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ABSTRACT

Instructional technology is defined as a systematic way of designing, carrying out, and evaluating the total process of learning and teaching in terms of specific objectives, based on research in human learning and communication and employing a combination of human and nonhuman resources to bring about more effective instruction. The main question regarding technology, therefore, is how it can be used to improve education by helping each individual to become increasingly responsible for his/her own learning. This report analyzes the following issues regarding the role and use of technology in education: (1) reluctance to use technology as an integral part of the teaching and learning process, in spite of societal acceptance of technology; (2) technology's ability to create excellence as well as mediocrity; (3) education/information technology as a likely vehicle for teaching problem-solving; and (4) the quality of instructional software. Technology should not determine educational goals but it can be used to achieve them if educators and policymakers know what the goals are, who the learners are, and how success can be measured. A list of references is included. (PS)

Education and Information Technology: What are the Questions?

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EDUCATION AND INFORMATION TECHNOLOGY: WHAT ARE THE QUESTIONS?

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One of the most interesting buttons being worn at a recent education convention read: "TECHNOLOGY IS THE ANSWER! But What Was the Question?" There is more than momentary humor in that catchy phrase; it could well be the slogan for the various movements which have brought their technologies to education. These "solutions" were seeking linkages with problems that would make the technology of the moment the beachhead of a new movement.

Thomas Edison said in 1922, "I believe that the motion picture is destined to revolutionize our educational system and that in a few years it will supplant largely, if not entirely, the use of textbooks." He followed in the tradition of the mid-fifteenth century professors who bemoaned the invention of printing because it would do away with the need for lectures. Post-World War II pronouncements of panaceas were hastened by rapidly developing inventions such as television, programmed instruction, and computers. The prophets do not cease nor do they reduce their endless quest for the machine or technique that will bring about the next revolution in education. They are among us today.

The latest prophets are the microcomputer advocates who demonstrate some of the same characteristics as their earlier colleagues who believed that one medium or another was about to revolutionize education. They feel that they have discovered a device or medium that will engage learners as no teacher has ever done before; they see potential for optimum learning by creating replicable instructional packages that can be used throughout the nation; and they feel that the use of microcomputers is consistent with the American psyche, which embraces new technologies as new religions. There is nothing "wrong" about these perceptions; they are simply naive in light of the history of innovations in schools.

Some of the same patterns were evident when educational radio, silent and sound motion pictures, slides and filmstrips, overhead projectors, language laboratories, and programmed instruction were introduced to the education establishment. These technologies were diffused and installed. Teachers than adapted them to fit their individual styles. In most cases they have become an additive or enrichment resource. Seldom have they achieved the status of an integral component in a curriculum or learning system in the schools. Now microcomputers have come along and teachers are once again faced with decisions about how to incorporate this new technology in their instruction. If they are confronted with the same limitations that they faced in previous similar situations, they will find that they have insufficient skills, little time, and limited resources. They also will be responsible for classes of 25 to 35 learners, probably the single most significant deterrent to innovation in the American classroom.

Holloway (1984) advances some propositions regarding factors which affect the use of technology in education.

- o Technical artifacts do not originate in education nor are they intended for teaching or learning.
- o Initial uses of technical devices are designed for the general consumer market industry, government, or the military.
- o The use of technical devices in education is determined by sales in other sectors--and sales are slower in education than in other sectors.
- o Technical devices must be adapted for education; they cannot simply be adopted. (p. 40)

Technology in education has evolved from audiovisual media to "new information technology [which] is founded upon recent development in three fields: computers, microelectronics, and telecommunications" (Hawkridge, 1983, p. 330). The primary significance of technology, however, lies not in the equipment, but in how it is used.

A Matter of Definition

The word "technology," then, is confusing since it may mean social technique, a procedure for task analysis, any applied science, a rigid procedure, or equipment and related artifacts. Each view has a set of perceptions and expectations. Each has important messages. If we use the word "technology" as a shorthand reference, we must be clear which definition and concerns are referenced or discourse will simply turn to disagreement" (Holloway, 1984, p. 3).

The potential for misunderstanding technology in education stems from the obvious manifestations of its presence--the equipment.

The confusion over definition is an issue of long standing. It is basically a conflict between product (hardware) and process (software). In its best usage, the definition is a blend of the two which has been cogently stated by the Presidential Commission on Instructional Technology (Tickton, 1970): "[Instructional technology] is a systematic way of designing, carrying out, and evaluating the total process of learning and teaching in terms of specific objectives, based on research in human learning and communication and employing a combination of human and nonhuman resources to bring about more effective instruction" (p. 21). It is in this vein that the term is used in this chapter.

"What Was the Question?"

The "question" should have addressed the way in which learning could be improved by helping each individual to become increasingly responsible for his/her own learning. Instead, most of the research focused on comparisons

between "traditional" teaching and teaching performed by medium x, medium y or medium z. Te results were uniform: no significant difference. Schramm's summary of research (1977) is often quoted: "A teacher can feel a great deal of confidence that motivated students will learn from any medium if it is competently used and adapted to their needs" (p. 267). This analysis leads to the conclusion that it is the systematic design and use of hardware and software which determines the effectiveness, efficiency and quality of instruction and learning. Clark (1983) states the conclusion:

> Five decades of research suggest that there are no learning benefits to be gained from employing different media in instruction, regardless of their obviously attractive features or advertised superiority....The best current evidence is that media are mere vehicles that deliver instruction but do not influence student achievement any more than the truck that delivers our groceries causes changes in our nutrition. (pp. 445, 450)

The Issues, Then

Although there are myriad questions which need to be explored regarding the role and use of technology in education, it is the issues that will be analyzed in this chapter. The previous discussion provides a context for the analyses which follow.

- o There is an acceptance of technology by our society but a reluctance to use it as an integral part of the teaching and learning process.
- o In education, as in society, technology has a potential for helping to create excellence as well as mediocrity.
- o Education/information technology is a likely vehicle for teaching problem-solving.
- o Software abounds but quality is scarce.

These issues, all interrelated, will be discussed one by one.

Societal Acceptance; Educational Reluctance

This era has been called the information age. No wonder. In the western world we have access to more information than at any time in history. The daily newspaper (and sometimes two or three) is augmented by journals and magazines of every description. Radio is ubiquitous--in the car, in the shower, and as we walk. Television comes to the home by satellite, multiple channels of cable, and by ordinary transmitters. And if that is insufficient there is always the videotape recorder with its endless library of video-cassettes. Once the information seeker leaves home, there are the library, the museum, and the night school. Once in the library, there is access to 2,590 databases (Williams, 1985), each with its own specialization. This wealth of information has been referred to as an "explosion," a "flood," and an "overload." Yet it continues to grow.

The computer has become the instrument and symbol of the information age. It too is becoming ubiquitous and is directly responsible for producing more information in more places than any instrument since the printing press. The computer has been widely adopted by business, industry, medicine, the military, government, and other sectors of society, without much resistance. Its capacity for handling, storing, and retrieving information in a timely and useful manner have made a place for this amazing tool. When combined with telecommunication systems, the computer is extended to other locations and has developed expanded utility. The computer has entered the home and even the schools.

In what seems to be a relatively short time period, the microcomputer has found its way into over 90% of the public schools in the United States (Hood, 1985; Quality Education Data, 1985). With an average of eight microcomputers per school building, there is a "micro-intensity" (school enrollment divided by microcomputers available for instruction) of one microcomputer for every 63.5 students (Hood, 1985, p. 30). The numbers tell us that there are more than half a million microcomputers in the elementary and secondary classrooms of the United States. We do not know how they are used; by whom they are used; for how long; and with what results. But they are there and are presumably being used in some fashion.

It is natural to turn to research sources to see if usage information can be found. A review of two decades of research on computer based instruction (CBI) by Hasselbring (1984) concluded that

> There is evidence that computers can be used to effect positive student gains in all curricular areas, but especially in math. It also seems that CBI is especially powerful for disadvantaged and students with learning difficulties....The greatest gains from the use of the computer seem to occur when it is integrated thoughtfully into the on-going curriculum and not used as a replacement for existing courses. (p. 15)

Naron and Estes (1985) confirm Hasselbring's conclusion in an in-depth study of 25 educational institutions in which trends and policies regarding technology in the schools were identified. Rogers and his associates at the Institute for Communication Research at Stanford University (1985) used a case study approach to investigate the process of adopting microcomputers and incorporating their use in the curricula of nine high schools in the San Francisco Bay area. Some of the findings were surprising in that schools in this area are normally considered to be in the vanguard of new technology:

1. About half the schools studied acquired educational mini-computers and microcomputers largely due to external pressure from gifting corporations, parents, or students, not because educators decided that the new machines represented a better way to present instruction.

2. The usual level of school planning is insufficient to adapt microcomputers to the curriculum.

4. The educational microcomputer is still a "fragile" innovation, but it is probably not a fad that will pass from the school scene in a decade or two.

7. Given the rapid evolution of microcomputers and courseware, and the explosion of teaching applications--literally from arithmetic to zoology--instructional use of the computer has yet to become routine in the high schools studied. Nor are applications likely to stabilize for several more years. (pp. v-vii)

It is likely that Rogers' findings would be generalizable to other school settings. We are left with the paradox of a society in which the information level outside the classroom is much higher than inside; where technology has become a way of life in commerce, government, health care, and the military, but not in the schools. When it does find its way into education settings, technology is additive and not integrative, an artifact of our times trying to find a place for itself in an established institution that has been noted for its resistance to innovation.

These realities have been acknowledged by a National Task Force on Educational Technology established by the United States Department of Education (Ridley, 1986). The Task Force report calls for a transformation of American education through deliberate and appropriate applications of technology to the teaching and learning process. It sees five major uses for technology in education:

- o To develop basic knowledge and skills more efficiently than is possible with conventional instruction.
- o To teach higher order concepts and reasoning skills that are more difficult to develop without the technology.
- o To develop an understanding of information technology and its uses in society and the workplace.
- o To develop proficiency in applying computers and related technologies.
- o To enable teachers to manage a mastery learning environment in which learning is tailored to fit each student's needs. (p. 61)

The Task Force's recommendations would help to bring about these goals through planning for mastery learning that would allow students to progress independently according to their own abilities; financing of computer-based education as a central and continuing aspect of the school budget; teacher education which would prepare teachers to use technology in an optimum fashion for teaching and management; curriculum and instructional practices which are based on active and interactive learning at a rate which is appropriate for each student; and research, development, evaluation, and dissemination which include studies in cognitive science, artificial intelligence, learning theory, and classroom applications of improved software based on the

research (Ridley, 1986). These recommendations, if implemented, would go a long way toward correcting some of the mistakes of the past and opening up new opportunities for schools to join the information society.

Technology Has a Potential for Helping to Create Excellence as Well as Mediocrity

The benefits of technology can be readily observed in medicine, transportation, communication, and commerce; likewise questionable consequences can be seen in pollution, delayed traffic on land and in the air, and computer errors. Technology is essentially neutral. It can be a tool to help people become more humane since it will perform mundane and repetitious tasks. Some tasks are performed better by people and some by machines. A technological approach is the interaction of individuals, materials, and machines in a systematic fashion to achieve predetermined ends.

Education is still largely labor intensive. Most concepts of education, in the institutional sense, focus on the teacher and a group of students. The conventional wisdom is that the smaller the group of students, the better the teaaching will be. One on one is considered to be the epitome--a personal tutor. There is very little data to support these premises. A good teacher can be good with one or one hundred students; a poor teacher does not improve with reduced numbers of students.

The ideal of a personal tutor for every student is economically not feasible. But an individualized learning program is possible if technology is a part of the system design. The new concept calls for teachers to be managers of learning rather than dispensers of information. This concept calls for use of a variety of resources geared to each student's needs. It must be systematically organized to let the teacher do what teachers do best--motivate, encourage, respond to difficult questions--and the machines to do what they do best--present information, drill and practice, assist in problem-solving. Teachers are thus freed from basic presentation of instruction and supervision and devote their time to small group activities and individual interaction with students.

Many of the technological trends in education point toward improved efficiencies, effectiveness and, eventually, excellence in learning (Ingle, 1984).

Use of mass media has decreased in favor of personal media in the instructional process. Even though television is available to about 71% of teachers nationwide, only about 30% are regular users, mostly in elementary schools (Riccobono, 1984). The use of instructional television among elementary teachers declined significantly from 42% in 1977 to 33% in 1982-83, while microcomputer use in elementary schools increased from 11% in 1981 to 82% in 1984 (Hood, 1985). It is likely that as size and cost are reduced, individual students will have their own devices for personal use in school and at home.

Use of technology for various administrative and management functions has increased in education. Most schools used technology in the office before the classroom. From the old central sound systems and telephone intercom, the school office graduated to data processing equipment for student records and, most recently, to modern computers for grade reports, test analysis, and budget management. The mission of technology in the school office is clear because its purpose is known; it is less clear in the classroom.

There has been a gradual blurring of the distinctions between media as new technologies are amalgamated with old media to yield new information products and services. An example of the blending is the use of telephones with microcomputers to form electronic networks. Sixteen-millimeter educational films are now available in several videocassette formats and are sometimes shown on cable systems within the school or school district if proper copyright clearances have been arranged. Videocassette recorders make possible more versatile use of the medium than earlier versions which were broadcast on a fixed schedule. These flexibilities permit new perceptions of media use within a technological framework.

Greater simplicity and lower costs of technological products are increasing their availability, use, and affordability for educational practitioners. Availability is an important key to use and affordability makes products available. Most of the research on innovations in education reveals that cost is not a primary deterrent to adoption and implementation of an innovation; leadership and commitment are more important. But cost certainly has to be a factor. Even though need is demonstrated or advocacy is strong, the money has to be found to purchase the equipment and materials. One of the greatest fallacies in reporting educational innovations is that acquisition of the machines is tantamount to comprehensive adoption. It is assumed that all aspects of the innovation will follow. This is simply not true. The acquisition of the product is an outward symbol of innovation and bears little resemblance to how they are being used or what results are being obtained.

There is customized development of locally produced materials designed for specialized instructional requirements for special learners. The passage of Public Law 94-142, the Education for All Handicapped Children Act, requires teachers of handicapped learners to develop Individual Education Programs (IEPs) for each student. This concept of individualized learning has been the ideal of educators for many decades. Now, by public law, it is required and some educators and parents are asking, why not for all learners, not just handicapped individuals? Special education teachers and others who are working with handicapped children have accepted mediated instruction as a necessary and desirable part of the IEPs. When the IEP is considered in its totality, it is an expression of applied technology where people, materials, machines, and methods interact in a systematic fashion to bring about desired outcomes. With computers, microelectronics, and telecommunications, the technology will become more sophisticated and, if properly integrated, lower in cost. There are three basic technological configurations which determine the cost, effectiveness and, eventually,

the quality of teaching and learning: additive, integrated, and independent (Wilkinson, 1984).

In the additive approach, materials are added to regular instruction as supplementary or enrichment activities and are not necessary for the achievement of basic instructional outcomes. The use of media is dependent on the classroom teacher, does not have a significant impact on student achievement, and represents an added expense for the educational system.

In the integrated approach, carefully selected or produced materials are integrated into regular instruction and provide an essential element leading to the achievement of basic educational outcomes. This approach represents an additional cost for the school system and requires extensive planning and preparation on the part of the teacher, but has the potential of creating a significant increase in student achievement.

In the independent approach, instruction is redesigned so that basic instructional outcomes are achieved through the active interaction of students and instructional materials without the direct intervention of the classroom teacher. Although this approach represents a major initial cost to the school system, it has the greatest potential for increasing the cost-effectiveness of education.

There is a greater push for technological "literacy" among students, teachers, and administrators. Fourteen states now require some work in computer science and 28 more are considering similar requirements. Educators foresee the need for technological literacy to be able to live and work in an information society but there is no agreement on what constitutes computer or technological literacy. Each state and many school systems are creating their own definitions and syllabi. The ERIC system has many documents and journal references on this topic. Computer literacy for students also gives rise to the question about computer literacy for teachers. Geisert and Futrell (1984) call for knowledge of computers sufficient for the use teachers will make of them. The teacher of computer science or programming obviously needs more technical knowledge than her/his peer whose students will use computers only for drill and practice or other classroom exercises.

There is greater use of educational technology in classrooms and homes by individual teachers and learners. Over 90% of the elementary and secondary schools in the United States have microcomputers (Hood, 1985; Quality Education Data, 1985). Three-fourths of all schools have one or more videotape recorders (Riccobono, 1984). Television monitors are also being used to receive cable signals and, to a lesser extent, satellite signals. The same monitors can be used as display screens for microcomputers. Home use of microcomputers is increasing and the products of technology have become integral parts of almost every household in America, whether rich or poor, urban or rural.

Education/Information Technology is a Likely Vehicle for Teaching Problem-Solving

When technology is considered as a process, it is problem-solving. John Kenneth Galbraith (1967, p. 12) defines technology as "the systematic application of scientific or other organized knowledge to practical tasks." In education, the "practical tasks" are focused on learning and it is the systematic use of technology that can facilitate the attainment of those tasks. The process of stating a problem, analyzing its components, creating alternative solutions, and testing them for the most cost-effective solution is the way technology works in any sector of society. Technology is the tool of problem-solving.

In education, after basic skills are attained, one of the most frequently sought-after goals is the ability to solve problems. Problem-solving is a form of inquiry in which the learner must ask the "right" questions. Formulating these questions is often in itself a difficult task but there is no end to the number of questions that can be asked once the problem is clear. The resources used to answer the questions may give rise to more questions and help to sharpen the focus. Resources include the teacher and other school support personnel such as the school library media specialist. Additional assistance can come from specially designed learning materials and from information databases. It is at this point that the products of technology enter the picture. The National Task Force on Educational Technology sees it this way:

> Alternative learning methods and procedures have begun to emerge that promise many learning options. It is becoming clear that individual learners (and teachers) need no longer to conform to one standard teaching/learning pattern for all. Programs can be custom-designed for each individual learner. When technology, the tool, helps make such learning not only possible but universally achievable, the educational system of the future will be within reach. (Ridley, 1986, p. 60)

Computer technology is especially adaptable to helping learners gain higher order thinking skills. Through the use of artificial intelligence, simulations, and games, the learner develops reasoning abilities. For example, the computer can simulate laboratory experiments in biology and chemistry. Higher order thinking skills are those that learners use to analyze and synthesize information.

The goal is to develop thinking ability, the ability to construct sophisticated associations between ideas. For example, it is fine for students to "learn" individual pieces of information like historical dates, mathematical formulas, or scientific facts. But more important is the ability to associate facts and create a thesis--whether that be an historical argument, a mathematical principle, or a scientific hypothesis (Pogrow, 1985).

There are many programs available and being developed to help learners acquire and practice problem solving skills (Pogrow, 1985, p. 29). The microcomputer is one of the best vehicles for delivering instruction in this area.

The information database, usually accessed by a computer terminal, is a major resource for locating information which will help to answer questions and thus solve problems. Just as a library shelf offers extensive information between the covers of related volumes, so the database provides facts and figures, usually in a defined subject area. Medicine, law, and education have professional databases, while the general public usually seeks information of a more general nature from specialized databases which include information about travel, consumer goods, and current events. It is in the use of these databases that students acquire some of the problem solving skills that they will use in future settings. Again, asking the "right" questions, choosing key words, and combining logical concepts helps to gain information that might lead to the solution of problems. These resources permeate the college and university library and are becoming more popular in public libraries. The next frontier is the school library media center. Some homes are already equipped to do database searching with microcomputers having communications capabilities. The trends are clear, according to Raymond Neff, Assistant Vice Chancellor of Information Systems and Technology at the University of California at Berkeley.

> Libraries are taking on computers to provide a higher level of information service, one that adds information manipulation to other services....Libraries are providing access to computerized databases and are offering new services to users to assist them in customizing the output of database retrieval, regardless of whether data are textual, numerical, or graphical. (Neff, 1986, pp. 8, 9)

With these powerful resources at the doorstep of education, the issue becomes one of how to help teachers and students use them in an optimum fashion.

The Quality of Instructional Software

One of the most common cries for quality is in regard to software for microcomputers. In an interview for a recent publication of the American Association of School Administrators (Neill, 1984), David Moursund, President of the International Council for Computers in Education, indicated that there has been an increase of "good" microcomputer software from 5% to about 25% over the past few years. Earlier, Wighton (1984) reported that "only 10% of the available materials are satisfactory for effective CAI" (p. 449). Despite slight improvement, the problem persists. Attempts to improve software quality are being made in the research and development efforts of instructional designers who are testing models of instruction for learning concepts. Such researchers as Merrill, Reigeluth, and Tennyson have translated knowledge of how learners acquire concepts into rules for designing effective instructional materials. These rules form a set of

instructions that have been tested and revised to create a validated model (Gerlach, 1984). Some of the research being conducted at the Educational Technology Center at the Harvard Graduate School of Education is seeking similar goals in the teaching of mathematics and science (Schwartz, Davidson, & Dickenson, 1985).

What is quality software? Quality varies depending on the objectives, the characteristics of learners, and the relationship of the material to the context of learning. Therefore, definitions of quality have to be set locally. Some software reviews are consistently high; some are not. Some developers of software have consistently high scores in published evaluations. Those organizations and programs which receive these high ratings should be reviewed carefully to determine the reasons for their success.

School districts should determine where products are needed and the form they should take. Efforts to evaluate the effectiveness of software should continue and be expanded in cooperation with the software developers.

Research on what "works" should be encouraged with special attention to younger children whose learning patterns are established during the first few years of schooling. Dissemination of research findings through channels that reach teachers should be pursued.

Some of the best information is obtained when software is actually tried out with the learners for whom it is intended. Such validation data goes a long way to improve instructional products and to provide useful data for teachers who are considering specific products. Agencies which are currently evaluating software usually ask for actual use data. Published evaluations from organizations like the Educational Products Information Exchange (EPIE) and MicroSIFT help in the software selection process, but the number of software packages evaluated is only a small fraction of those available on the market. Extension of these services would serve education well.

Final Words

Toffler's "third wave" is lapping on the shores of education. Some of the sands are shifting and the stones are bearing the marks of technology's lapidary wheel. There has been no major reorientation of the beach, but the wind and water of time have left their marks. Evolution will continue unless some cataclysmic event shifts directions and new forms emerge. It is likely that computers, microelectronics, and telecommunications will be that force in education.

The prognosis is for clear skies and a gentle breeze. The products of technology have established beachheads. Supporters abound. Money does not seem to be a major obstacle. The sands are shifting and there are only a few footprints along the new windswept beach. Is permanence ever possible?

We have raised the specter of Santayana's admonition that those who have not learned from history are condemned to repeat it. Technology should not determine educational goals; but it can be used to achieve them. Past

forays into media-land have yielded less than spectacular results. Until technology is seen as a tool and a vehicle to achieve educational goals, it will be merely another artifact in the arsenal of instructional resources. Its use must be orchestrated with all the other elements which constitute teaching for the purpose of helping students to reach learning objectives.

From this perspective, technology relates to all fields and disciplines represented in this publication. The issues discussed here are central to many of the issues presented elsewhere. When technology becomes an issue in itself, we should recycle our concerns back to the beginning by asking, "What is it we want to do? Who are the learners? How will we know when we are successful?"

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