else (e.g., reduction of class size).

Where does technology come in? A poor 8th. Attempting to do more in the same time or the same in less time is feasible in the education system only under special circumstances—only when things are not going well—meaning that none of the other systems' success modes are working.

Under conditions of increasing financial resources, all of the other seven modes of growth are more attractive than technology. But we are no longer in an era of increasing resources; we're in an era of limits. In an era of limits, when faced with static or declining resources, then and only then will the education system "rank an increase in efficiency as more desirable than a decrease in differentiation. That is to say, instead of reducing the number of its programs by consolidation, the system will seek to maintain them with diminished resources" (p.17).

At present time, conditions internal as well as external to the education system provide a favorable climate of incentives for dealing with matters of educational technology. Motivation alone is not enough. But if the choice is incentives or non-incentives, choose incentives.

Green makes another important point. If there is to be a continuing general societal market for any technology, that technology must be used. If its use requires the exercise of new and specialized skills, then these skills will have to be acquired and widely shared within the population or there will be no market for the technology. (In a society where people lack the skill for reading time, there is unlikely to be a large market for clocks and watches.)

> The history of every new technology victorious in the market is the history of the downward drift in the social acquisition of its principles and the skills of its applications. The first computer programmers were the inventors and creators of the hardware. They were persons highly trained in mathematics and engineering. The next generation of programmers were doubtless possessed of training almost as advanced. But surely, the third generation were taught the art of programming without either prior training in advanced

> mathematics or engineering or in programs of the system designed to produce programming skills. They were trained either by the agencies who marketed the hardware or by those who wished to use it. They could not have been trained by the system because in the beginning of any new technology, there never are such programs in the system. But as the principles of the technology become better and more widely understood and as the required skills become more clearly identified, programs will develop first at the advanced levels of college and then will extend into the secondary and even elementary schools. In 1840 there was only one textbook in calculus available in the United States, and it was used at advanced graduate levels of the system. Now there are 150, and the topic is taught in many high schools.
>
> In short, if X is a technical capacity desired for the technological market, then that capacity will be sought first at a relatively high level of the system and then at succesively lower levels. The path in the social acquisition of such technical skills is downward, and moreover, it is downward, eventually, within the system. Their social acquisition does not require the existence of the educational system. There are methods of accomplishing the same result by extending indenture, apprenticeship, or home study. But if the system is available, it will be used. And it is likely to be used, because it is the most efficient solution to the problem of creating and sustaining the market for any technology (p.56-57).

Turning to conditions apart from the education system, it is easy to interpret the present public mood as "anti-education," the fact that acknowledgement of the era of limits hit the federal government like a ton of bricks is not making life simple for anyone in education these days. But that's a description, not a complaint. Educational technology is more appealing in an era of limits than in an era of growth. Soundly justified r&d is a tried-and true route to increasing productivity, eliminating waste, inefficiency, and for accomplishing other aims which the present Administration has a strong mandate from the American public to make happen.

Turning to CEDaR institutions, we now have resident within our institutions the core capability necessary to justify a technological initiative in education. Key to this capability is our expertise in such matters as program implementation, the dynamics of schooling—instructionally and administratively—and our working understanding of the economics, politics, sociology, and psychology of the education system. It is ignorance and incapacity in these areas that has thwarted educational technology initiatives in the past. Certainly, we don't know all that we need to know, we don't know how to do all that we'd like to do, and we would never contend that we could or should even try to carry off any endeavor—technological or otherwise—single handedly. However, the public investment in CEDaR institutions over the years has now created a resource of unrivaled expertise for forwarding educational technology. The resource is impressive and it would be foolish for us—of all people—to ignore it.

What sorts of things can we do? That will take a good deal more deliberation among all of us and that's why we're here. I know CEDaR well enough to recognize that anything that any of us suggests is categorically rejected by most of the rest of the group as the initial response. Sorting out the cans-can'ts, tis-taints, and shoulds-shouldn'ts takes some work. But in that spirit let me suggest a few leads associated with low-tech, intermediate-tech, and high-tech equipment systems.

Low-tech equipment is given very little attention by ed tech revolutionaries, but it seems to me that these equipment systems have the best immediate potential for schools. Of the equipment systems that happen to be underutilized in school instruction at the present time, the hand-held calculator has to head the list. Hand-held calculators are now so cheap that cost is almost inconsequential. As an instructional aide for quantitative problem solving, one could ask for no better. Calculator-based instruction is less glamorous than computer-based instruction, but it's a good deal more feasible.

If the calculator is too modest a device base, then let's open it up further to the full alpha-numeric keyboard. Here, we would have to hang on more electronics than can be held in one hand, but not a lot more, if it were done thoughtfully. And that would open up the endeavor to verbal as well as quantitative problem solving.

Complementing our low-tech equipment for alpha-numeric information processing is the cassette recorder. This opens up language and other forms of audio storage and retrieval.

With this cheap set of equipment there is very little in instruction that can be done better by a higher-tech equipment system. Moreover, the configuration gives us a solid base for teaching about technology as well as about science in our schools. If we think science teaching is weak, we know that technology teaching is virtually non-existent in our schools outside of college-level schools of engineering. One could make a good argument that learning technology is more important for elementary and secondary students today than learning science, but there is no reason why we can't teach both technology and science.

At an intermediate-tech equipment level, the videotape recorder and the microcomputer certainly warrant attention. It will take a few years for the cost of this equipment to come down to the level of school feasibility. However, that will happen as fast as our programmatic r&d to justify the equipment for school improvement purposes can expect to progress.

At a high-tech equipment level, I can't get particularly excited. Communication satellites, cable TV, and large-scale-high-speed processors are glamorous, but they have real deficiencies in education. The liabilities relate to matters of scheduling, student interaction, flexibility, and over-powering equipment capacity of the functions provided. It's the "big stuff" that excites engineers and the press. And it may be that someone else can set forth a more attractive argument for the potential of the high-tech equipment than I can. If so, I'll happily join the justification. Until then, I'll continue to hold that the emphasis on high-technology in education is misplaced.

Finally, a fourth lead warrants consideration. Irrespective of what CEDaR does in the area of educational technology, the misanthropes, mountebanks, and nihilists can be counted upon to remain active in the area. The school community is not currently well equipped to deal with these bad guys. Coping responsibly with this situation requires a resource more substantial than a clearinghouse function. It requires the kind of overall coordination of expertise that the CEDaR Central Office does so very well to provide a trusted communication mechanism that other parts of the education community can draw upon. Providing this service would be a worthy contribution.

There may well be other leads that are more attractive than these. The potentials I've set forth are ideas at this point and ideas are cheap. I believe they support the conjecture that future attention to educational technology will benefit CEDaR's commitment to programmatic r&d and school improvement, but I don't place much more stock in them than that.

There is no question that the endeavors of programmatic R&D and school improvement can proceed successful without increased attention to educational technology. Neither is there any question that the promotion of educational technology will proceed with or without CEDaR. I believe the behavior of the bad guys is predictable—they'll continue to do what they've been doing. The bright promise is with the good guys. I'm with them.

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4 Multiple Visions for School Use of Technology

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An Introduction to
Multiple Visions for School Use of Technology

A panel of experts in technology and instruction shared with seminar participants their reactions to many of the issues discussed in the papers contained in this volume and raised during the course of the meeting. The panel's comments and suggestions are highlighted in this section of the volume, Multiple Visions for School Use of Technology.

All the panel members commented on the education community's ability to design effective technology-based learning environments, although their assessment of that capability differed. All made recommendations concerning an appropriate role for educational research and development in the technology movement. They made specific recommendations about technology-related research issues as well as practical suggestions about the services r&d organizations can provide to schools immediately.

The panel members were Dexter Fletcher from the Army Research Institute; Joseph Lipson of the National Science Foundation; and Robert Seidel of HUMRRO.

Multiple Visions for School Use of Technology

Joseph Lipson, National Science Foundation

Joseph Lipson, special assistant to the assistant director of the National Science Foundation's Science and Education Division, touched on the following areas in his remarks: effective learning environments using computers; school organization and technology; technology's future; and technology resources.

Effective Learning Environments Using Computers:

- We should not design computer-based learning environments that do not allow for human interaction, except as a form of homework. That is, there is a kind of homework that can be done on computers. Except for that application, we should be thinking of using the stimulus of the display screen, computer, and videodisc as a stimulus for human conversation.

- We need a great deal more attention to the emotional factors that attend learning, whether we have computers or not.

- We need to pay more attention to how we can present knowledge so that it can be grasped by a student who doesn't already know it.

- We need to pay attention to what we ask the student to do. We have often seemed to have the idea that the mere presentation of information was educational, an incorrect assumption.

- We need a great deal more attention to the social factors of the learning situation because the simple argument is that a lot of what we do is determined by our perception of what other people expect of us. This network of social interaction is important in determining students' behavior.

School Organization and Technology

- Schools are stable, long-lived organizational systems that were designed for the technology of the classroom, the textbook, the homework assignment, and the blackboard.

- Because they're stable, because they were designed for an alternative technology, the existing technology, any departure from equilibrium tends to generate forces to bring it back to equilibrium. So it is not surprising that it is difficult to introduce a new technology. Every organization that survives, evolves a system for helping people be productive with its dominant technology and schools do that. The organizational structure helps teachers to be productive with the classroom, the textbook, etc. Now, if we want people to be productive with this new technology, which is quite different, we'd better give a bit of thought to changing the organizational structure to help them to do that.

Technology's Future

- Technology will first penetrate the military and industry because they have such a tremendous economic incentive for cost effectiveness in training. Then technology will enter the "how-to" market—how to care for your baby, how to repair electrical wiring. Finally, it will begin to be put to the service of the handicapped and the affluent will tend to acquire these devices for their children.

- There is a social indicator, a distant early warning, that affluent well-educated parents may pull their children out of school and educate them at home or send them to private school. The technology [illegible] only accelerate this.

- In the past, schools have tended to rely on words and symbols because they were cheap and powerful. When we finally had to teach people procedural knowledge—knowing how versus knowing what—we tended to take students out of the formal classroom and put them either in the laboratory, the apprenticeship system, or the field. These are what I call "high information" environments as opposed to the low information environment of the textbook. The promise is that with the computer and videodisc, we can begin to put procedural knowledge into the formal curriculum.

- Voice recognition. We'll have voice recognition sooner than we think. 1985 is the date I've been reading.

- One of the questions we have to face is whether we will evolve into a kind of symbiotic relationship with computers or whether we will become the pets of computers.

Technology Resources

- "Acceleration of Evolution" by John Black, in The Futurist, February 1981, suggests that the impact of technology is going to accelerate at such a rate that it's almost impossible to predict what the future will be like.
- Today and Tomorrow in America by Martin Mayer;
- "What Makes Computer Games Fun, What Makes Things Interesting", by Tom Malone, Xerox Palo Alto Research Center;
- Hearings from the House Subcommittee on Science, Research and Technology; and
- The Micromillenium by Christopher Evans.

Multiple Visions for School Use of Technology

Dexter Fletcher, Army Research Institute

In his remarks, Dexter Fletcher, coordinator of Tri-Service Training Development at the Army Research Institute, focused on: parallels between military and school use of technology; technology research and development; and learning environments and technology.

Parallels Between Military and School Use of Technology

- o In the military you find a great deal of interest in technology at the level of the chief of naval operations or the chief of staff of the army. At this level technology is conceived of as one way to reduce the cost of what in fiscal year 1982 will be a $10 billion investment in special schooling. However, if you go lower in the ranks, you find there are no incentives for the local commander to use technology. He is there to make himself and his command look good. He's not going to introduce any innovations that may fail. In the services, then, there are incentive problems in introducing technology just as there are in public schools.

- o Educators point to declining SAT scores over the last few years but this decline has occurred when the proportion of the gross national product directed to education has doubled. That investment has been in traditional technology—lectures, standard school room practices. It may be that we have reached the limits of the technology we currently have. If we're going to increase schools' productivity, then perhaps we should make an attempt to make use of the new technology.

- o Neither the services nor public education has been very good at selling technology. We don't talk to people who are concerned about national priorities. They are people who have a lot of other concerns about what we're doing in education. There's a need to address the benefits of the investment in r&d and in technology in terms they want to hear.

Technology Research and Development

- There is nothing inherent in the device or technology, such as the videodisc, microprocessor, touch tone phone, or book, that brings about a revolution. It is, instead, the device's functionality—how you use it. Videodisc, for example, in itself is not very interesting. When you use it for something like surrogate travel or interactive movies, it becomes very interesting.

- Simply looking at the world and seeing microcomputers, and predicting a revolution is not sufficient. We in educational research and development need to employ the new technology and begin to work on its functionality but that functionality will not flow by any easy or immediately obvious means.

- The high verbal ability of people in education has long been noted as well as their low quantitiative ability. If we are to use the new technology, that's got to change.

Effective Learning Environments Using Technology

- We need to escape from the passive information technology metaphor—the passive business information metaphor—as a metaphor for instruction. In fact, that's not what happens in instruction nor is it what occurs in communication. We tend to pass highly selective cues. These are matched by an ongoing sensory simulation by the receiver. It's a very active process as is learning. What that says is that we can't just take information and pass it out to students through channels. We need to create an environment in which they learn.

- o Technology can provide a learning environment rather than merely providing information. A simulated real world environment is one example of what technology can provide.

- o As educational researchers and developers, we need to be able to sustain r&d efforts aimed at designing technology-based learning environments over a long period of time. We need to have the freedom to tinker, experiment. I don't know where we're going to find those environments, but I'd make a prediction that they're probably going to come from private education. Unless public education catches up the real payoff for technology will be in private educa ion.

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Robert Seidel, HUMRRO

In his comments, Robert Seidel, vice president and director of HUMRRO's Eastern Division, highlighted the following areas: r&d support for schools' technology needs; and school structure and technology.

R&D Support for Schools' Technology Needs

- One of the most important services the r&d community can provide is to help teachers learn how to use computers, learn what they're all about, what computers mean to them, their students, their administrators, and how they might implement them in their classrooms. In other words, provide an awareness program to build teacher literacy at the preservice and inservice levels.

- The importance of this kind of assistance is illustrated by a drill and practice program in New York City was highly successful during the first year. In the second year, everthing stopped. One of the real problems was that there was no preparation or continuity of the roles in which teachers and administrators interacted with the computers.

- The key to working with schools as they implement technology is strong preparation backed up by an appropriate bureaucracy. We were recently involved in a project with four schools—three public and one private. Two were inner city public schools; one was a middle class public school; and the private school drew students from all over the city. During the course of the project we provided training for the teachers and orientation for the principals and the students. We followed an entire program to develop a strong, implementing environment. A year after the project was over (HUMRRO played a turnkey, management role), we checked back. The private school was selling time on the time sharing system. They were increasing the number of students and the number of subjects on the computer. In one of the public schools they were tying to scrape together enough money to pay the maintenance for the equipment.

o The point is, it takes strong preparation and it takes an appropriate bureaucracy for technology to work in a school. An appropriate bureaucracy is almost like appropriate technology. Small is beautiful.

School Structure and Technology

o In addition to helping school people implement technology, we need to create a social support system for technology. For that we need a lean bureaucracy or we're not going to have technology in public education and, quite possibly, we're not going to have public education either.

o We currently have a group model of instruction in public schools that's labor intensive. There are a specified number of days of instruction and grades and grade levels. If you look at the use of computerized high-technology, you've got a model of instruction that's competency-based. The administration is functionally related to management and it is capital rather than labor intensive. To me this reinforces what Joe Lipson said earlier, you're going to have home and private school use of computers and public schools may suffer irreparable damage.

o We can design effective learning environments now. Maybe they won't be totally computerized. But it nevertheless is the case where you have clear instances of effective learning environments that utilize technology.