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ABSTRACT

Intended for use by educators, school administrators, and other educational decisionmakers, this guide describes what is known about media, explores school and student characteristics that can affect the selection and acceptance of media, and identifies the conditions under which media can be used most productively in teaching basic skills. Individual chapters focus on the challenges facing administrators in today's school systems; the meaning of basic skills, how they are learned, and what techniques are useful in teaching them; currently available educational technologies and the uses to which they can be put, with emphasis on computers, television, calculators, electronic devices, and audiovisual media; the impact of media on school achievement, learning, school productivity, school faculty and staff, and management; instructional materials selection, including the evaluation of published materials and the design and development of materials; the total cost of media, methods of assessing cost-effectiveness and cost-benefit, and how to solicit bids; and steps or activities in deciding whether to use media in basic skills education. A glossary, references, and resource lists are appended. (LMM)

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A Guide to the Use of Technology in Basic Skills Education

Kristina Engstrom, Principal Author

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Kristina Engstrom

Table of Contents

I. Introduction

This book is about the use of technology in teaching basic skills. It addresses issues of major concern to educators and school administrators, including:

What are the basic skills needs of our students?
Are these needs changing?
How do people learn basic skills?
What instructional techniques can be used to teach basic skills?
What technologies are available?
What are their capabilities?
What are their limitations?
How can we determine their cost?

The authors recognize that a great deal more must be learned about learning theory, about assessing learning styles, and about determining educational objectives before we can expect to match all learners with appropriate educational technologies. Furthermore, if we had a formula that could tell us what technology to use with a specific type of learner for a specific purpose, we would not always be able to apply it. We would, and should, expect other factors to enter into educational decision-making. For example, it may be impractical to have equipment readily available for instructional use. We may find ourselves in possession of 30 new microcomputers and have no idea how to use them. A major source of funding may support the purchase of one medium and not another. In the course of this guide, the authors explore these conditions and their effects on the selection and use of technology.

Imperfect as our knowledge is about the learning process and the impact of technology upon it, we can acknowledge the things we do know.

1. We know that "media" is defined as a means of communication used for teaching and learning. In this guide, we use the term to include photographic and electronic devices used for delivering information and for building skills in an education setting.

2. We know that "technology" in its broadest sense connotes the use of a systematic process of designing and delivering instruction which does not necessarily involve the use of media. This book focuses on technology as represented by media and encourages systematic decision-making about its application to educational problems.

3. We know that, under the right circumstances, media can do some things as well as good teachers and some things better, e.g., a photograph of an ostrich describes ostriches more effectively than a teacher's words.

4. We know that no single medium is more effective than others for *all* purposes.

5. We know that media are most effective when educators are familiar with their capabilities and their limitations.

This guide describes what we know about media, explores school and student characteristics that can affect the selection and acceptance of media, and identifies the conditions under which media can be most productively used. The authors hope that this book will increase the knowledge of its readers about media and provide them with a process by which they can apply this knowledge to the continuing challenge of meeting the needs and interests of their students, faculty and community.

The *Guide* begins with a brief examination of the challenges facing administrators in today's school systems. It then proceeds to explore the meaning of basic skills, how they are learned, and what techniques are useful in teaching them. In the fourth chapter, currently available educational technologies and the uses to which they can be put are described. Five types of media are addressed: computers, television, calculators, electronic devices, and audio-visual media.

In Chapter V, the authors discuss the impact of media on student achievement, learning, school productivity, school faculty and staff, and management. Chapter VI deals with one of the most critical factors in the effective use of educational technology, the selection of the implements necessary to educate learners, i.e., materials. As increasing numbers and types of materials appear in the marketplace, it becomes more imperative than ever for educators to select materials wisely. Furthermore, the availability of appropriate materials may change an educator's mind about using a medium. This chapter focuses on the evaluation of

published materials and provides some suggestions for material design and development.

The cost of media is always a concern to school administrators and school board members. Many have found that just as it is difficult to place a specific value on a medium, it is also a challenge to determine its total cost. Chapter VII describes the cost components that should be included in an accurate cost estimate, discusses some methods of assessing cost-effectiveness and cost-benefit, and provides suggestions for soliciting bids.

Our reluctance to prescribe a system for decision-making notwithstanding, in Chapter VIII we suggest steps or activities school decision-makers might undertake in deciding whether not to use media in basic skills education.

This book includes a glossary (Appendix A) and lists of references (Appendix B) and resources (Appendix C) which readers may use when seeking more information about educational technology. We hope that this appendix, as well as the information and suggestions provided in the text, will be helpful to educators, school administrators, and other educational decision-makers in the coming years.

II. The Challenge for Administrators in Today's Schools

The Demand

School administrators are well aware of increasing pressure from parents, institutions of higher education, employers, and the military to remedy the lack of basic skills in the nation's children and youth. The outcry about our illiterate young and adult population is not a new one; it dates back to the ancient Greeks, to the early days of America, and, most recently, to the late 1950s when schools took a large part of the blame for America's failure to win the space race with Russia. While Federal, state and local government, and private sector response to this problem has resulted in uncounted programs and large expenditures of dollars, public perception remains that our schools are not doing enough to teach basic skills.

The evidence that has been used to support the contention that young people do not know the basic skills has been cited in newspapers, popular magazines, professional journals, and Congressional reports. The legislative history of the Basic Skills and Educational Proficiency Program (Title II of the Education Amendments of 1978) serves as a summary of examples of the perceived decline in educational achievement.

- The National Assessment of Educational Progress found that 13 percent of 17-year-olds were functionally illiterate.
- The same national assessment found that the writing skills of 17-year-olds were declining.
- One university reported that 25 percent of its incoming freshmen had to take remedial courses in basic subjects. Other post-secondary institutions cited the inability of their students to spell, use proper grammar, and express themselves clearly in writing.
- The Navy reported difficulty in finding recruits who could read well enough (that is, at the sixth grade level) to do military work and was requiring many of its recruits to enroll in remedial reading courses.

Articles published since the passage of the Basic Skills Act reiterate the themes that American education is not able to teach cognitive skills or to deliver a well-motivated and hard-working labor force. Such statements raise another problem about basic skills, that there is little agreement among parents, educators, or the general public about what basic skills are. Are they only the three R's? Are they reading, writing, arithmetic, *and* behavior, such as good manners, obedience, and respect? Are a sense of job responsibility and dedication to the quality of work basic skills?[1] Have our expectations regarding basic skills changed with the introduction of communication and information technology? Since one job in two is now related to the handling of information[2] that is, collecting information, storing it, transcribing, retrieving, analyzing, packaging or distributing it, shouldn't students be prepared to deal with it? Should basic skills now include critical reading, listening, television viewing, and use of information? Computer literacy? Today, educational decision-makers are not only faced with insistent demands to improve basic skills but also with the difficult task of defining what these demands mean.

Administrators are also hearing from their teaching colleagues who urge that different theories about learning be accommodated in decisions about instructional programs, curricula, materials, and equipment. The historic model of public school education in which the goal was to expose all students to the same curriculum, taught in the same way, is being replaced by individualization models for meeting the individual needs, interests, and capabilities of every student. Legislation addressing the education of handicapped and gifted students explicitly cites this goal. Although not yet fully realized, recognition that students of the same age, in the same grade or class, do not have the same educational needs or learning patterns is changing the way that educators plan and deliver instruction. Educators are also working on teaching strategies that

[1] See, for example, J. Fred Bucy, President of Texas Instruments, Inc. in a speech on "What Industry Expects from the Educational Community," delivered on March 4, 1981, to The Governor's Symposium on Career Education, Texas Education Agency.

[2] David P. Snyder, "Welcome to the Information Age," *VocEd*, April 1979, p. 28.

actively involve students in the learning process. If both needs, i.e., to individualize instruction and to involve students actively, are to be met, additional resources must be found.

At the same time that demands are being placed on schools to improve basic skills education and to accommodate individual student needs, costs are rising, school populations declining, and school budgets being cut. Schools can no longer rely on local taxpayers to approve large budgets without debate, and funds from Federal and state sources are not as likely to close the gap as they were in the 1960s. Thus, administrators are now more inclined to consider all aspects of an educational problem and a number of alternative solutions before committing their meager educational dollars.

The Claims

Administrators hearing demands to improve basic skills, to individualize learning, and to limit spending must balance the various claims that are made for solutions to the problem. Many of these claims appear under the rubric of "educational technology," although there are different points of view regarding what educational technology is and how it can contribute to a solution.

Some proponents of educational technology urge the use of its products to solve educational problems such as:

- Developing student skills in identifying the major theme of a story by having students listen to a radio broadcast of *Hansel and Gretel.*
- Teaching left to right reading orientation by using a film strip.
- Stimulating ideas for writing a story by viewing *The Waltons.*
- Storing and maintaining student performance records in a computer data bank.

In a broader sense, educational technology encompasses the systematic design, implementation, evaluation, and management of solutions to educational problems. Proponents of this definition claim that education problem-solving should lead from needs assessment to evaluation and involve both human and non-human resources. They stress that solutions to particular learning problems will not necessarily entail the use of media.[3] For these proponents, educational technology is a process, not products or things..

Finally, administrators will get advice to return to the old ways of teaching. The back-to-the-basics movement represents not only dissatisfaction with the current practices that are believed to produce students who cannot read, write or do arithmetic, but also discomfort with the use, or proposed use, of technology to meet educational needs. Because they believe that television has contributed to illiteracy in today's young people, for example, many people find it hard to reconcile television viewing with learning basic skills, despite the continuing success of programs like *Sesame Street.* Similarly, reactions to the use of calculators in schools, particularly with young children, are often negative; the belief that using calculators diminishes thinking is widespread.[4] The fact that computers are still a mystery to many adults may contribute to skepticism that they can be part of the solution to educational problems. Knowing that equipment schools purchased in the past has often not been used may add to the hesitancy of taxpayers to purchase new equipment. It is little wonder that parents, teachers, and members of the community continue to raise questions about the use of technology for educational purposes.

Another cautionary note comes from educators who warn of the dangers in believing that the products of technology will solve educational ills.[5] The use of machines to replicate poor educational practices, such as failing to provide helpful feedback to students, contributes no more to improving education than teachers who ignore a student's work or punish students making mistakes. Similarly, computers which greet a student, "Good morning, Sam," and do no more, are not individualizing instruction. Fortunately, improvements in the use of technology are made very year as the knowledge and skills of educators increase. Researchers are using technology to learn more about learning, so that problems that have more to do with teaching than with technology can be resolved.

[3] Allan B. Ellis, *The Use and Misuse of Computers in Education,* New York: McGraw-Hill, 1974, p. 53.

[4] One article that attempts to dispel anxieties about calculators is: Arthur Kessner and Twila Slesnick, "Myths About Calculators in the Schools," *Calculators/Computers Magazine,* Sept./Oct. 1978, pp. 78-81.

[5] Ellis, *op. cit.,* p. 54.

A Solution?

How can school board members, superintendents, and other educational decision-makers evaluate the various claims that are made for and against educational technology? The prospect may appear overwhelming, especially when any decision, even one to maintain the status quo, will have organizational and budgetary implications, as well as educational ones, and will have an impact on students, faculty, staff, parents, and the community at large. The intent of this guide is to provide assistance in making that decision an informed one by providing information about technology and its possible impacts on curriculum content, instructional techniques, faculty and staff, and school setting. Since no single solution to the problem of improving basic skills will work for all schools, the authors provide information and suggest processes that should contribute to a number of answers.

III. Learning Basic Skills*

Plato was among the earliest of the philosophers to inquire, "What is worth learning?," and through the ages each generation has had to resolve this central social issue. The resolutions have been based on a number of factors – convictions about what people need, political power, the status of organized knowledge, the influence of religion, economic conditions, national security, social mores of the time, interpretations of history, conceptions of morality, technological advancements, geography, and distinctions among social classes, among others. Resolutions change with time and with economic, political, and social conditions and, consequently, affect the definition of what should be taught.

For example, Plato's answer to his question defined basic skills as rooted in the nature of the universe and man's ability to better understand his world. Much later, Rousseau, trying to extricate Emile from a corrupting society, saw education as the way to *re*construct society. In the new world, Jefferson and Webster proposed education as the way to construct a new social order. Dewey, observing the growing influence of industry on all aspects of American life, saw schools as "active centers of scientific insight into natural materials and processing points of departure whence children shall be led out into a realization of the historic development of man."[1]

Similarly, the choice of institutions responsible for imparting valued learnings to the members of a society is an expression of that culture's values. In this country, it began informally with families playing the dominant role and schools a relatively minor one. We have moved, particularly since the turn of the century, to a reversal of those roles. It is only in the last ten years or so that serious questions have been raised in the United States about the appropriateness of schools assuming a larger responsibility in the total educational endeavor.

Just as society's values affect the definition of basic skills and the assignment of responsibility for teaching those skills, society's values control decisions about *how* basic skills should be taught. As industrial America created new methods to make itself more efficient, the concept of the assembly line was coupled with behavioristic psychology, and curricula became defined as a series of discrete, measurable, observable behaviors. The movement to quantify the school program (i.e., to state behavioral objectives, to teach with the purpose of meeting them, and to test students on their attainment) was very much with us at the turn of the century.[2] The era of the "science of education" abated between the two world wars with the growth of progressive education.[3] In the 60s the major vehicle for curriculum reform was the revitalization and reorganization of the subject matter disciplines.[4] In the 70s the scientific movement reappeared and continues today;[5] what is to be taught is selected on the basis of what can be measured by testing which, in turn, affects how things are taught.

The "back-to-the-basics" movement with its emphasis on reading and arithmetic brought a decline in the 1970s in time devoted to science, social studies, and mathematics instruction.[6] The question that will confront teachers and other educational decision-makers, parents and other school patrons, and legislators in the decade of the 80s will be the extent to which the trend of narrowing curricular offerings will continue. Despite shrinking budgets and expectations that have characterized the beginning of the 1980s, there are data to suggest that the trend will be altered.

*This chapter was developed in part by Robert M. McClure, Ed.D., Manager for Instruction and Professional Development, National Education Association, Washington, D.C.

[1] John Dewey, *The School and Society*, Chicago: University of Chicago Press, 1899.

[2] See, for example, Charles Hubbard Judd, *The Psychology of High School Subjects*, New York: Ginn and Co., 1915.

[3] The Progressive Education Society, "A Quarterly Review of the Newer Tendencies in Education, Part I," New York: The Society, April 1924.

[4] See Jerome S. Bruner, *The Process of Education*, Cambridge: Harvard University Press, 1960.

[5] See, for example, Leon Lessinger and Associates, *Accountability Systems for Planning in Education*, Homewood, Ill.: ETC Publications, 1973.

[6] M. Suydam and A. Osbourne, *The Status of Pre-College Science, Mathematics, and Social Sciences Education*, Volume II, Washington, D.C.: Government Printing Office, 1978, pp. 2-8.

What Are Basic Skills?

Although what is basic to one may not be so essential to another, most people see reading, writing, and arithmetic as central to the public school curriculum. Employers, admissions officers in colleges and universities, parents, and students themselves are strongly urging schools to return to an emphasis on the skills of communication and computation. Few of these people, however, would be satisfied with limiting the total school offering to the three R's and would variously insist on history, geography, citizenship education, science, art, music, and other subjects as essential curriculum components. Considering the trend at the beginning of the 1980s to increase curriculum offerings and assuming the validity of data from public opinion polls[7] it is possible to predict the most likely basic skills curricula in the near future and through the end of the century.

Clearly, language will continue to be a dominant part of the curriculum with continuing emphasis on reading skills. Writing, speaking, and listening will be emphasized with particular attention to improving the quality of communication. The focus of language arts teaching will change from grammar and spelling to the writing process and the structure of written products.[8] Critical reading, listening, and viewing skills will become more central as society recognizes the need for citizens to distinguish between propaganda and fact. Proficiency in a second language will be considered a basic skill for all graduates before the end of the century. Our economic need to relate with all nations may make it mandatory that Americans become bilingual.

Educators may increase their use of the computer as a delivery system for instruction in arithmetic and English, but the most dramatic change in the curriculum will come about in developing student understanding of computers and other technology to prepare them as consumers, employees, and citizens in the age of information. It may no longer be enough that students perceive computers as deliverers of instruction; both literacy and future employment may depend on their learning to *use* the computer:

- to use computer data bases;
- to simulate physical, natural, mechanical, and social systems;
- to solve problems;
- to edit text and to use other functions of a word processor;
- to understand computer models for decision-making;
- to create graphs and other pictorial devices that convey information.[9]

Education in the physical and natural sciences will become even more basic in the curriculum. Science instruction will begin with very young children and continue throughout the high school where the emphasis will be on the basic principles of science as they relate to daily living, on new developments in science, and on understanding the processes that result in new scientific discoveries. Science education will not be reserved for those aspiring to college admission; "...in these offerings students will learn more than they presently do about fundamental operations so as to become more enlightened decision-makers in the complex affairs of our society."[10]

Accompanying the emphasis on language, mathematics, computer literacy, and science will be renewed curricular concentration on problem-solving, using abstractions and symbols, applying knowledge directly, and developing the capacity to deal rationally with unanticipated events. Because such objectives are not bound to single course topics, opportunities to develop these higher cognitive skills will be spread throughout the curriculum. In some schools *they* will be viewed as basic skills, and traditional subject matter will be employed as a support to their achievement.

[7] Recent Gallup polls, for example, have demonstrated wide agreement on the necessity for young people to understand how our government operates, the interdependence of nations, and the ability to write effectively. George H. Gallup. "The 11th Annual Gallup Poll of the Public's Attitudes Toward the Public Schools" in *The Phi Delta Kappan*, September 1979 (Vol. 61, No. 1), pp. 33-45.

[8] Andee Rubin. "Making Stories, Making Sense." *Language Arts*, March 1980, p. 286.

[9] Arthur W. Luehrmann, "Should the Computer Teach the Student, or Vice-versa?," *Creative Computing*, Nov.-Dec. 1976, p. 45.

[10] Robert M. McClure, "The Unfinished Agenda," *Education in the 80's: Curricular Challenges*, Lois Edinger, Paul Houts, Dorothy Meyer, editors. Washington, D.C. National Education Association, to be published July 1981.

There is a renewed demand in society for attention to the humanities[11] which we can expect to increase. In addition to proficiency in a language other than English, schools will focus more attention on the human condition through literature, history, and philosophy. The current trend to "moral education" will continue in some fashion although it is difficult to know in the present highly charged political climate what form the curricular offering will finally take.

The performing and visual arts have become more central to American life and as standards have risen and changed so has the desire for improved education in these fields. Aesthetic principles, opportunities to become proficient in one or more of the arts, and the knowledge necessary to be a discerning consumer of the arts will all become more central in the school program.

As Americans gain more leisure time and increase their understanding of health, nutrition, and recreation, programs that develop health awareness and good health habits throughout life will increase. Expertise in a recreational sport will be a basic skill in elementary and secondary schools.

It also seems likely that the trend toward providing more time for career and vocational education will continue and that three related developments will occur: 1) career and vocational education will be more fully integrated with each other and with parts of the curriculum, 2) vocational skill training will be broad enough to give future employees more job satisfaction and career development potential, and 3) the role of the private sector in preparing youth for the world of work will become more pronounced.

While there may be agreement among Americans about the future, broad goals of education, there is considerably less agreement as to what the specific curriculum offerings in schools should be now. For the purposes of this guide, we will henceforth define basic skills as the acquisition of skills related to effective communication which include:

- the ability to use spoken language;
- the ability to organize one's thoughts in speech and writing;
- the ability to understand another person's thoughts through listening and reading;
- the ability to use symbolic mathematical concepts both expressively and receptively; and
- the ability to understand and use common forms of information and communication technology.

In the following section, how people learn these skills will be the topic of discussion.

How Do People Learn?

No matter what the skills that society-at-large, a community, or a school defines as basic, the ingredients that lead to success in teaching them may be the same. Although we still have much to learn about how people learn, educators know from experience, and research supports, that the following ingredients are important parts of learning. People learn:

. . . When their current and changing interests, needs, and abilities are accounted for. Most educators know from experience that students have different needs and interests, that they have different learning styles, and that they move through curricula at different paces. Those of us who have been learners recognize that the significance of course content to our lives is a key factor in our learning it. We know we learn best when the content matches our abilities in a way that is stimulating but not too difficult. We also want flexible instruction that can meet our changing needs and to know that our needs and interests are receiving personal attention. Any teacher who has tried to incorporate these qualities into daily practice knows the difficulty of planning and delivering individualized instruction to every student in his or her class![12] Nonetheless, many teachers have successfully used instructional techniques and materials that enable students to operate at their individual paces and that respond to their educational needs. The appropriate use of educational technology can broaden this opportunity for all students and, at the same time, relieve the teacher of some of the planning and teaching burden.

[11] See, in particular, The Rockefeller Foundation, *The Humanities in American Life*, Berkeley: University of California Press, 1981.

[12] Ludwig Braun notes that the traditional educational system provides only 15 seconds of personal attention per hour. A computer can provide 100 percent attention. In "Computers in Learning Environments: An Imperative for the 1980's," *BYTE*, July 1980, p. 112.

. . . **When they are actively involved in learning.** Although there is an important place in education for lectures or presentations, reading, listening to recorded sound, and viewing films or television, no strategy that is non-participatory can be substituted for active involvement in learning. Students learn more and retain more when they learn by doing and when they can use what they are learning. The learning of basic skills is no exception; people learn to speak by talking, using words to communicate, not by studying communication.

. . . **When they interact with others.** People seem to enjoy learning situations and complete their learning tasks when there are others present with whom they can interact.[13] Research is currently in progress on the level at which human interaction is necessary to produce effective learning, but it is clear that consultation with teachers and joint problem-solving with other students[14] are important ingredients in learning.

. . . **When a variety of techniques and materials are used.** Just as the stimulation of others helps make the learning experience more enjoyable, if not more productive, so does exposure to a variety of instructional techniques and materials. Many educators believe that learning is more effective when the learner is reached through more than one sense, although there is some, inconclusive, evidence that *simultaneous* multisensory inputs (e.g., the visual and aural aspects of film) may be less educationally productive than media that address only one sense at a time.[15] Some research on sensory preferences for learning indicates that, except for people with sensory handicaps, there is no significant difference in sensory capabilities among people.[16] Should these research findings become firmly established, it will not mean that learners are not stimulated by variety. It will only mean that they cannot process more than one type of sensory input at a time.

. . . **When the design of the instructional materials is interesting and stimulating.** Visual appearance or aural or tactile interest is also important to the learner. Materials which are colorful, animated or otherwise attractive catch and maintain interest and thus motivate students to begin or continue work on a learning task. Design may also detract from learning if it is irrelevant to the purpose.

. . . **When they receive feedback on their performance.** All learners want to know how they are doing, that is, whether they know the concepts they are supposed to know or whether they are performing a task correctly. Feedback may be in the form of speed or accuracy scores, comparison with other learners, or subjective judgments by the teacher or student. No matter in what form it is given, it is important for the learner to know whether he or she should move on to new material or continue to work on the old.

. . . **When they practice and review a skill or concept.** If new skills are to be remembered, learners need to practice them until they are solidly mastered. Similarly, skills and knowledge will be forgotten if they are not reviewed at some point after mastery. Basic skills can be practiced and reviewed with most kinds of media as well as with textbooks and pencils and paper.

As any good teacher knows the successful use of these ingredients depends on their appropriateness to the learning objective and the manner in which they are carried out. Teachers who can orchestrate the people and things present in the classroom to produce effective learning will find that they have used the ingredients discussed above.

What Instructional Techniques Are Useful in Teaching Basic Skills?

It is difficult to imagine an instructional technique that would *not* be useful in teaching basic skills. In fact, as we have seen above, the more techniques that teachers have available the more likely they are to be effective in reaching all the students in their classes. Although instructional techniques do not fall easily into distinct categories, many educators describe them in the terms used below. They are described in an approximate order of familiarity in the classroom environment.

[13] Jack A. Chambers and Jerry W. Sprecher, "Computer Assisted Instruction: Trends and Critical Issues," *Communications of the ACM*, June 1980 (Vol. 23, No. 6), pp. 336-337.

[14] David W. Johnson, "Student-Student Interaction: The Neglected Variable in Education," *Educational Researcher*, January 1981, pp. 5-10.

[15] Research reviewed by Wilbur Schramm, *Big Media, Little Media*, Beverly Hills: Sage, 1977, pp. 33-34 and 53-56.

[16] Schramm, *supra.*, p. 39.

Information Delivery

A student-teacher interchange, a lecture, or the presentation of information and ideas by media such as films, television or computer. It is commonly used in the teaching of basic skills.

Demonstration

Displays of physical or mathematical relationships shown on paper or a blackboard, on audio-visual equipment, television or computers. Demonstration is a common technique in teaching basic skills.

Drill and Practice

The presentation of a number of practice problems or a sequence of exercises designed to reinforce learning gained from another source. The technique is most useful when students must commit material to memory or must practice certain skills until they can perform them quickly and correctly. In teaching basic skills, drill and practice is used for learning and applying spelling and punctuation rules, learning multiplication tables, and applying basic number facts and operations. In the past, drills were always conducted by a teacher; now, computers and hand-held electronic devices provide drill and practice efficiently and tirelessly. Other features of these tireless teachers may include keeping track of right and wrong answers, providing feedback, and accelerating or providing remedial exercises based on performance.

Problem-Solving

At the most unsophisticated level, this technique requires the learner to propose a solution to a teacher-generated problem. At more complex levels, the problem-solving technique calls for learners to state their own problem, test hypotheses, propose and then evaluate solutions. The use of computers for problem-solving may also involve the student in writing a computer program that will solve a problem. The technique is used in all basic skills teaching and is used with all instructional media from paper-and-pencils to computers.

Tutorial

This technique presents a new concept to a learner in small, sequential bits, give examples to illustrate the concept, drills the learner, provides feedback on the learner's performance, and finally summarizes the information learned and the relationship of that learning to other instruction and to real world problems and issues. It is a technique that the best teachers have used with individual students since teaching began. It provides the basis for programmed instruction texts. Since few teachers have the luxury of using the tutorial method in today's schools and programmed instruction is limited in effectiveness, we are fortunate to have computer programs which can provide tutorial instruction in topics such as reading and arithmetic. PLATO from Control Data Corporation and TICCIT from The Hazeltine Corporation are two examples of systems that have employed a tutorial approach.[17]

Instructional Games

The application of one of more specific skills or concept in a competitive or cooperative environment. Games are used for instruction on the theory that people will learn something because it is fun or challenging. The game technique is used to develop general problem-solving skills and to practice the application of specific skills, such as arithmetic, manual dexterity, or spelling, in a different context. To have any long-lasting effect, games should be integrated with the rest of the instruc-

[17]The Control Data PLATO (Programmed Logic for Automated Teaching Operation) System, developed in 1959 at the University of Illinois, is a world-wide network of computer-based education which supports instruction in over 100 cities. It provides instruction to students who range from beginning readers to commercial airline pilots. With over 10,000 PLATO lessons currently available, PLATO is one of the most comprehensive networks of computer-based education.

Like PLATO, TICCIT (Time-shared, Interactive, Computer-Controlled Information Television) offers a wide variety of lessons on subjects including basic skills instruction. TICCIT can serve from 20 to 125 students (as compared to PLATO which can serve over 1,000). TICCIT's use of minicomputers means that the entire computer system can be located at the same site where the terminals are located. PLATO, on the other hand, uses large main-frame computers in three central facilities.

TICCIT, also like PLATO, offers graphics and animation capabilities, speed of operation, and a feature which allows users to develop instruction for use on-site.

tional program. A number of instructional games are available for audio-visual, video, and computer systems, as well as hand-held electronic devices.

Simulations

Simulations represent the key aspects of an environment, real or fictional, which the learner can affect by making decisions to change specific elements. The learner sees the results of his or her decision but does not experience them personally as would happen in real life. Simulations can be programmed on computers, or audio-visual or printed materials can convey information about the environment concerning which the learner is expected to make decisions. Simulations generally do not teach basic skills, rather the learner must apply skills such as mathematics, reading comprehension, hypothesis formation, and problem solving, in working out the problems posed in the simulation. In fact, many educators believe that learners should become familiar with concepts through concrete experience before encountering them in simulation.

Exploration (Inquiry)

Allows students to take content introduced by a teacher or media for the purposes of generating their own ideas about the information and extending learning through experimentation, exploration and discussion. Exploration gives students an opportunity to develop research skills, to problem solve, and to apply their knowledge.

Each of the techniques described above can contribute to the learning of basic skills. Each serves different educational purposes and in theory has the capacity to meet the learner needs discussed above. In considering a specific computer program, film or other medium for purchase or use, the school administrator will find that each has different contributions to make in teaching basic skills. In the next chapter, we examine the capacities of a number of media in teaching basic skills.

IV. Using Technology in Basic Skills Education*

In Chapter III we looked at basic skills, how they are defined, how they are learned, and techniques that are useful in teaching them. This chapter examines the role of technology in teaching basic skills. Specifically, it describes five kinds of media systems which have resulted from or been affected by information and communication technology:

- Computers
- Television
- Calculators
- Electronic learning devices
- Audio-visual media

Each system is discussed in terms of its capacity to meet the criteria for a good learning situation and the extent to which it can accommodate the instructional techniques described in Chapter III. Both capabilities and limitations are explored. The descriptions close with a review of the issues that administrators should think about in deciding whether or not to acquire or to continue use of the delivery system in their districts.

* This chapter was developed in part by **Robert M. Caldwell**, Ph.D., Associate Professor of Allied Health Education, The University of Texas, Dallas (computers); **William B. Perrin**, Associate Executive Director, Agency for Instructional Television, Bloomington, Indiana (television); **J.D. Gawronski**, Ph.D., Director for Planning, Research and Evaluation, San Diego County Department of Education, California (calculators); **Richard C. Carter**, Faculty Member at Lesley College, Cambridge, Massachusetts (electronic learning aids); and **John H. Humphrey**, President, Informedia, Inc., Jackson Heights, New York (audio-visual media).

Computers

Computers are unique among educational technologies in that they can be designed to interact with learners. The other technologies that are being examined in this guide are most often used as one-way paths for disseminating facts and ideas. Neither audio recordings, motion picture films, nor live television broadcasts interact with students, permit students to advance at their individual paces, give immediate feedback, or allow use as a problem-solving tool to the extent that computers do. Until recently, one shortcoming of computers was their inability to replicate sound, color and motion with the same quality as film and television. As we will see, videodisc systems may overcome this limitation.

The capabilities and cost-effectiveness of information technology have been increasing exponentially since World War II! Since 1943 the amount of information that can be processed within a given time by one dollar's worth of computer hardware has doubled approximately every two years. This means that, for the first time since the printing press enabled teachers to put their spoken words into a portable and permanent form, a quantum leap in the extent and quality of services that education can provide is possible.[2] The technological revolution that produced the computer for military and industrial use is now available for increasing the educational productivity of teachers and students as dramatically as the introduction of printed books 500 years ago.

Although all computers have the same functional components, i.e., input, memory, output, and central processing unit, each type differs with respect to: 1) the amount of information it can store, its memory; 2) the physical size of the system; 3) the amount of information it can process and the speed at which processing occurs, its processing power; and 4) cost.

The main frame or macrocomputer has the largest memory capacity and the most power of any of the types of computer. Its size and costs are also large. It can

1 J.C.R. Licklider, "Social and Economic Impacts of Information Technology on Education," Cambridge, Mass.: Massachusetts Institute of Technology, pg. 8.

2 Dustin H. Heuston, "The Promise and Inevitability of the Videodisc in Education," a paper submitted to The National Institute of Education, September 1, 1977, pp. 12-14.

support as many as 1,000 terminals at a time which means that people who are physically distant can communicate through terminals connected to the main frame. This capability is useful in situations where a student cannot attend a class but needs to communicate with his or her teacher or fellow students for instruction, game playing, electronic mail, and other purposes. The storage capacity of a main frame is important because it increases the educational strategies available to a teacher as well as the size of the data-base.

A **minicomputer** is a smaller and less expensive version of the main frame. It has less processing power and can support fewer terminals (at the most, 120 terminals), but can perform the same functions as the main frame.

The lower cost of **microcomputers** has made them affordable for schools and home consumers. Although they have a smaller memory capacity and less processing power than their larger cousins, their light weight makes them easy to move from place to place and their flexibility makes them good candidates for school use. Their capacity can be increased through networks which connect microcomputers for the purpose of sharing information and through connections with larger systems through **modems** which allow information to pass from one system to another through telephone lines.

Because microcomputers are becoming the popular choice among school administrators, the discussion about the capabilities and limitations of computers will focus on microcomputers.

Capabilities

Computers can transmit information in a variety of ways that are appropriate to student needs, interests and abilities and can provide students with immediate feedback when designed to do so. They can increase motivation and interest in exploring new ideas and can be used to manage student progress.

Transmission of information. Computers have the capability to store, organize, and present information to students as they or their teachers request it. This means that students and teachers not only have information available at their fingertips, they also have what in effect are: 1) a highly competent research assistant to compile, sort, arrange information and 2) a typist to type it out. For example, a seventh grade student assigned to write a paper on the black-footed ferret can key in to a computer system like LEXIS and receive full text on recent court decisions relating to this endangered species. LEXIS will also provide the student with other citations to law journal articles and other relevant literature.[3]

Using such data bases as LEXIS and NEXIS, which covers news services, students can have direct and immediate access to the particular information in which he or she is interested without having to wait while irrelevant information is presented.

The ability of computers to store information and student records varies depending on the size and type of computer. The memory capacity of microcomputers ranges from 4,000 (4K) to 64,000 (64K) electrical codes, each of which generates a piece of information; the largest computers, main frames, can store millions of pieces. To increase the memory of one microcomputer, it can be linked to other microcomputers in networking systems to share information. In addition, microcomputers and terminals can be connected to main frames through a modem. This capability gives students and teachers access to the large data bases stored in main frames, significantly increasing the information available to students in schools which have microcomputers only.

Skill practice with feedback. Many skills, such as mathematical computation, vocabulary, and other language skills, require repetition and practice before they are fully mastered. When designed to do so, computers can assist the skill acquisition process, which is often tiresome for both teachers and students, in several ways:

- *Immediate response.* A computer can respond to a student's answer to a question or problem as soon as the student gives it. Students using a computer for drill and practice do not have to wait for their teacher to review their papers. They know immediately whether their answer was right or wrong.
- *Increased number of question-answer-response sequences.* A computer can present as much material to a learner as necessary for him or her to master the skill. A computer will adapt to the pace of the individual learner; in most cases this means that learners move more quickly through exercises than would be

[3] A true story cited by Beverly Hunter. *An Approach to Integrating Computer Literacy Into the K-8 Curriculum*, Alexandria, Va.: Human Resources Research Organization, 1980. p. 3.

possible in a class that has no computer. It also can select those techniques which are most appropriate to the student's style.

- *Effective sequencing of material.* Most instructional material, whether it is in textbooks, workbooks or a teacher's lecture notes, is intended for presentation to the learners in an ascending level of difficulty; computer courseware for teaching basic skills is similarly designed. Computers, however, can also be programmed to diagnose the learner's ability as he or she enters the sequence and then to place the learner at the appropriate place in the sequence. Computers move the learner to the next level of difficulty as soon as he or she has correctly answered a predetermined number of questions. Finally, when programmed to do so, computers can route learners through remedial sequences when they are having difficulty in mastering a particular skill.
- *Learner controlled drill and practice.* Some drill and practice computer programs give students the options of 1) deciding how they want to progress through a sequence given their present level of ability, 2) determining the number of problems they want to try, and 3) determining the level of difficulty of those problems. These features place students in control of the kind and amount of drilling they wish to have and, as a result, can be highly motivating.

In serving any of the above functions, computers have limitations. A courseware designer who has not anticipated a particular learner's response or who has not designed an alternative path that meets a student's needs or learning style offers something that only approaches individualized instruction but does not provide it. However, a computer can be programmed to enable students to give feedback to the designer about a lesson; such suggestions can often be incorporated quite easily into the lesson. Few other media give students or designers this opportunity.

Motivation. Some research[4] has shown, and many of us intuitively believe, that there is no substitute for teacher-student interaction to encourage students to explore new material or to complete a program of coursework. Student-student interaction can also be highly motivating. Although no basic skills learning environment should be without teachers and fellow students, computers can also motivate students by serving as a communication link between students and their teachers or colleagues who may be physically distant.

The motivational qualities of computers include:

- Learning at one's own pace which may be slower or faster than that of peers at any given time.
- Initiating learning on one's own; not having to depend on a teacher to begin a lesson.
- Learning in privacy and being free from exposure to ridicule from one's peers or loss of patience by one's teacher.
- Choosing the content that one is interested in pursuing.
- Having fun in learning how to control a machine to do what one wishes.

Since there is mounting evidence to the effect that the use of computers motivates students to learn and, as a byproduct, to stay in school[5] their ability to capture and hold student interest are of major importance to school officials and parents who are concerned about high attrition rates.[5]

Discovery and exploration. Discovery and exploration are qualities that computers can stimulate, although they are not unique in this regard. Other media, including books, films and instructional television, and teachers, are also stimulators of creativity, as we are all aware. Simulations, games, and other computer-based activities, such as those provided by Seymour Papert's LOGO programming language for learning fundamental ideas such as geometry and physics through exploration, are particularly conducive to computer application.

Managing instruction. The ability of computers to keep and update records of student achievement means that students are exposed to instructional material that is appropriate for their particular needs and

[4]Jack A. Chambers and Jerry W. Sprecher, "Computer Assisted Instruction: Current Trends and Critical Issues," *Communications of the ACM*, June 1980, pp. 336-337.

[4]Chambers and Sprecher, *supra.*, pp. 335-337; Ludwig Braun, "Computers in Learning Environments: An Imperative for the 1980's," *BYTE*, July 1980, pp. 8-9; Frederick H. Bell, "Can Computers Really Improve School Mathematics?," *Mathematics Teacher*, May 1978, pp. 431-432.

[5]Educators and others may well be appalled by today's drop-out rates. In some schools more students drop out than graduate during any given year.

abilities. Computers can be programmed to adapt the amount and complexity of information provided a student to that student's response to previous instruction. Although many schools prefer their teachers to perform these functions, computers can also be programmed to diagnose a student's academic problems and prescribe a course of study based on that student's weaknesses. The extent to which a program can diagnose learner needs, match them with performance objectives, and maintain achievement data, learning style information, and the like depends on the skill of the designer. The more comprehensive and sophisticated programs of this type will require more storage capacity than simple ones.

Computers with management programs, or Computer-Managed Instruction (CMI), can:

- Generate or give diagnostic tests, or both.
- Score tests and print out profiles of individual or class performance.
- Collect and maintain a record of the elapsed time of program use by students, the number of questions answered correctly and incorrectly, and the time taken by a student to answer a single question.[7]
- Make learning prescriptions for a student based on his or her performance.
- Generate a list of materials that address a particular content area, skill or learning objective.
- Create unique materials for a particular student with a defined need or interest.
- Create lists of students with similar needs or interests. With such a list, for example, a teacher can identify all students in the class that need work in subtraction and list materials that are appropriate for each student.
- Direct a student having difficulty in mastering a particular skill to alternative remedial branches.

Many computer-assisted instructional programs are accompanied by computer managed instruction (CMI) packages, although CMI packages are offered separately as well and can be used to manage instruction offered in print and other non-computerized forms.

[7]Jurg Nievergelt adds that none of this data will be of any use unless it is reviewed and acted upon and warns against collecting more data than is needed for a specified task. In "A Pragmatic Introduction to Courseware Design," *Computer*, Sept. 1980, p. 17.

Increasing the Capabilities of Computers

As we have seen, computers by themselves have a number of capabilities which are not completely shared by other media, including practice with feedback, efficient and quick transmission of information, and management of student progress. These capabilities can be enhanced and new capabilities can be added by the use of peripherals, or hardware features, and by linking computers with other media.

Peripherals. With peripherals, the number of functions that computers can accomplish increases. Some of the most common and useful peripherals for the basic skills educator include:

- *Text editors or word processors.* These devices, which some argue are the most useful technology for teaching the communication skills, can help students learn a basic writing skill, i.e., editing.[8] Using a word processor for editing eliminates its mechanical aspects of erasing, cutting and pasting and allows the writer to focus on content and style. When combined with an automated dictionary capability, students can quickly learn the meaning and correct use of words as they revise text.
- *Printers.* Hard-copy printing units can be used to record instructions for running a program and to print student records, tests, and other material.
- *Voice and music synthesizers.* This relatively new technology enables a computer to reproduce speech or musical sounds, recognize speech, and respond appropriately to it. Voice synthesizers are potentially useful in teaching sight to sound correspondence, an important skill in learning reading and speech communication. Voice-response and voice-activated units will improve the computer's capability to interact with the basic skills learner,[9] when the technology becomes available for educational use.
- *Graphic generators.* Microcomputers which display text only in upper case letters are problematic in teaching reading and language arts. Graphics genera-

[8]George A. Miller, *Automated Dictionaries, Reading and Writing: Chairman's Report of a Conference on Educational Uses of Word Processors with Dictionaries*, Washington, D.C.: National Institute of Education, Dec. 1979, p. 3.

[9]Reisman, Sorel, "What is 'Interactive Video'?," *E-ITV*, June 1981, p. 29.

tors solve this problem by giving computers the capacity to print lower case letters, letters in various sizes and styles, bar graphs, charts, and mathematical symbols.

- *Joysticks and paddles.* These devices allow students to move images to different places on the screen and to respond to questions without typing. The feature is particularly useful in teaching very young children and students who cannot type, particularly handicapped students.
- *Touch-sensitive screens and light pens.* Similar to joysticks and paddles, these devices enable students to manipulate images on the screen without typing. Students simply touch some portion of the screen to indicate their response to a question or use a light pen for the same purpose.
- *Graphics tablets.* These devices enable the user to trace or create artwork which is then converted by the computer into high resolution graphics. This capability is particularly useful in situations where illustrations help students to comprehend text or where graphics represent a concept.

Computer-computer and computer-terminal communication. Computers can be linked with other computers to increase their storage capacities and other capabilities. One such linkage is that between a microcomputer and a main frame which allows the microcomputer to "download" a course or an instructional module from a main frame. That is, material is taken from a larger computer and copied for storage and use on a microcomputer. Other types of linkages include:

- *Information access systems,* which give researchers access to a number of resources such as news services, bibliographies, Wall Street price indices. Educators can gain access to information about available educational courseware through at least one such system.[10] Adaptations and improvements in curriculum made in one school can be passed along to others through their computers.
- *Electronic mail,* which enables teachers, students, or administrators to communicate with each other through their computer terminals. Teachers, for example, can leave messages for students about their assignments, attendance, or progress; and students can communicate with each other about joint projects. Students, teachers, and administrators can share views on any topic through *electronic forums* which operate similarly to electronic mail.
- *Games.* Students who are physically separated can play games if their terminals are connected to a common main frame or between microcomputers. In this capacity, computers can keep and report scores for each of the players.
- *Consultation.* Any member of an extended electronic community can request another person to help via computers when he or she encounters problems with a program. Assistance can thus be provided even when the consultant is not physically present.

A New Technology: Videodiscs

As discussed above, computers generally lack the ability to produce sound, motion, and color of the same quality as motion pictures or television. The advent of the videodisc greatly expands the capability of computers and supplies these missing qualities. An example will illustrate one educational potential of computer-videodisc interaction:[11]

> I am writing a paper on the effects of the skiing industry on small town life in Colorado. At my teacher's suggestion, I use the Aspen Movie Map videodisc which takes me on a simulated drive through Aspen. As I take this drive I find I can go down any street in Aspen, can see its buildings, and view the nearby mountains. I can go anywhere I want because I control the videodisc on which panoramic photographs, graphic illustrations of buildings, and sounds of Aspen are stored. I can stop and study one view, turn right or left or go straight ahead at any intersection, back up, and go inside buildings facing the street. I can look inside a restaurant for example and read its menu. I can change seasons with the monitor's channel knob and see Aspen at different times of the year. Finally, when I am finished with my tour, I can summon a list of relevant literature about Aspen and

[10] MICROSIFT, operated by the Northwest Regional Educational Laboratory in Portland, Oregon, evaluates courseware in grades K-12.

[11] The Aspen Movie Map described here exists. See Andrew Lippman, "New Possibilities Presented by Interactive Videodiscs," *Report of Interactive Videodisc Applications Conference,* New York, N.Y.: American Video Institute, 1980, p. 5.

other small western towns to help round out my paper.

Videodiscs,[12] which first became available to home consumers in 1978, are devices capable of storing large amounts of information, in a variety of formats, that can be rapidly retrieved.[13] The thin, plastic-coated discs, similar in appearance to long-playing audio records, can have a number of features depending on whether a disc is read by laser or a stylus and groove system. The more significant features of the laser reflective videodisc include:

- *Large storage capacity.* A disc has 54,000 frames on each side, and each frame represents one picture. Still pictures, moving pictures, text, sounds, and computer instructions can be recorded and stored on these frames.
- *Durability.* The plastic surface which coats a videodisc makes it resistant to dust, fingerprints, and hard classroom use. Players which employ a laser beam to read a videodisc do not subject the disc to wear or scratching since there is no mechanical contact with the disc as there is with a stylus.
- *High fidelity sound and stereo capabilities.* The two audio tracks on laser-type discs allow the recording of speech in two languages and the recording of music in stereo.
- *Freeze-frame capability.* A student can stop action and study a single frame or picture for as long as he or she likes. This feature is particularly useful for studying charts, diagrams, and graphics.
- *"Near-perfect image" capability.*[14] Videodiscs can present pictures that are clear and sharp, and, of course, in color, qualities that are especially important when one frame is being studied.
- *Slow motion, fast play, and scan in forward and reverse.*
- *Electronic index and direct, automatic random access.* These capabilities enable a student to find and use information no matter where it is stored on the disc.
- *Capability of compressing information.* Using encoding and decoding techniques, single frame events can be compressed so that a presentation that takes a few moments of actual screen time can be expanded into hours of use by a learner.[15]

Not all videodisc players have the capabilities listed above which accounts in part for the range in their prices in March 1981 from $500 to $3,000. The major reason for the range hinges on whether or not the videodisc player includes a built-in microprocessor. Systems which have a computer capability, sometimes called "intelligent videodiscs," combine the color, motion and sound capabilities of television, the technology from which videodiscs arise, with the computer's ability to provide interactive and individualized instruction. If the most sophisticated videodisc systems available at this time were being used in the classroom,[16] students could gain quick and efficient access to a particular piece of information from the large amount stored whenever he or she chose and could control the kind and sequence of information that they wished to access. Neither students nor teachers could record on their videodiscs, however, since they are still a play-back only media. Thus, schools will have to buy or rent factory-made discs in the same way they buy or rent long-playing records or film.

Limitations

The central place which computers now have and will continue to have in the information age, as well as their qualities as an instructional medium, make a compelling argument for their inclusion in a school's collection of instructional devices. As with any medium, however, computers have a number of limitations, some of which are inherent to the medium itself and some are external.

Cost. In the past, the cost of computer hardware has been so high that only a few schools could afford it. Now, with the advent of microcomputers and the yearly

[12] See the March 1981 and June 1981 issues of *E-ITV* and the February 1981 issues of *Instructional Innovator* which are devoted to interactive video and videodiscs.

[13] Frank Clement, "Oh Dad, Poor Dad, Mom's Bought the Wrong Videodisc and I'm Feelin' So Sad," *Instructional Innovator*, Feb. 1981, p. 12.

[14] "What's New in Video," *Instructional Innovator*, Feb. 1981, p. 9.

[15] John Blizek, "The First National Kidisc-TV Becomes a Plaything," *E-ITV*, June 1981, p. 41. This article describes the first videodisc designed especially for children.

[16] A number of permutations of the basic videodisc are being announced and can be expected on the market in the near future. As in considering any media, the careful administrator will investigate the variety of formats and interchangeability before selecting one kind.

decline in cost to purchase, computer hardware is more affordable.

The costs of courseware and the devices used to transmit electronic messages continue, however, to remain high. Courseware is expensive, whether purchased from commercial publishers or developed by teachers in school. Its cost is not likely to decline to the same extent as hardware, although the contributions that teachers and students can make to the design of lessons may reduce costs. The use of satellites, cable and fiber-optics may bring the costs of communication down in the future,[17] but overall cost may still be a limitation for many schools.

Application. Of the limitations that inhibit the use of computers in education, the most difficult to resolve is that involving inappropriate use. Lack of understanding about what computers can and cannot do leads to two problems:

- *Unrealistically high expectations.* Without linkages to other systems, microcomputers have limited memories. Buyers who are not aware of this limitation unrealistically expect their microcomputers to perform complex and sophisticated tasks.
- *Unnecessarily narrow applications.* Many educational applications of computers have mirrored techniques, such as imparting content by means of the printed word, and programmed instruction, that are already in the repertoire of teachers. Using computers for these purposes is not cost-effective, since programmed instruction is probably as effectively learned from workbooks.[18] Similarly, using a computer as a page-turner is extremely costly. Such applications mean that the full capabilities of computers are not being realized and their use as a tool for finding new ways to teach both old and new things has not been fully explored.

These misunderstandings reside not alone in teachers but also in courseware designers who simply adapt conventional techniques and materials for use on computers.

Materials. One of the major limitations in effective use of computers for instruction has been the lack of appropriate materials. As we have seen, one cause of this is a lack of understanding about the range of computer applications on the part of designers and teachers who may not know enough about computers to demand better materials. Newer technologies such as the videodisc suffer even more from the lack of materials. As was the case with computers and other technologies, work on hardware development began sooner and has gone at a faster pace than work on materials.

Because the materials issue is such an important one, we have devoted a whole chapter, Chapter VI, to it.

Teacher Preparation. As compared with the application of computer technology in business, industry, engineering, and defense, until recently, education received little attention from designers and manufacturers nor have educators been as involved in its application to training and education as their counterparts in other fields.[19] Thus, teachers for the most part have been left out of planning, research and courseware design. Many believe that ignoring teachers in the developmental phases has affected their acceptance of computers in the classroom.

For computers to be perceived by teachers as a useful part of the education process,[20] teachers must believe that computers have a realtive advantage over other teaching devices. The perception of teachers that computers are more complex than any other educational device must be addressed in teacher training programs, in-service training, and through increased exposure to computers.

Image. Popular concerns about the use of computers and other electronic technologies to emphasize facts above concepts and principles, to disseminate propaganda, and to promote uniformity serve as a warning to those who wish to apply technology to education.[21] Its potential power over many aspects of our lives must be channeled toward positive ends.

[17] Licklider, *op. cit.*, p. 15.

[18] Lou Frenzel, "The Personal Computer - Last Chance for CAI?," *BYTE*, July 1980, pp. 88-90.

[19] Licklider, *op. cit.*, p. 15; and John H. Grate, "A Systems Approach is Needed," *AEDS Monitor*, Oct./Nov./Dec. 1978, p. 17.

[20] Helena C. Martellaro, "Why Don't They Adopt Us?," *Creative Computing*, Sept. 1980, pp. 104-105.

[21] J.C.R. Licklider, "Impact of Technology on Education in Science and Technology," in *Technology in Science Education: The Next Ten Years*, Washington, D.C.: National Science Foundation, July 1979, p. 9.

Issues for Administrators

Many administrators within the next few years will be faced with making a decision about whether to buy computers for instructional purposes or to expand their schools' audio-visual capabilities. Pressures by parents, students, and future employers to prepare young people for roles in the information age will influence that decision and may even change the question to "What kind of computer should the school buy?" Among the issues that will confront the administrator will be:

- *Educational goals, instructional and management objectives.* Is computer-assisted instruction consistent with the community's or school's goals?, and will computers contribute to the attainment of the teachers' instructional objectives and the administrators' management objectives?
- *Relative merits of computer types for school needs.* Irrespective of cost, what kind or kinds of computer, i.e., main frame, mini, or micro, is most appropriate for the school?
- *Cost of installation and operation.* How much can the school afford and what financial trade-offs could be considered?
- *Availability of good materials.* What materials are available? Are there enough different materials available to justify purchase of a particular kind of hardware?
- *Teacher and staff expertise and knowledge.* Do teachers know how to use computers to their full advantage? What will it take to prepare teachers and staff to use computers?

Computers offer a good deal of promise for improving the quality of education. The problems listed above as issues for administrations are solvable. They must be solved if the promise is to be fulfilled.

Television

At one time television appeared to offer great potential for teaching and learning, perhaps more than any other technology. It was easier to operate than motion picture equipment and film, for example. With color, sound, and motion, it broadened learning horizons beyond the textbook and the classroom. It offered immediacy; viewers could participate vicariously in events happening all over the world and in space. And, it was familiar;[22] as much a part of the home environment as the kitchen table and almost as available in schools.[23]

Despite these qualities and the wide variety and increasing numbers of programs now available, instructional television (ITV) has not reached its full potential. The major constraint on its use has been the inflexibility of broadcast schedules which has meant that both teachers and students have had to adjust their work to fit them. Furthermore, neither teachers nor students could control programs in the following ways:

- Programs could not be stopped in the middle of a broadcast and replayed for review.
- Similarly, since programs could not be randomly accessed, students had to wait until material that was significant to them appeared.
- Instructional material was designed for the "average" student at a given grade level. The student who found the material too difficult or too easy was not offered another version that met his or her needs.
- Finally, as with audio-visual media, students were in passive roles. They could not respond directly to what was being presented nor could the television respond to them.[24]

[22]Such familiarity may be a mixed blessing. On the one hand, extensive exposure to the often frivolous entertainment on television which young people have at home may result in a less than serious attitude toward television viewing in school. On the other hand, teachers may be hesitant to open their own teaching styles to invidious comparisons with the color, animation and variety of television.

[23]"Television programming for instructional purposes (ITV) is available in approximately 72% of all classrooms in the U.S. Peter J. Dirr and Pedone, Ronald J., *Uses of Television for Instruction, 1976-77; Final Report of the School TV Utilization Study*, National Center for Education Statistics, Washington, D.C., 1979, p. 7.

[24]Dustin H. Heuston, "The Promise and Inevitability of the Videodisc in Education," an unpublished paper submitted to the National Institute of Education, September 1, 1977, p. 76.

New technologies that have recently become available or that will become available in the next few years have begun to address these problems, by offering a number of options from which to select. The next sections describe the capabilities of these technologies, their limitations, and issues for administrators.

Capabilities

Instructional television programs reach classroom television screens in a number of ways: broadcast from public television stations or from commercial stations, cable, video tape or cassette, and videodisc, and Instructional Television Fixed Service (ITFS). Each of these sources of programming has educational capabilities which are discussed below in ascending order of instructional flexibility.[25] Satellites, which are distribution systems rather than a program source are discussed last.

Broadcast from public television stations. Most of the almost 300 public television stations in the United States broadcast instructional television programs weekdays during school hours. Because teachers and students must adjust their schedules to the time of broadcast, if they have no recording capabilities, this source is the least flexible of all. While these stations can originate programs in their own studios for use by the local school system, most rely on their network connections with the Public Broadcasting Service for instructional programs since the production of high quality programs tend to be extremely costly. Stations also have access to educational programs from regional or state networks of which they are members.[26] About one half of the programs broadcast from public television stations come from the Agency for Instructional Television, a non-profit American-Canadian education service agency.

A number of the programs produced for broadcast on public television address basic skills in ways that are creative, colorful and intellectually stimulating. These include *The Electric Company* (a remedial program for primary school children with reading difficulties), *All About You* (a series on health), *Sesame Street* for pre-school children, and a 60-minute program series called *Think About* which address the skills essential to learning, i.e., language arts, mathematics, reasoning and study skills. Many of these and other basic skill programs offer printed guides for teachers suggesting pre- and post-program activities, discussion questions, and additional resources.

The cost of this delivery system to schools is relatively low, sometimes consisting only of a broadcast fee based on the number of hours of use.

Broadcast from commercial television stations. A number of programs that are broadcast by commercial stations are used by teachers to supplement instruction. Most broadcasts that are appropriate for this use are made after school hours thus somewhat limiting their use except as homework. Few are aimed primarily at teaching basic skills, of course, but they are often the subject of instruction in critical television viewing skills which many believe are basic for today's young people.[27]

Cable television. Cable television has several advantages over both public and commercial broadcasting. First, the quality of the picture may be greatly improved because cable television, whether wire or, more recently, optical fiber, is relatively unaffected by topographical or weather interference. In addition, cable distribution has the potential of increasing the number of channels that are available. As a result, teachers can choose programs from commercial television, public television, videotape and cassette recordings, and pay television, if desired. Cable can deliver programs produced in school by teachers or students. In some schools students are producing their own videotapes and live television shows which are delivered to classrooms by cable and other delivery systems. These uses are excellent for basic skills development in writing (for example-scripts) and for visual, oral and sensory communication.

Like satellites, cable systems have the capacity for two-way communication and multichannel delivery.[28]

[25] Dirr and Pedone, *op cit.*, p. 9. Also see Herbert S. Dordick, Bradley, Helen G., and Fleck, Glen, *ITV: A User's Guide to the Technology*, The Washington, D.C.: The Corporation for Public Broadcasting, 1979.

[26] The regional networks are: Eastern Educational Television Network (EEN), Central Education Network (CEN), Southern Educational Communications Association (SECA), and Pacific Mountain Network (PMN).

[27] See, for example, Ned White, *Inside Television: A Guide to Critical Viewing*, Palo Alto, Cal.: Science and Behavior Books, 1980. This course for high school students is intended to teach critical viewing skills. It was produced by the WGBH Educational Foundation and Far West Laboratory for Educational Research and Development.

[28] For descriptions of two communities' involvement with two-way communication for educational purposes, see Robert J. Cooley,

Because cable systems are franchised by local government, the terms of agreement may include the installation of cable service in public schools at little or no cost to the schools. Thus, the cost to schools for establishing or increasing their access to television programming by using cable is relatively low, perhaps the least expensive of all television delivery system.[29]

Instructional Television Fixed Services (ITFS). Instructional Television Fixed Services is a type of over-the-air transmission system designed specifically for delivering instructional programs to schools and other groups. Its advantages[30] include:

- The ability to transmit up to four channels simultaneously, thus serving the needs of more than one school. (Cable has this capacity as well.)
- The ability to provide round-the-clock services.
- Variety in choice of programs.
- The ability to repeat programs.
- Flexibility of scheduling.
- Relatively inexpensive operating cost.

The major disadvantages of ITFS are the high capital costs of equipment installation and the complexity of FCC licensing procedures, which probably account for its limited use (three percent) in the nation's schools.[31]

Because ITFS has multiple channel capacity, it can target its programs to the needs of specific learners. For example, an ITFS system can offer seven programs daily for fourth grade students, using its other channels for other grade levels.[32] In comparison, public broadcasting, which has only one channel, must diversify its program offerings to try to meet many needs.

Video tapes and cassettes. The second most common source of programming after public television is in the form of tapes or cassettes. Schools may buy cassettes from the government's National Audio-Visual Center in Washington, D.C., the Agency for Instructional Television, the Public Broadcasting Service, the Great Plains National Instructional Television Library, ITV Co-op, and commercial companies and may record programs off the air. (There are a number of restrictions regarding the duplication and classroom use of both television and radio programs about which administrators and teachers should be aware. These are described in detail in Chapter VI.) The ability to record television programs has freed teachers and students from rigid broadcast schedules. Not only can teachers choose the time for the presentation of the program, but also the way in which the program is viewed, i.e., all at one time or in segments, with no repeat or many repeats, either whole or in part. Because it has been recorded, the program is available for viewing by individuals who may have missed the original presentation or who wish to see it again.

Increasing numbers of programs are being prerecorded on cassettes. Selected programs are captioned for hearing-impaired users. Computers can now be linked to video cassette players, as they can to videodiscs, enabling the presentation of instructional material that is determined by the student and appropriate to his or her responses and needs. Thus, the material that appears on a conventional television screen is the result of communication between the student, a computer program, and a video cassette (or videodisc) player.[33]

The popularity of video cassettes in the home market can be attributed to their ability to record television programs off the air. This capability makes them attractive to educators as well since it allows them to use programs at the time of their choosing. Prerecorded cassettes on music, film, and instruction are also available for purchase or rental to schools as well as the home consumer.

Videodiscs. As discussed earlier in this chapter in the section on computers, videodiscs are one of the most exciting technologies to be developed in recent years. They have the ability to give students access to a large amount of information, from which they can select the items of most importance to them. Students and teachers can also control the sequence of information they wish to access and the rate at which it is presented.

"A Tale of Two Communities," *Instructional Innovator*, February 1981, pp. 26-29.

[29] Educational Policy Research Center, *Instructional Television: A Comparative Study of Satellites and Other Delivery Systems*, Syracuse, N.Y.: Syracuse Research Corp., 1976, pp. 17-18.

[30] Samuel J. Sauls, "ITFS and Broadcast ITV-Competition or Symbiosis?," *E&ITV*, October 1979, pp. 8085.

[31] Dirr and Pedone, *op. cit.*, p. 9.

[32] Sauls, *op. cit.*, p. 82.

[33] James J. L'Allier, "Some Basic Questions About Interactive Video," *E-ITV*, June, 1981, p. 30.

As noted above, few, if any, videodiscs designed for classroom use now exist.[34] During the 1982-1983 school year, however, an educational videodisc program will become available for upper elementary and junior high use. This program, *ABC/NEA SCHOOLDISC*, was developed by ABC television and the National Foundation for the Improvement of Education, a creation of the National Education Association (NEA).

At the heart of the SCHOOLDISC programs is student-teacher interaction, rather than student-machine interaction which might have been emphasized if the system had been integrated with computer technology, a decision which would have involved higher development and production costs. The ten one-hour programs enable the teacher to select as many or as few topics as he or she considers relevant, to stop and start programs at will, and to branch as student needs require.[35] The SCHOOLDISC programs deal with science, math, language skills, social studies, the arts and current events. For teachers, there is a program on trends in education as well as supplemental printed teaching guides. In the future, NEA and ABC will be collaborating again on the production of discs for the lower elementary grades. Other commercial and non-profit groups are likely to be involved in their own developmental efforts in the near future.

Satellites. Although not a source of programming, satellite transmission is another instructional television option. Satellites deliver television signals over long distances, thus providing transcontinental and transoceanic coverage. While this capability can add to the variety of basic skills and other instructional programs available, satellites operate on a broadcast schedule which limits flexibility. This problem can be remedied by recording broadcasts on videotape or cassette.

Satellite systems are the most expensive instructional television delivery system to install. Linking up with a satellite requires large capital expenditures for transmission and reception equipment, and, in addition, operating costs are high. There is a monthly charge for renting time on a satellite plus the costs of operating the transmission facilities.

As we have seen, every television programming source has its own technical advantages and limitations. In spite of these differences, they share educational capabilities which include:

- Good sound, motion, and color capabilities.
- Dramatic capability.
- Immediacy in viewing current events.
- Stimulation of creativity in students, e.g. writing stories based on characters or events seen on television.
- Stimulation of reading, e.g., some teachers have found that a television program, such as *Little House on the Prairie*, can stimulate a desire to read the book on which it is based or to learn more about the program's subject through reading.[36]

Like other media television is a good mechanism for developing students' prediction skills (e.g. What do you think will happen to the Incredible Hulk next?), sequencing, and comparison skills (How is the Incredible Hulk like Batman?).[37] The fact that students are so familiar with television can be used to unique advantage in building problem-solving and critical skills.

Limitations

Although the technologies described above have greatly improved the instructional capabilities of television, disadvantages remain.

Television programs are still designed for the "average" student. Students who wish an easier or a harder version of the material will not have access to it.

Most instructional programs continue to treat students as passive recipients of instruction. To date, television has been used too often as a one-way medium. The integration of videodisc systems with computer technology promises to counter that limitation by enabling students and videodisc systems to interact.

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[34] Ken Winslow. "Videodisc Systems - A Retrospective," *E-ITV*, March 1981, p. 38.

[35] Telephone conversations on August 4 and August 31, 1981, with Jack H. Kleinman, Executive Director of the National Foundation for the Improvement of Education, a non-profit, tax-exempt foundation created by the NEA.

[36] Rosemary Lee Potter. "Using TV to Teach Thinking Skills," *Today's Education*, Sept.-Oct. 1980, p. 54.

[37] Potter, *supra*, p. 53.

Videodisc technology has limitations. At present, videodisc systems have no recording capabilities, and, as a result, their content cannot be altered by the user. However, with a computer-videodisc combination, each of the 54,000 individual pictures stored on a disc can be presented in any order and at any rate of speed that the user selects. The integration of the two technologies provides limitless flexibility.

A second, more technical, problem with videodisc systems is that in their present stage of development they loose sound when the disc is played at still frame or slow motion. Thus, if a student wishes to study one frame, no sound will accompany the picture.[38]

Neither videodisc nor cassette systems are necessarily compatible which may mean that a videodisc or cassette produced for use on one player cannot be used on another. Administrators should determine the compatibility of various systems before making a purchasing decision.

Although broadcast television is without parallel, except for motion pictures, in producing well-designed, colorful, and attractive programs for educational use, the lack of similar materials for videodiscs at the initial stage of development poses a limitation for the education user. Increased demand for a variety of materials of high technical quality will fill this gap.

Issues for Administrators

The major constraint in using television as a basic skills instructional medium in the past has been the control exercised by broadcasters over broadcast schedules. Because new copy technologies, i.e., cassettes and videodiscs, have the capabilities of overcoming this limitation, administrators must decide whether to invest in video cassettes or to wait until a variety of videodiscs with good instructional materials are available on the market.

Video cassettes enable teachers to tape programs from their television sets and use the programs in their classrooms when appropriate. Videodiscs have no recording capabilities. Cassette tapes are not as durable as videodiscs. Videodiscs appear to have more advantages than either television or microcomputers standing alone by combining the best of both technologies, but it will take time for a wide variety of good videodisc programs to become available for educational uses.

The second major issue is that of copyrights. A real problem for administrators is that broadcasts can be copied easily on video cassettes without regard to copyrights. Readers should refer to Chapter VI for a discussion of copyrights, and, in any case of doubt, contact the office in the state agency that is responsible for collecting and disseminating information on recording rights.

Calculators

As calculators have steadily decreased in cost and increasing numbers of people use them in their businesses and homes, they have also been making their way into classrooms. At first they were unofficially introduced to schools by students bringing them from home;[39] since 1975, however, educators have begun to pay serious attention to their use in school programs. Mathematics teachers have been in the vanguard of this examination.

Mathematics teachers were among the first educators to realize that calculators could save time on computations, thus freeing students to concentrate on problem-solving, measurement, estimation, and other mathematical competencies. These teachers question the high priority that is traditionally given to computation and the low priority given to other mathematical skills and believe that the use of calculators for computation would permit concentration on conceptual skills.[40] Teachers from disciplines other than mathematics, particularly on the high school and college levels, usually support this position, preferring that their students focus on problem identification, analysis, and solution rather than on numerical calculations. This

[38] Blizek, *supra*, p. 43.

[39] It has been reported that 75 percent of the 9-year-olds, 80 percent of the 13-year-olds, and 85 percent of the 17-year-olds own their own calculators or have one available for use. See Marilyn N. Suydam, *Using Calculators in Pre-College Education: Third Annual State-of-the-Art Review*, Columbus, Ohio: Calculator Information Center, August 1980, p. 3.

[40] Arthur Kessner and Twila Slesnick, "Myths about Calculators in the Schools, *Calculator/Computer Magazine*, Sept./Oct. 1978, p. 78. According to Kessner and Slesnick, children spend 75 percent of their first seven years of mathematics instruction learning and relearning the procedures necessary to do addition, subtraction, multiplication, and division computations. They spend the remainder of their time on all the other mathematics skills.

support assumes that mathematics is not only calculation but includes the "basic skills" of problem-solving, estimation, functions, graphs, measurement, and simple statistics.[41]

Reactions to the use of calculators for instructional purposes have not been uniformly positive, even among teachers.[42] Some are opposed to all uses in school. Others would prohibit use by children in kindergarten through the third grade and restrict usage thereafter. According to a 1981 report on a survey conducted by the Priorities in School Mathematics (PRISM) project,[43] mathematics educators are, not surprisingly, more favorable toward increased use of calculators than any other group sampled, and parents seem to be the least favorable. For the school administrator deciding whether to purchase calculators for basic skills teaching may involve working with both teachers and parents to come to an agreement.[44]

Capabilities

For the basic skills teacher, two types of calculators can be considered. (A third type, scientific calculators, which are appropriate for advanced studies in high school and colleges, are probably too sophisticated for the basics skills learner.) One of these types is the **simple three- or four-function calculator.** The three-function calculator performs addition, subtraction, and multiplication; division is included in the four-function. The simplest calculators have decimal point, equal sign, and clear keys. A clear entry key is also useful, as is a memory register where a number can be stored while the calculator is performing a computation. The stored number can then be retrieved, displayed, and used in subsequent calculations.

The second type is the **programmable calculator,** which usually has the features of the four-function calculator plus a drill and practice capability. Like computers programmed for drill and practice, these calculators[45] present computation problems, such as 5+7=?, students push the keys indicating their answers, and the display indicates whether their answers are correct. The most simple of this type of calculators is preprogrammed by the manufacturer. The more sophisticated allows teachers to program exercises.

Calculators of either type are used to develop the more basic computational skills which consist of:

- Communication with and about numbers. For students who do not have fine motor skills, a calculator can serve as a writing tool.
- Counting
- Number recognition
- The concept of one-to-one correspondence
- The concept of "between"
- The concept of numbers before and numbers after
- The concept of numbers greater than, less than, and equal to.

Although these basic skills are relatively easy to teach with calculators, there is more controversy about using calculators to teach these than there is about using them to teach more advanced concepts in later grades. It appears from the PRISM study that there is relatively little argument about whether to use calculators with college or even secondary students. On the other hand, people are less ready to accept calculators for elementary school teaching.

Limitations

Like computer courseware, instructional materials for use with calculators in basic skills education have been not available, inadequate in quality, or not integrated into the curriculum. While good materials are becoming more available every year, they are still scarce and often deal only with a specific topic, such as functions or exponents. Some materials provide rows and columns of numbers for students to add, subtract, multiply, or

[41] *Report on the Conference on Needed Research and Development in Hand-Held Calculators in School Mathematics*, sponsored by National Institute of Education and National Science Foundation, undated, p. 6.

[42] Kessner and Slesnick, *op. cit.*, p. 78.

[43] National Council of Teachers of Mathematics (NCTM), *Priorities in School Mathematics Project: Executive Summary*, Reston, Va.: National Council of Teachers of Mathematics, 1981.

[44] Administrators will probably encounter more resistance from parents, teachers, and others to the incorporation of *calculators* in the curriculum than they will to the use of computers for instructional purposes, according to the PRISM study.

[45] Theresa Denman, *Calculators in Grades K-3: Why? What? How?*, Calculator Information Center, Bulletin No. 6, Columbus, Ohio, January 1979, p. 2.

divide. This kind of material is obviously not very useful or rewarding to the student.

Another factor which limits the use of calculators is teacher acceptance. Similar to the situation with computers, although for different reasons, a few teachers feel that calculators should be banned completely from the classroom. Those who support the use of calculators do so only for limited purposes. The PRISM project[46] found support for the use of calculators was in most cases limited to checking answers and doing chains of calculations. There was some support for including the solution of word problems and equations, homework, development of ideas and concepts, and most computations. On the other hand, there was practically no support for the use of calculators for learning algorithms; teaching slower students; learning facts about numbers; and taking tests. Thus, a major limitation is based on theories and beliefs about learning. It appears that we must know more about how people learn mathematics, whether they learn the concepts that lie behind mathematical operations or just the computational mechanics and whether calculators can help teach those concepts, before a judgment can be made about the best use of calculators.

Issues for Administrators

In deciding whether to integrate calculators as aids to classroom instruction, administrators should consider three questions:

- What should mathematics basic skills be? Should they focus on computation or move beyond that to include estimation, problem-solving, measurement, and the like?
- Should calculators (or computers with calculator-like capabilities for that matter) have any role in teaching basic skills?
- If so, which skills should be learned using calculators? And, at what point in the mathematics learning process should calculators be introduced?

Because the answers to these questions should reflect the goals of the community, information about the strengths and limitations of calculator use should be distributed to teachers, parents, and other members of the community. If a decision to use calculators is made, it will be relatively easy to determine the kind of calculator to purchase and to arrange for their maintenance and safe-keeping. Similarly, training teachers on calculator use can be short and inexpensive. Thus, unlike computers, television, and visual aids for which questions regarding cost, maintenance, repair, and teacher training are more troublesome, the key issue in deciding about calculators is a pedagogical one.

[46] NCTM, *op. cit.*, pp. 30-31.

Other Electronic Learning Devices

Hand-held electronic learning devices, other than calculators discussed above, use some of the same teaching techniques as other media, most notably drill and practice and games. Because these devices are inexpensive, as compared to the "big media" described in earlier sections of this chapter, they may be considered by decision-makers as a substitute for some of the functions of computers and perhaps instructional television.

The simplest hand-held electronic learning devices are limited to drill and practice of elementary arithmetic computation skills. The device presents a problem which the student answers by punching in a number. The device responds to the student's answer by presenting another problem if the answer is correct or repeating the same problem if incorrect. After a predetermined number of incorrect answers, the device shows the correct answer and moves to a new problem. At the end of a predetermined set of problems (usually 10) at the same level of difficulty, some devices tell the student his or her score.

The same kind of simple technique is used in devices that develop spelling and writing skills. Some have voice synthesizers that correctly speak a word under study for the student to check his or her own response. (A popular example of this kind of device is Texas Instruments' "Speak and Spell.")

Other, more sophisticated, devices are intended to develop students' problem-solving skills, such as sequencing, logical thinking, and estimating. For example, a programmable toy called "Big Trak" requires students to move the "Big Trak" robot wherever the student wishes it to go. The student must use his or her knowledge of numbers, computation skills, and understanding of direction to get the robot to perform.

There are other devices that require students to use their manual and/or problem-solving skills to win a game. Many of these games are computer-based; older students may be familiar with playing "Star Trek" and similar games in movie theatre lobbies or at home.

Capabilities

Well-designed programs for electronic learning devices which use the game technique have three elements[47] in common:

- *Challenge.* To be successful, or to win, the student must reach a specific goal the attainment of which is uncertain when the student begins the program.
- *Fantasy.*[48] Mental images that can not be sensed or that are beyond the experience of the person involved. The program must have some element of fantasy in which students picture physical objects in their heads or make believe that they are someone whom they are not (e.g., ruler of a kingdom).
- *Curiosity.*[49] Games which arouse students' curiosity by building in elements of novelty and surprise are most successful.

These elements must be reinforced with immediate feedback to the student.

Advantages of well-designed programs include:

1. The student's privacy can be respected without much difficulty since the student can interact with the device only and not teachers or other students.

2. They provide variety. A number of different problems can be programmed so that, while the student is using the same skills, he or she is dealing with different content each time.

3. They are highly motivating because they contain elements of challenge, fantasy and curiosity.

4. Finally, hand-held devices are relatively inexpensive.

Limitations

One of the most obvious limitations is that the hand-held devices can be used by only one (in some cases two) student at a time. Also, on most devices under $100 the levels of difficulty or the particular problem sets are programmed into the machine by the manufacturer. If they do not match a student's particular math problem or are different from the reading/spelling vocabulary used in a school's curriculum, there is nothing one can do. It is not unlikely that inexpensive machines with more flexibility will be developed in the future, but at the moment this inflexibility may be considered a disadvantage.

Hand-held devices programmed for arithmetic drill and practice usually present arithmetic symbols and make no connection between the symbols and the operations or sets of objects that they represent. If teachers are not alert to this problem, students will memorize the patterns in the program and then will not know the meaning of the operations represented by the symbols or how to figure out problems that are not in the program.

Issues for Administrators

Because the capabilities of the best programs for hand-held learning devices are present in microcomputers, one of the first questions an administrator has to deal with is whether to invest in these devices which have a limited purpose or to apply funds to the purchase of computers. In schools that have computers for instruction, administrators might encourage the full use of their game capabilities.

Administrators should also investigate the extent to which students play video games or games such as "Speak and Spell" at home. Since many of the games available today were initially intended for the home consumer, students may not find them as interesting or as motivating as computer games or other educational media to which they have not been exposed.

Finally, if a decision is made to investigate hand-held learning devices further, the wise administrator

[47] Thomas W. Malone. *What Makes Things Fun to Learn?: A Study of Intrinsically Motivating Computer Games*, Palo Alto, Calif.: Xerox Palo Alto Research Center, August 1980, p. 49 *et seq.*

[48] Malone, *supra.*, p. 56.

[49] Malone, *supra.*, p. 5.

will examine the motivational capabilities of their programs, their durability, and the extent and quality of their feedback.

Audio-Visual Media

The audio-visual media have traditionally had value as adjuncts or aids to a teacher's instructional program. We deal with them in this guide because they are generally part of the delivery system repertoire which schools have available and should be considered as viable resources by administrators making decisions about the acquisition and use of other, newer technologies. They perform some instructional tasks, such as presentation of information and drill, as efficiently as any other system and thus a decision to substitute them with other media should not be made without considering its cost and educational impact. Audio-visual media include audio devices (records, tapes and radio), still pictures (opaque projections, overhead transparencies, slides), and moving pictures, (filmstrips and movies). These are the "little media" for which Wilbur Schramm makes a convincing case in his book, *Big Media, Little Media.* Instructional television and other "big media" are reviewed in previous sections of this chapter.

Capabilities

Audio media, such as radio broadcasts, records, cassettes and tapes can provide an almost infinite variety of content from music and drama to instruction on the pronunciation of vowel sounds. Still or moving projected images, or visual media, are similarly versatile in contents, providing, for example, graphic illustrations of sentence or mathematical concepts, animation for vocabulary building, and instruction on word order. Audio-visual media in combination can catch the imagination through color and sound and can make new ideas, current events, and information about the world and universe accessible to students.

Although the needs of the student population are, as always, the key determinant in making a good selection, audio-visual media have inherent qualities about which the teacher and administrator should be aware.

- Because most audio-visual materials can be previewed by the teacher or administrator, their authenticity of content, understandability of presentation, absence of stereotyping, and appropriateness to educational goals can be determined before exposing students to them. The opportunity to preview materials, the case with most media, is obviously important to teachers.

- Operation of audio-visual equipment in class is usually directed by the teacher. While students may operate the equipment, it is under the control of the teacher, who may stop the machine at any point to discuss a concept, to review, or to give students an opportunity to practice skills. Similarly, the teacher can turn off the soundtrack and make his or her own presentation to accompany the pictorial representations.

- Audio-visual media give students someone other than the teacher to listen to and something other than printed material to look at and thus add variety to instructional programs. Visual media add color and motion to the classroom, unequaled by other media except television and computer-videodisc systems. They offer new sounds and sights to students and take them vicariously to places they've never been.

- Like other media, audio-visual media allow the teacher to bring into the classroom scientific, social or other phenomena which could not be demonstrated or experienced otherwise.

- Audio-visual media are conducive to use with groups. All members of a class or another large group can focus on one screen or one sound; and all are involved in the same audio or visual experience. The sharing of an experience can promote the sharing of ideas as students respond to and discuss the event. Interaction with peers and teachers is an important element in developing communication skills which the appropriate use of audio-visual media can provide.

- The availability of rear screen projectors for film and filmstrips, headphones for radios and record players, and 8mm films which miniaturize motion pictures has meant that the needs of small groups and individuals (for example, handicapped students) can be addressed.

- Traditional audio-visual equipment is inexpensive as compared to some emerging technologies and, used singly or in combination with other audio-visual media, can be as effective as big media in filling certain instructional functions. Limitations in the amount and quality of instructional materials available for new media and the relatively good quality of audio-visual materials may make audio-visual media the preferred media for a school district.

Because audio-visual media are familiar to most teachers, are relatively easy to operate, and offer instructional flexibility, many administrators have chosen to rely on them as the major component of their schools' media capability. As with other types of technology, however, the potential of audio-visual media has not been fully realized. In too many cases, attention is paid more to the input, i.e., the medium, than to the outcome, i.e., what students are expected to learn. Thus, educators cannot tell whether students have succeeded, what they have learned, and whether the medium had anything to do with the success or failure.

The quality of available materials is the other major variable in the effective use of audio-visual equipment. The difficulty for teachers and administrators is not a lack of materials but in selecting from among the large number that is available. This important topic is discussed in Chapter VI.

Limitations

Although audio-visual media have the potential of serving many educational purposes, they have drawbacks as well. As with other media, most of these drawbacks are a function of uninformed use rather than an inherent problem with the media. Among limitations of this kind are:

- Failure to match a medium with specific teaching objectives and with student learning needs. A medium selected on any basis other than its ability to contribute to the achievement of a specific learning objective will be limited in the effects it produces.

- Failure to take advantage of audio-visual media, such as audio-cassettes, filmstrips, and slides, that can be operated by students. Some schools have media centers which are set up for students to operate the equipment themselves and many audio-visual materials are designed for individual student use. In many instances, however, teachers use audio-visual media only for large group presentations. While large group work has an important place in education, students also need to control the presentation of material, its pace, its sequence, and content.

- In many school districts, especially large ones, audio visual materials must be ordered from a central facility. Because a number of teachers may want a particular film at the same time, it may not be available to a particular teacher at the optimum time in the course of instruction. As with many other media, scheduling for use can be a real problem.

In addition to the limitations which arise from improper use or from operational difficulties, audio-visual media are limited in their ability to provide individualized feedback or direct reinforcement to the student on his or her performance. Audio-visual media can only present information and ask questions. Responses of the student must be judged by the teacher.

Issues for Administrators

Most schools today have some audio-visual equipment available; for example, it is not uncommon to find an overhead projector in most elementary classrooms in a school district. Many schools have at least one motion picture projector on the premises; some have a full complement of equipment including record players, cassette and tape recorders, opaque, overhead and slide projectors. The typical problem for today's administrator is not, therefore, whether or not to acquire audio-visual equipment but, rather, how to ensure that the equipment is used.

A radical decision to discard school equipment is not likely to be received with favor by teachers, school media specialists, school board members, or community members. Such a decision is neither necessary nor advisable in situations where inefficient use can be attributed to mechanical breakdown, poor scheduling, or inaccessibility of equipment. Most frequently, the capabilities of the media are unknown to teachers and for that reason have not been realized.

Understanding that the educational use of audio-visual media may be limited as compared to newer technologies with respect to student control and responsiveness to student performance, the major issue for administrators is whether their school should:

- Expend resources to ensure that existing audio-visual equipment is repaired, accessible and used to its fullest capacity;
- Expend resources to train teachers in the instructional uses of audio-visual media;
- Expend resources to acquire more audio-visual equipment; and/or

- Replace or supplement existing equipment with newer technologies that offer a broader range of educational uses.

Summary of the Contributions of Technologies to Effective Learning

Each of the five technologies described in this chapter has capabilities that can contribute to basic skills learning. Each also has limitations, either technically, practically, or pedagogically. It is unlikely that administrators who wish to enhance their schools' current educational capabilities will consider, or select, one medium and ignore the others. Rather, they will attempt to plan an educational program which is a complement of different technologies. Although the realization of the plan may take a number of years, the more administrators know about the present and predicted capabilities of each technology, the more likely it is that their plans will be fulfilled. In this section we review the impact of the media systems examined in this chapter on the characteristics of effective learning situations described in Chapter III.

On Meeting the Current and Changing Interests, Needs, and Abilities of Individual Students

Media which operate at an individual learner's pace and respond directly to the student's input save both the student's and the teacher's time. At the present time, no media can replace the capability of teachers in this regard, although computers have the potential in specifically defined areas.

On the other hand, any medium at any given point in the learning process, can meet an individual's needs. For example, a filmstrip on a subject of particular interest to a student can fulfill this goal. For a student with a hearing impairment, media which rely on visual images to transmit content will meet at least one of that student's needs.

On Involving Students Actively in Learning

Computers have the potential for making the most significant impact since they can be controlled by the learner if programmed to do so. Media that rely on a passive learner or audience of learners, like film and conventional television, are limited in this respect.

On Promoting Interaction with Others

A good teacher can ensure that any media is used to promote human interaction. Media that are particularly conducive to this use include film, television, and other audio and visual media which are usually shared by a group of learners. Although most computer-assisted instruction promotes student-computer interaction, computers with an electronic mail capacity can also serve as a vehicle of communication for students and teachers.

On Providing a Variety of Techniques and Materials

One of the major purposes of using media is to add variety to the repertoire of teachers. Types of media that offer the most variety in terms of instructional techniques are computers and videodisc-computer combinations.

On the Design of Interesting and Stimulating Materials

Just as media add to the variety of learning experiences available to students, media can enable teachers to add interest and stimulation to the classroom. Whether they actually do so depends on the design quality of the materials.

On Providing Feedback to Learners

Computers can have the most impact with respect to this ingredient since they extend the teacher's

ability to provide relevant feedback to every individual. No other media has this power.

On Providing Opportunities to Practice a Skill Until It is Mastered

Teachers cannot always give students the individual attention they need to master a skill. A tireless tutor like the computer is the best media to fulfill this learning function because it can be designed to change the material presented to the learner or the sequence in which it is presented to meet the individual's needs.

In weighing the impact of a medium on learning, the decision-maker is likely to find that computers have the greatest potential, to date unrealized, for meeting teaching goals. Little of the potential will be realized unless program designers and teachers deliberately build these capabilities into the system. None of these attributes are inherent in any teaching situation; they must be explicitly planned for and adopted. Such planning takes a good deal of time, more than preparing a traditional education program.

V. Assessing the Impact of Technology on Education*

Chapter IV described the capabilities, educational uses, and limitations of five types of media and summarized the issues connected with each type that will be of most interest to school administrators. This chapter assesses the impacts that media have on students, teachers and administrators, noting the differences among media that may affect decisions about their use. Although every school district will base its decisions on its own current needs, available resources, and future plans, the authors hope to contribute to the process by examining short- and long-term impacts of decisions.

What Achievement Gains Can Our Students Make with Media?

It is hard to imagine a medium that does not add something to student achievement, at least temporarily. New equipment or material often has the effect of increasing student interest in instructional content simply because it is new. Once the novelty wears off[1] however, both students and teachers can lose interest and the innovation fade from neglect, if no efforts are made to integrate it into the educational program or to involve students in its use.

The type of measurement used to assess the impact of media on student achievement differs among researchers. Measures have included comparative test scores, amount of time to complete a course or instructional module, and degree of retention of learning. Some researchers also include in their studies evaluations of changes in student behavior or student attitudes toward the medium under investigation. Although it is difficult to summarize the findings from such studies, those writers who have attempted it believe that the studies have shown no significant difference in learning when a medium is used as compared to teacher instruction and no significant differences between media.[2]

1. *Test scores.* Use of media for instruction has resulted in improved scores or in no significant differences when compared to scores of students not using media. However, findings based on the use of standardized tests may be questioned, as should the appropriateness of the comparison measure. For example, is it more appropriate to compare experimental group scores to the scores of a control group or to the same learners' scores when they were not using the medium?[3]

2. *Learning time.* Most studies have shown that the use of computers has resulted in more rapid mastery of skills, usually expressed in terms of progress in grade level for each month or year of computer use as compared to progress with no computer use. The advantages of any saving in time are: a) that it allows students to move more quickly to new subject matter and new skills, b) that it helps slower students reach grade level more rapidly, and c) that such gains improve the self-concept of student who may have had a history of falling behind their classmates. Claims regarding reduced learning time should be

*This chapter was developed in part by **Kenneth L. Modesitt**, Ph.D., Corporate Education Director, Texas Instruments Inc., Dallas, Texas, and **Frank DiGiammarino**, Ph.D., Director of Planning and Computer Services, Lexington Public Schools, MA.

[1] It should be noted that the fascination of using computers as an aid to learning "appears to last for months and years, rather than days and weeks." Frederick H. Bell, "Can Computers Really Improve School Mathematics?," *Mathematics Teacher*, May 1978, pp. 431-432.

[2] Reviews of effectiveness studies appear in Ludwig Braun, "Computers in Learning Environments: An Imperative for the 1980s," *BYTE*, July 1980; Marilyn Suydam, "Using Calculators in Pre-College Education: Third Annual State-of-the-Art Review," Calculator Information Center, August 1980; James A. Kulik, Chen-Lin C. Kulik, and Peter A. Cohen, "Effectiveness of Computer-Based College Teaching: A Meta-Analysis of Findings," Center for Research on Learning and Teaching, The University of Michigan, May 1980; and Wilbrum Schramm, Big Media, Little Media, Beverly Hills: Sage, 1977.

[3] Robert J. Seidel, "It's 1980: Do You Know Where Your Computer Is?," Alexandria. Virginia: Human Resources Research Organization, March 1980, pp. 6-7.

examined closely to determine whether there has been significant gain, since we should expect students to make one year, or month, of progress in one year, or month, of work, irrespective of the use of media.[4]

3. *Course completion.* This measure, which obviously is most appropriate for students who are not required by law to attend school or complete a specified course of study, is used on the theory that if students are in school, they are learning. Thus, a reduction in attrition should mean an improvement in student achievement. Such a reduction might also mean that students are enjoying the course more, which, if a lasting phenomenon, should contribute to achievement. On the other hand, a *high* attrition rate could mean that the student population is transient, moving from one school to another constantly, and have little to do with instructional techniques. Additional data would be necessary to show a correlation.

Studies that measure retention and transfer of learning, changes in student behavior, and changes in student attitude about the medium under study have been less common than those mentioned above, although there is some data showing that retention rates of material learned by means of computer may be lower than by traditional means.[5] To balance that finding, the use of computers seems to improve student attitudes toward computers both as instructional media and as tools for solving problems outside of the school setting.[6] One study,[7] however, found that student attitudes about computers were not positive and course completion rates dropped when there was little or no personal interaction between students and teachers.

Qualitative measures, such as teachers' opinions on student achievement and student involvement in learning activities, are also used in determining the impact of media on achievement. These kinds of information are generally available when quantitative data may be lacking or questionable.

Since student achievement may not be the most important, or only, criterion for the district, other factors that may be examined are discussed below.

What New Skills and Knowledge Will Our Students Learn with Media?

It is generally accepted that media add variety and interest to conventional instruction, but their potential for improving education is much greater. Some scholars attribute the failure to realize that potential to the inclination of people to couple new technology to old purposes rather than using it to accomplish new ones. Thus, while the use of media may be resulting in gains in student achievement, its potential for adding new skills to the curriculum, for changing teaching approaches, and for transforming learning has not been reached.

The LOGO experiments at the Massachusetts Institute of Technology, at the Lamplighter School in Dallas, Texas, and other elementary schools are good examples of the efforts being made to replace old methods of mathematics and language instruction with something quite different. The LOGO approach is to try to make the processes used in computers as clear as possible to students and to create activities in which children teach or program a computer rather than vice versa. LOGO researchers are finding that students who are put in control of their learning are becoming adept in skills such as geometry and writing more quickly and solidly than students who do not have this opportunity.[8]

[4]Seidel, *supra.*, p. 5.

[5]Chambers and Sprecher, *op. cit.*, p. 336.

[6]Chambers and Sprecher, *supra.*, pp. 335-336.

[7]A study of the TICCIT project in which entire mathematics and English courses in a college and a community college were conducted with computers. Reported in Chambers and Sprecher, *supra.*, p. 336.

[8]See Seymour Papert, *MINDSTORMS: Children, Computers and Powerful Ideas*, New York: Basic Books, 1980; and Coleta Lou Lewis, "A Study of Preschool Children's Use of Computer Programs," *National Education Computing Conference Proceedings*, 1981, pp. 272-275.

What Impact Will Media Have on Student Attendance, Attrition and Absenteeism and on Our Ability to Serve Individuals Outside the System, Local Government, and Business?

Taxpayers feel that the public facilities and equipment for which they pay should be used to their fullest capacity and produce results. These concerns mean that administrators are increasingly being called to account for the productivity of their institutions. When considering the purchase of educational media, one question to be asked is "What, if anything, will this medium add to our productivity?"

As described above, there is evidence to support contentions that the effective use of media increases student interest and motivation and that interest and motivation have a direct effect on attendance[9] In short, students who feel they are learning tend to come to school. Whether the use of a medium will, *by itself*, increase attendance, especially over the long term, is open to question. Research[10] indicating that dropouts are more common where interactions between students and teachers are infrequent or non-existent leads us to believe that the use of media *alone* will not have any lasting educational effect.

The impact that media can have on increasing the productivity of school system facilities is much clearer.

Within a school system, computers purchased for instructional purposes can be used in guidance and counseling, personnel, financial accounting, record-keeping on courses, energy use control, state and federal reporting, and longitudinal research. Schools also increase the use of their computers, television facilities, and other media capabilities by offering services to non-students. Such uses include:

- Adult education
- Continuing education
- In-service training for service providers, such as nurses, physicians, as well as teachers
- On-the-job training
- Workshops for individuals who own personal computers
- Computer time during non-school hours and weekends for the general public

School systems have also afforded libraries, local government agencies, businesses, clubs, and other organizations the use of their equipment. Many public schools share facilities with other school districts or educational institutions, including universities, colleges, private and parochial schools. Sometimes computers intended for instructional use become so popular with administrators and other users outside the school that there is no time for student use!

Almost all of these activities have cost, as well as public service, implications since sharing use usually means sharing costs. Consideration of these non-school system applications could mean a significant difference in a decision to purchase especially when initial costs of facilities, equipment and installation are substantial. On the other hand, extensive use by a number of different parties for different purposes will require administration and organization and may increase maintenance costs as well.

[9] Braun, *op. cit.*, pp. 8-9 Braun cites an example of the community college in which an attrition rate of 60 percent with traditional instruction was lowered to 20 percent with computer-aided instruction.

[10] Chambers and Sprecher, *op. cit.*, p. 336; and John H. Grate, "A Systems Approach is Needed," *AEDS Monitor*, Oct./Nov./Dec. 1978, p. 17.

What Impact Will Media Have on Teachers and Other School Personnel?

Any innovation introduced to a school system is not likely to be incorporated unless it is understood and supported by those whom it directly affects. Passive resistance on the part of teachers toward new procedures, educational strategies, or teaching devices has caused the demise of many potentially good ideas and products. The experienced administrator will make every effort to prevent this by ensuring that teachers and other staff understand the capabilities and limitations of a medium and by training them in its use. All too commonly teachers use equipment for the wrong reasons in the wrong way. Result? - disappointed teachers, frustrated students, dissatisfied parents, and angry taxpayers.

Since most teachers have either received formal training in, or learned from experience about, overhead slide and film projectors and tape recorders, they are usually willing to use these kinds of equipment. Even with audio-visual media, however, teachers are not always aware of the full range of their possibilities and thus do not take full advantage of them.

The acceptance and use of newer technological media are even more problematic. Teachers who do not feel threatened by machines, particularly computers, may still approach them warily. Who among us has not, at least initially, felt reluctant to use an automatic bank teller machine for fear we will do the wrong thing and look ridiculous? Imagine being bested by a machine in front of your students! Young people, on the other hand, do not have this fear and often help their teachers through the familiarization process.

To improve the chance of success in introducing a medium to a school, the school's teachers need to understand the medium and its instructional uses and limitations and to become skilled at using it. Several authors[11] have suggested that teacher training begin by showing teachers how media can support them in the performance of specified teaching functions. A hierarchy of competencies,[12] which takes this approach into account, might include:

1. *Knowledge about the medium.* The medium's role and use in society in general and education in particular. The extent to which the medium supports the performance of traditional teaching functions.

2. *Skills in using the medium with techniques* such as drill and practice, simulations, graphic demonstrations, calculating tool, and exploration of new content or concepts.

3. *Skills in using media in the management of instruction,* including test generation, administration and scoring, student recordkeeping, and curriculum materials generation. Skills in interpreting data for purposes of diagnosis and prescription.

4. *Skills in evaluating materials:*

   - Identification of appropriate types of material to meet educational objectives and student needs
   - Assessment of materials relative to content, presentation, and technical quality

5. *Skills in adapting published material.* Understanding of copyright law as it pertains to reproduction or modification of material.

6. *Skills in designing and developing materials.*

While there probably is general agreement that teachers and other staff should attain competence in the first five categories, there is less so regarding the sixth, design and development. Many people[13] feel that the disadvantages of relying on teachers to generate their own materials, including the time required and their lack of technical expertise, outweigh the advantages of creating materials that are specifically designed

[11] Heuston, *op cit.*, pp. 16-19; and Nick Solntseff, "What Do We Tell the Administrators?," *Creative Computing*, March 1981, pp. 100 and 102.

[12] For an example of a comprehensive list of computing competencies, see Robert P. Taylor, James L. Poirot, and James D. Powell, "Computing Competencies for School Teachers," *National Educational Computing Conference Proceedings*, 1980, pp. 130-136.

[13] C. Victor Bunderson, who has developed a model for designing computer-assisted instruction programs, estimates that following his system "can require 200, 300, or more hours of work on the part of a team of authors, instructional designers, programmers, and media specialists to produce a sequence that would take an average student only one hour to complete." Cited in Alan B. Ellis, *The Use and Misuse of Computers in Education*, New York: McGraw-Hill, 1974, p. 53.

for a particular student with particular learning needs. Time devoted to materials development takes time away from critical teacher functions of evaluating, diagnosing, prescribing and instruction. On the other hand, grassroots movements initiated by teachers who have developed materials and who wish to discuss design problems and to share their material with colleagues provide evidence of the interest and knowledge that many teachers have in using technology to improve instruction. Such teachers and their organizations[14] can help administrators make decisions about the acquisition and use of media in school systems. Their support and involvement in educating other teachers can contribute to the more effective use of media in the classroom.

The requirements for teacher preparation that different types of media will demand differ mainly by degree. Preparation that exposes teachers to a variety of uses should be a part of the planning and implementation process whether film projectors or microcomputers are being acquired. Similarly, irrespective of the medium being considered, teachers need to improve their skills in evaluating the educational and technical quality of materials and in adapting materials to meet their needs. Because teachers may be both uncomfortable and unfamiliar with the use of computers and calculators for instructional purposes, preparation should be more extensive.

Although the preparation of teachers for the use of media may take place informally through the activities of teacher clubs and organizations in some school districts, most teachers will have to rely upon other sources for training. Among these sources are:

- Pre-service or continuing education courses in universities. Most universities now offer courses in the use of media in education, and some offer courses specifically in educational television, calculators, and computers.

- Courses offered by professional organizations, such as the Association for the Development of Computer-based Instructional Systems (ADCIS), Association for Educational Data Systems (AEDS), Association for Educational Communications and Technology (AECT), Society for Applied Learning Technology (SALT), and the Calculator Information Center.

- In-service training by state education agencies and groups, such as:
  - The Oregon Council for Computer Education
  - Minnesota Educational Computing Consortium
  - Region IV Education Service Center, Houston, Texas
  - New York State's BOCES system

- In-service training by equipment manufacturers or distributors. Manufacturers and distributors may include training of customers as part of a purchase agreement.

In-service training should both precede and accompany the introduction of a new medium to a school if its full benefits are to be realized.

What, if Anything, Will We Have to Do to Accommodate a Medium?

The introduction of any innovation or new equipment into a school or classroom has an impact on management. In assessing different media for installation in a facility, it pays to consider any disruptions they might cause and plan for these changes before making a purchase. Among the accommodations that may have to be made are building renovations, provisions for equipment and material storage, scheduling use of equipment, provision for moving equipment or students, provision for down-time and repair, and increasing security.

Changing School Buildings

Of the types of media reviewed in this book, only television and computers involve significant environmental changes. Requirements placed on the physical plant might include:

[14] See, for example, Tim G. Kelly, "A Grassroots Approach to Teacher Training: the Oregon Council for Computer Education," Topics in Instructional Computing, pp. 47-53. In a report to the Northeast Regional Education Planning Project on "Applications of Microprocessors in the Schools" (May 15, 1980), Technical Education Research Centers, Inc., listed 20 organizations in the northeast region which were involved in materials sharing at the time of the report.

- Changed or increased electrical power which in turn may require the installation of new power lines or a separate service box. Voltage surges can destroy a computer's memory. To avoid this loss, programs should be copied on several discs and a printed copy of the program should be kept in a separate file.
- Modification of walls, ceilings or floors to increase a room's capacity to hold heavy equipment, to install power lines, or to install air conditioning. Heat can destroy the memory in a computer program.
- Installation of coaxial cables and outlets or new telephone lines.
- Installation of some means of discharging static electricity.

Provision for Equipment and Material Storage

Many schools set aside a storage room for equipment to keep it secure and clean. When equipment, such as calculators, are kept in the classroom, dust covers or some other means should be used to keep them free from chalk dust and other harmful substances. Whether in a central storage area or the classroom, a check-out system should be instituted to keep track of the equipment. Similarly, systems for storing, cataloguing and locating materials need to be set up.

Scheduling Use of Media

Few schools can afford to provide every classroom or every student with instant access to equipment whenever desired, with the possible exception of calculators which are inexpensive enough to provide every student. Scheduling has for some been one of the major drawbacks to the use of television. The advent of video tape and videodiscs has mitigated this problem to some extent although administrators must still organize the use of video equipment. In the future perhaps every student will have his or her own computer with video capabilities, just as all students are given textbooks for the year, but, in the meantime, careful scheduling is a necessity.

Provision for Moving Equipment

In situations where equipment must be moved to students, rather than students moved to the equipment, it is important that the equipment is both portable and durable. Most equipment available to schools today is built with hard use in mind, but wear and tear can be limited by storing equipment in areas that are accessible to classrooms.

Provision for Maintenance and Repair

Depending on the amount of equipment in their inventories, some schools will find it cost-effective to appoint an in-house specialist to maintain and service equipment. Such an individual may have been educated as a media specialist in which case a minimum amount of training about the specific equipment being purchased may be all that is necessary. While media specialists may not be able to do extensive repairs, they can help the district avoid needless expense by inspecting equipment on a regular basis and performing maintenance services.

A variety of service contracts are available from both vendors and service organizations, including standard format and customized contracts. Since each kind has its advantages and disadvantages, individual circumstances will dictate what is best for each school. The major variables in making a decision should be:

- The tolerance of the instructional program for operating without films, computer programs, video tapes, or other media for a period of time.
- The repair record for specific type of equipment.
- The need of the system for an immediate response to a service request.
- The ability of the system to pay.

Types of service contracts include:

1. *Flat Rate.* Stipulates a monthly service fee which is paid each month without regard to the number of calls or pieces of equipment services.

2. *Per Call.* Stipulates a fee for each repair made.

3. *Prime Time.* Usually reserved for computer centers, language laboratories, and other uses considered essential to the day-to-day operation of the school. Prime time is usually considered 8:00 a.m. to 5:00 p.m. or 8:00 a.m. to 12:00 noon, during which hours the vendor is required to service equipment if a request is made during a specified time.

4. *Extended Time.* Extends "prime time" to 24 hours a day. The service provider must also agree to respond within an agreed-upon time after receiving a service request. Under this kind of contract, service personnel are required to remain at the site until the equipment is repaired.

Provision for Security

Administrators should also install security systems to prevent theft of equipment. This may include locking each piece of equipment as well as the room in which they may be stored. For computers in which sensitive or confidential material like student records may be stored, special care must be taken to preclude unauthorized access to the data.

Provision for Upgrading

The impact of media on management can be a significant one in terms of planning effort and expenditure of funds. Although some of the management tasks, such as building renovation, described above will occur only once during the life of the equipment, many will continue and perhaps require increasing expenditures as the equipment gets older. As technical improvements in equipment are being made and instructional materials improve in quality, schools will want to upgrade their media. Good management requires that plans for upgrading, repairs, and other continuing costs be included in the operations of the school.

Summary

We have examined five kinds of impacts that media may have within an educational system: on student achievement, learning, productivity, school personnel, and management. Some of these are positive, e.g., increased student achievement and learning; some are negative in the sense that the acquisition of media will require additional staff or financial resources. Some impacts that seem positive may have negative repercussions. For example, an increase in the productivity of a school through continuous use of its equipment will require resources to organize and manage that use. Finally, some seemingly troublesome impacts, such as the planning and training required to prepare teachers for the use of media, are likely to have a positive long-term return regarding increased student achievement and learning. In deciding whether or not to use media in a district or school and, if so, what medium to use, these impacts and their long-term effects should be studied.

VI. Evaluating and Developing Materials*

The promise of technology for improving the basic skills of students and preparing them to be productive citizens in an information-based society often leads schools to purchase equipment without finding out whether it meets a school's needs, whether teachers will use it, or whether there are instructional materials available. This chapter addresses the last and most common complaint, that is, the lack or inadequacy of materials, and proposes a strategy which those who select and those who design materials can use to meet their educational goals. By way of introduction we examine the nature of the complaint and its basis.

Is there a materials gap?

The briefest glance at any current catalogue of instructional television programs, computer software, or audio-visual materials will counter often heard statements that no materials are available. In fact, based on the sheer number of listings, one would think that enough materials were available to meet every conceivable educational need. The problem then seems to lie elsewhere; either available materials do *not* meet needs or potential users can not determine whether they do.

Most of the materials currently available have been designed to meet a limited number of educational functions: to introduce or enhance subject matter, to check arithmetic answers, to provide drill and practice, or to provide programmed instruction. While each of these functions is important, the fact that most materials have been designed only for these functions has led to redundancy and has meant that other educational areas have been neglected. For example, it is difficult for educators to find good materials that allow a student to work through a problem which he or she states, from hypothesis testing to evaluation of a proposed solution. In a study conducted by the Technology-Assisted Learning Market Information Service (TALMIS)[1] it was found that computer courseware available for drill and practice and tutorial uses met or exceeded the anticipated demand while the demand for simulations and educational games was greater than available courseware. Some writers believe that there are innovative materials available, but because they do not fit the conventional curriculum and traditional concepts of grade level, they are judged to be irrelevant by educators and for that reason are not used[2]

Similarly, more materials for media use are available in some subject areas than others[3] The supply of spelling, reading and language arts materials is meeting, if not exceeding, the demand; but the demand for mathematics materials outstrips their supply. Very little material is available for computer literacy education in the elementary schools. Thus, while there appears to be enough to satisfy all needs, there are gaps for some educational purposes and in some subject areas, particularly those that are not conventional.

The quality of available materials ranges from very good to very poor. The educational materials industry goes to great lengths to make their films, television programs, computer courseware, and other materials colorful and physically attractive in order to attract buyers, but often these materials lack substantive value. They are not based on what we know about learning, and the results of their use with students are disappointing.[4]

There have also been problems in linking educators with the materials they want. This means that those who are selecting materials have difficulty in evaluating their potential value in the classroom, since there is no documentation on the purpose of the materials, student prerequisites, techniques, and the like.

*This chapter was developed in part by Catherine E. Morgan, Educational Consultant, Kensington, Maryland.

[1] "The 1980-1985 Kindergarten-High School Market for Instructional Computing Hardware and Software," cited in *TALMIS Industry Update*, February 1981.

[2] "Applications of Microcomputers in the Schools," A Report to the Northeast Regional Education Planning Project. Technical Education Research Centers, Inc., Cambridge, Massachusetts, May 15, 1980, p. 20.

[3] The TALMIS Report, *op. cit.*

[4] In the TALMIS K-12 report cited above, 31 percent of the superintendents surveyed complained about the quality of computer courseware.

An overriding problem regarding materials is a general lack of criteria for evaluating those that are available. Thus, while there may be a number of materials available in language arts, those who select them often rely on intuitive judgment about their value because they have no other criteria. While intuition often works, many materials screening committees, teachers, and others who select materials are frustrated because they don't know what to look for or how to tell when they have found it.

In the end, then, the materials problem is a two-pronged one; in some cases, the right materials are not available at all, and in other cases, educators need assistance in selecting materials from those that are.

Who should fill the gap?

In those cases where needed materials are not available, the major candidates for filling the gaps are teachers and commercial producers. Both groups have been active in developing materials, and there is no reason why both should not continue to make contributions.

There have always been some teachers who prefer to prepare their own audio-visual material and, more recently, generate computer courseware. In fact, in the computer courseware area, materials design and development was begun by teachers who were interested in filling the educational courseware gap. On the other hand, most teachers rely on publishers to fill their materials needs, a reliance which is both expected and desired. After all, for educational, social and practical reasons, we do not expect teachers to write textbooks or produce films or television programs. For the same reasons, schools rely on publishers to fill their needs for computer courseware and audio-visual materials.

Those teachers who have developed their own materials have done so for a variety of reasons, including a lack of funds to purchase materials, to satisfy a creative urge, or simply interest in learning how to use a new medium. Many teachers prepare materials because they want control over content, format or design of materials they use in the classroom. Time and the kind of expertise required generally set the limits to the extent a teacher will go to develop materials. Preparing a set of transparencies for a writing class may take an hour or two of the teacher's time plus a good sense of design. A routine drill and practice computer program takes somewhat more time, although the time and expertise required has been reduced since the introduction of authoring systems that guide the teacher through the design and development process. One student hour of an individualized learning sequence can require 100 hours of instructor time to produce. Obviously, this kind of intensive effort, that is required to produce a good film or television program, or for that matter a book, cannot be supplied by most teachers.

The other major source of materials is, of course, commercial. Because equipment manufacturers and materials producers and publishers have greater access to resources, they are probably better candidates for research and development into new techniques and new kinds of materials than are teachers. In the television and audio-visual fields, leadership in research and development, as well as product dissemination, has traditionally been the role of industry. The computer industry is following this example. In the future, their efforts should complement those of educators on a continuing and increased basis.

What can be done to improve materials?

Whether one is designing and developing materials or selecting them, criteria are necessary for determining whether or not the materials will fill an educational need, are appropriate to the learning situation, and will accomplish what they intend. Just as it is difficult to imagine one textbook that could meet every educational need (even McGuffey's Reader had its limitations), no television or computer program or other technological material will be right for every situation. The challenge in both designing and selecting materials is to understand the situation for which the materials have been or are being developed. The factors which must be considered in meeting this challenge are:

- The goals of the school system.
- The needs of the target population, the students.
- Equipment available.
- Curricula.
- Interest and skills of teachers.
- Funds.

Because educators are more likely to evaluate materials than to design and develop them, the discussion that follows focuses on the evaluation

process. At the end of the chapter, we turn to design issues.

A Materials Review and Selection Process

Assessing and Articulating Materials Needs

Selection of any kind of material for instructional use begins with an assessment and articulation of need. Such an articulation can be relatively broad, for example, "We could use an arithmetic textbook for our third grade students." Conversely, it can be quite narrow, for example, "We would like materials on word capitalization and sentence punctuation for a few third grade students who are having difficulty producing a piece of writing without violating capitalization and punctuation rules." To the extent that the potential learner or learners, the kind of media (e.g., printed workbooks versus instructional television), and the instructional purpose can be specified, the review and selection process will be more effective and efficient.

Information that is particularly useful in narrowing down the materials that will be reviewed includes:

- Grade level or ability level of students for whom instructional material is being sought.
- Anticipated skills or knowledge of students when they begin to use materials.
- Expected skills or knowledge of students when they complete the materials.
- Content or skill area which the material addresses.
- Learning styles of students. Special instructional needs, e.g., visually-oriented materials for hearing-impaired students.
- Preferred medium of instruction.
- Anticipated plan for integrating material into course curriculum and total instructional program.
- Resource constraints, if any, e.g., amount of money available for purchases.

Special needs, interests or constraints, such as appearance of materials, durability requirements, and avoidance of racial, cultural or sex bias or stereotyping, should also be noted.

Sources of needs information may include test scores, opinions of teachers, administrators, parents and specialists, and student records. The extent of detail depends largely on the intended use of the material. That is, if materials are being sought for a course in mathematics, then information on the objectives of the course, the instructional approaches to be used, the sequence of topics to be covered, and the instructional materials already planned for use should be described so that a fully integrated program can be developed.

Assessment and articulation of needs will help the materials selector weed out the large number of materials that are not appropriate and to focus on those that are.

Obtaining Material for Review[5]

The first step in reviewing materials is to find out what has been written about them in magazines, newsletters, bibliographies, catalogues, promotional brochures, and program guides. (A number of these resources are listed and described in the Appendix.) Information about material research and developmental projects funded by the Federal government is also available. The purpose of going through this step is to eliminate those materials that are inappropriate for any reason, including cost and incompatible equipment requirements.

At this point, the reviewer may decide that additional information is needed before he or she requests a preview copy of the material, especially if there is a charge for preview copies. Writing directly to the publisher with specific questions about materials should provide that information. Some of the questions that might be asked are:[6]

1. For which grade levels or ability levels is the material intended?

[5]Readers are encouraged to obtain, The National Council of Teachers of Mathematics, *Guidelines for Evaluating Computerized Instructional Materials*, Reston, Virginia, 1981. The *Guidelines* are the source of many of the ideas in this chapter; permission has been granted by the NCTM for the use of these materials.

[6]NCTM, *supra.*, p. 10.

2. Has the material been tested or validated with students at those grade or ability levels?

3. What are the instructional objectives of the materials? What content areas are covered?

4. What kind of equipment is required for the material's use? For computer software, what are the system and memory requirements?

5. In what form, or forms (disks, cassette tape, cartridge, print), is the material available?

6. What support materials (teacher's guide, tests, printed enrichment materials, follow-up activities) are available?

7. What are the costs of the basic materials and the accompanying support materials?

8. What is the procedure for obtaining a copy of the material for review? If there is a charge, what is it?

9. Can the publisher provide a list of buyers of this material?

The information obtained from the publisher should help to eliminate still more materials. Reducing the list of candidates as much as possible will mean a saving in time when the materials are previewed and a saving of money in those cases where there is a charge for preview copies.

In addition to obtaining material directly from the publisher for review, it may also be possible to examine materials that have been purchased by another school or school district in the area. A conversation with users in that school or district can provide valuable insights about the material.

Reviewing the Material[7]

By the time the reviewer is ready to begin examining materials for the purpose of selection, the number of items should be relatively small since candidates will have been eliminated in the earlier steps in the process. The four steps described below are recommended.

1. Use the material as it is intended to be used in the classroom. Simulating actual use helps to identify the instructional capabilities and limitations of the material. When reviewing materials that will be used directly by students, e.g., computer courseware or instructional materials for calculators, simulating student responses will indicate the degree to which, and the accuracy with which, the material designer has anticipated student needs. Reviewing films, television programs, audio tapes, and other media through the eyes and ears of students is also helpful in selecting the right materials.

2. Evaluate the materials. Evaluations should be based on the reviewer's use of the materials in order that they can be compared to the publisher's claims. Suggested evaluation criteria are discussed in the next section.

3. Complete the documentation on each piece of material reviewed. Descriptive information about the material that is developed by the reviewer should be compared to the documentation provided by the publisher and added to the information collected for that material.

4. Make the selection. After all descriptive and evaluative information has been collected, the reviewer or a materials section team makes a decision.

The *process* for selecting materials, illustrated in Exhibit 1, is straightforward; the *content* of the evaluation is somewhat more complex. Content issues, or evaluation criteria, are described below.

Evaluation Criteria[8]

The feelings and beliefs held by reviewers about how people learn will affect their priorities and will provide a specific focus to the review task. Therefore, no set of criteria proposed by one group or individuals will necessarily be important or relevant to another. The criteria suggested here are not intended to be adopted by school districts, schools, or teachers without critical examination.

The criteria listed below are divided into two categories, requirements and considerations. The requirement category included all those qualities that

[7] NCTM, *supra.*, p. 11.

[8] The material in this section relies in large part on NCTM's guidelines for material review, cited *supra.*, pp. 14-16.

the authors feel *must* be present in materials for them to have an impact on student achievement and learning. The considerations category includes qualities that *may* be present in materials.

REQUIRED QUALITIES

Content

Definition of purpose
The purpose of the materials, its objectives and content, should be clearly defined. If it is not specifically stated, the reviewer may reject material on this basis alone or examine it further to see whether its purpose is implicitly stated.

Significance of program purpose
A piece of material may be irrelevant to the needs of the students for whom it is intended. It might treat a subject that is of no importance to the learner or, conversely, treat an important subject irrelevantly.

Compatibility with instructional program
The material should be compatible with the instructional program in which it will be used, with respect to its goals, its theoretical base, and the learning style or styles of the students for whom it is intended.

Accuracy of content
The content of the material should be correct and clear. It need not treat a subject comprehensively so long as it clearly states the areas it is covering.

Absence of bias or stereotyping
All content, pictorial as well as textual, should be free from bias and free from stereotyping on the basis of race, ethnicity, sex and handicapping condition. Content should be representative of total population.

Instructional Qualities of Importance to Both Teachers and Students.

Quality of directions
Directions need to be clear and concise. If intended to be understood and followed by students themselves, language should be appropriate to the potential users' reading level. Directions should tell student users where they will be going (objectives) and what they will be doing (content and activities).

Quality of response
If computer courseware is being evaluated, the reviewer should determine whether it provides immediate feedback after each response by the student. The student should know whether his or her answer was right or wrong and, if wrong, what the correct answer is in terms that relate directly to the student's input. Responses should not be negative, sarcastic, or cute as students will soon get bored with, if not antagonistic to, such responses.

Exhibit 1.

Steps in Materials Review and Selection

Assessing and Articulating Material Needs

Obtaining Material for Review

- Review literature
- Review information obtained from the publisher
- Review information provided by users.

Reviewing Material

- Use the material as intended for classroom use
- Evaluate the materials
- Complete documentation on materials

Ease of use
When materials are intended for direct student use, they should be as simple and as easy to use for the student as they are for the teacher.

Physical appearance
Visual media should be attractive to the eye. Although graphics, animation and color are not required for every piece of material, it is important that all materials be designed well. Materials which contain too much text or too many graphics may detract from learning.

Instructional Qualities of Importance to Teachers

Adaptability
It makes good sense to select materials that can accommodate a number of ability levels and thus be used by more than one student, class or grade. Adaptability may be an inherent part of the material, for example, computer courseware that includes several degrees of difficulty. If it is not built in to the material, guidelines should be included to help the teacher adapt the material to different student needs.

Durability
Durability is of interest to both the teacher and the administrator: the longer material lasts, the more use can be made of it. Durability is particularly important in cases where the same piece of material is to be used by a variety of people.

Lack of mechanical and technical error
Material must be exempt from all errors so that students are not confused by inaccurate responses to their input. Teachers should not be put in a position which requires checking the material for errors. Computer courseware which sends students through repetitive non-productive loops or into dead-end paths should be avoided.

DESIGN CONSIDERATIONS

Depending on the capabilities of the equipment or hardware being used and the educational philosophy of the designer, materials may incorporate a number of other features. While the authors attach no inherent value to these features, one or the other in each category below will be apparent in any piece of material. The evaluator should know which of the features he or she is looking for before making a final judgment about material quality. We are calling these "design considerations" to distinguish them from required elements.

Teacher Involvement or Lack of Involvement
Some materials are intended to be used independently by students without the intervention or involvement of teachers. Others explicitly involve the teacher as consultant, presenter of information, diagnostician, prescriber, or evaluator. Elsewhere in this book, we have discussed the research showing the negative effect on student achievement when teachers are absent. Since the research is not conclusive on this issue, designers may choose to eliminate or limit teacher intervention for a particular kind of material. Evaluators should, therefore, judge each piece of material on its merits in this regard. For example, if the material is designed to be used independently, the evaluator should decide whether student independence is appropriate for the particular content, skills, or instructional technique.

Active or Passive Student Involvement

Although all materials should engage the learner, not all materials need to actively involve him or her. For example, a film or television broadcast does not necessarily need direct student input to be informative and interesting to the student. Material using drill and practice or tutoring techniques must involve the student. Again, the purpose for which the material is being selected and the extent to which it is needed to provide variety in the total instructional program are the factors to be weighed.

Student or Teacher Control

This is another area in which the judgment will be based on the instructional purpose of the material. In some cases, the teacher may want the student to select the number of problems to be worked on and their level of difficulty, or to decide what kind of information he or she wishes to explore. At other times, the teacher may want to control the selection of content or sequence of instructional task to be sure that students are exposed to or learn specific subject matter.

Presence or Absence of Graphics, Animation, Color, or Sound

Use of these features may enhance or detract from instruction, and not all features must be present in every piece of material. Relevance to the instructional purpose, need to illustrate a particular content area or concept, and need to add variety to the total instructional program are key factors in deciding whether these features should be present.

Personalization or Neutrality of Materials

Some computer courseware has been designed so that the computer's response to a student's input is personalized, that is, using the student's name in response statements. Not all educators feel that attempts to humanize the computer in this way are either necessary or desirable. Many educators believe that the computer should be seen as a machine since that's what it is. Whether materials should be personalized or not and the kind of personalization desired is a matter of philosophy and taste.

Self-Contained Material or Need for Supplementary Material

Instructional material may require that the user have access to information other than that contained in the material, for preparation, follow-up, or review purposes. On the other hand, some material is entirely self-contained. Again, materials must be judged on their merits. Factors to consider include the availability of supplementary materials, their cost as compared to the basic material, and their relevance to the learning objectives.

Report of Student Performance

Some materials, particularly computer courseware, have the capacity to report on a student's performance on completion. Although not a required feature, evaluators should review the manner in which the information is given to the student to judge whether it will have a negative or positive effect.

Exhibit 2, which follows, summarizes the criteria reviewed above. Readers of this book are expected to add criteria they think are important and to eliminate those that are not relevant, since this set of criteria will not be appropriate in every situation. A list of criteria such as the one we have suggested here can easily be transformed into an evaluation checklist by the addition of rankings. The evaluator's checklist, plus documentation of the material's descriptive characteristics, will provide a permanent record for potential users.

Exhibit 2.

Evaluation Criteria Summary

REQUIRED QUALITIES

Content
Definition of purpose of materials
Significance of materials to educational goals
Compatability with instructional program
Accuracy of content
Absence of bias or stereotyping

Instructional qualities of importance to teachers and students
Quality of directions
Quality of response
Ease of use
Physical appearance

Instructional qualities of importance to teachers
Adaptability
Durability
Lack of mechanical and technical error

DESIGN CONSIDERATIONS

Teacher involvement or lack of involvement
Active or passive student involvement
Student or teacher control
Presence or absence of graphics, animation, color or sound
Personalization or neutrality of materials
Self-contained material or need for supplementary materials
Report of student performance

Design and Development of Materials

In the course of this chapter we have examined: 1) how to review and evaluate materials [process, Section A] and 2) what qualities to look for in materials [evaluation criteria, Section B]. Throughout this examination we have assumed that appropriate materials were available and could be identified if a rational process was followed and criteria for selection were clear and agreed upon by all concerned parties. We know, however, that materials may not be available that meet specific needs nationally, such as mathematics courseware, or locally, such as a need to teach fourth grade students to identify the main idea in expository writing.

Although publishers, equipment manufacturers, and others are beginning to fill this gap, educators may want to develop materials that are tailored to their students and their circumstances. This section describes a process for materials design and development for those who consider it a continuing need and a challenge.

The process[9] described below contains a number of steps that are performed intuitively by many materials designers. The authors have articulated them in order to rationalize the process for people just beginning design efforts, to stress the importance of documenting design decisions, and to promote the integration of high design standards in the design process. The process described below in narrative form is summarized in Exhibit 3, which appears at the end of this section.

Analyze the Situation

The education situation drives and, to some extent, constrains the design of materials. Analysis of the situation will inform the designer *what* is to be taught, *to whom*, and under what circumstances. The step is important because it helps the designer understand the scope of the task, set limits to it, and match subject matter, student and method of presentation. Some of the questions that must be answered include:

What subject matter do you wish to address? The answer to this question can be fairly broad at this point in the process, e.g., long division, critical reading, capitalization.

Who are the students for whom this material is intended and what do they know with respect to that content? The answers may include grade levels, ability levels, and learning styles that have been obtained from school records, tests, and/or observations. If any of the students in the intended audience have special needs these should be identified. This information will affect the choice of learning objectives, teaching techniques, and media.

What are the skills of the teachers who will be using the materials? Even if the designer and the teacher/user of the material are the same person, the designer should consider whether the material will be so idiosyncratic or difficult to use that other teachers will not be able to incorporate it into their programs.

What equipment is available? The answer to this question may limit the options available for designers regarding choice of media and thus limit the kind of material that can be used. The designer should identify the capabilities and limitations of the equipment and take advantage of its strengths. For example, a computer can be programmed to respond to a user's input. An instructional program that treats the subject matter as a textbook or film would and that does not involve the student with frequent questions is wasting this capability. (This kind of misuse of computers is sometimes called "electronic page turning.") On the other hand, the computer cannot deal with a student's ideas that are outside the domain of its program.

The technical features of a piece of equipment will also constrain the designer and therefore should be identified before design and development work begins. For example, if the available computer does not have speech capabilities, the designer may want to rethink his or her decision to use the computer as a medium for instructing students in vowel sounds or other basic listening and speaking skills.

What materials are available? The designer should find out what others have done in developing

[9]Readers are referred to Harold J. Peters and James W. Johnson, *Author's Guide: Design, Development, Style, Packaging, and Review*, CONDUIT. The Peters and Johnson guide will be most useful to teachers and others who are designing computer courseware for the first time. In addition, the reader is referred to an article by Jurg Nievergelt in *Computer Magazine*, "A Pragmatic Introduction to Courseware Design," September 1980, pp. 7-21.

materials for the equipment available. This will help avoid duplication and may also stimulate creativity.

How long is the module? Most teacher-designers will be involved in developing short, discrete instructional modules that will last from 30 to 60 minutes. Some will be developing material that will be used for some period of time every day for a week or more. And a few might be developing materials for an entire course. In any case, the designer should be able to articulate the approximate time of use for both planning and design purposes.

At the end of the analysis phase of a materials development project, the designer should know the content of the material, the characteristics and needs of the student audience, the media available, and the estimated time of use.

Plan and Schedule the Developmental Process

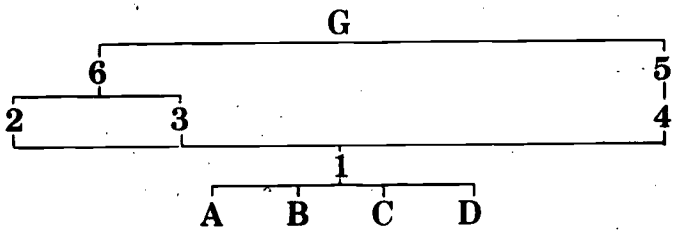
The five basic steps of materials development work, design, development, testing, implementation and evaluation, can now be described and scheduled. The planning phase helps the designer identify: 1) the resources he or she might need (e.g., a computer programmer or an illustrator); 2) the time needed for completion; and 3) budget requirements. Any one of these factors, if not available to the extent needed, may cause a reduction in expectations and require the designer to limit the scope of work.

Design the Product

The design phase is the key phase in the developmental process for it is here that creative decisions are made that will affect the content and quality of the material. Every designer has his or her own way of sequencing and completing design work, but most complete the following steps.

Where should the student audience be going? This question asks for a goal statement, such as, to teach students to become critical readers. It is derived from and may be the same as the statement about content area above. Having the goal in mind through the design and development process helps the designer keep on track.

What steps, and in what sequence, must they follow to get there? This question asks for a set of interim, or enabling objectives, which must be met if the goal is to be accomplished. The arrangement of the objectives identifies the sequence in which each should be met. Although all objectives must be important to achieving the goal, they may not necessarily be dependent on one another. This is because few learning sequences are linear. A common hierarchy of objectives might look like this:



where A, B, C and D are prerequisite skills, 1-6 are enabling objectives and G is the goal of the learning package. Objectives 2, 3 and 4 depend on 1, but objectives 2, 3 and 6 may be taught before 4 and 5, or vice versa. All are needed to accomplish the goal.

Using the goal of teaching students to become more critical consumers of television as an example, the design may have four objectives:[10]

- Ability to evaluate and manage one's own television viewing behavior.
- Ability to question the realism of television programs.
- Ability to recognize arguments on television, and to counterargue.
- Ability to recognize effects of television viewing.

None of these objectives are dependent on another and therefore could take place in any order.

Although the skill areas of mathematics and basic verbal knowledge are replete with examples of dependency hierarchies, reading comprehension and problem-solving prototypes are almost nonexistent. Therefore, designers must base decisions about the appropriate objectives and their instructional sequence on their own experience.

[10]Ned White, *Teacher's Guide to Inside Television: A Guide to Critical Viewing*. San Francisco: Far West Laboratory for Education Research and Development, 1980, pp. vii-viii.

What instructional technique or techniques are most appropriate to meet this goal, accomplish these objectives, and teach these students? One or a number of techniques might be used, such as information presentation, followed by drill and practice, and ending with a problem-solving exercise. The selection should be driven by goals, objectives and the characteristics of the students.

For materials which are intended to cover a large topic area over a period of time, variety is also important to sustain interest.

What other design considerations should be integrated into the design? During this part of the process, the designer identifies the qualities that the materials should have in terms of the following:

- Teacher involvement in instruction or no involvement or some of each?
- Active or passive student involvement or some of each?
- Student or teacher control of pace, sequence, etc., or both?
- Presence or absence of graphics, animation, color or sound?
- Personalization or neutrality of materials?

The answers to these questions will affect instructional group size and selection of media described below.

What size should the instructional group be? The answer to this question is related to both the previous and following answers, since some techniques and some media lend themselves to a particular group size. For example, drill and practice tends to be an individual activity whereas presentation of information tends to be a group activity.

What medium or media of instruction should be used? In Analyzing the Situation, the designer would have found out what equipment was available and might have had a particular medium in mind when deciding to develop materials. In this step, the designer reconsiders that preference. Some of the factors[11] that should enter into a reconsideration of the preferred medium are:

- The estimated number of users and the expected life-span of the materials. These should be weighed against the cost of development. If cost is high and the number of users is low or the life-span short, then a less expensive alternative should be considered.
- The requirements of the subject matter. If the subject matter requires human interaction or development of manual skills, media should play a limited part in teaching the course or content area.
- The skills and abilities of the target population. Students may not be ready to work individually, in which case media which are based on one-on-one interactions may be inappropriate. Similarly, if the entry-level abilities of students are the same, reliance on media that promote individualized learning may be unwarranted and wasteful.

The initial assumption favoring the use of a medium should be tested against decisions about objectives, student characteristics, instructional techniques, instructional qualities, developmental costs, and group size.

Do you want to verify your data regarding the entry level or prerequisite skills of the student audience and, if so, how will they be measured? A designer/teacher who knows the students for whom he or she is developing materials may feel that entry level, placement or diagnostic tests are unnecessary. On the other hand, designers may want to include such tests to assist other users who will not necessarily know how the materials fit their students' needs.

How will student performance be monitored and evaluated? Materials should include some means of determining whether students are meeting the objectives in a timely fashion. Pre- and post-tests should be included in the design as should other means of testing progress so that students and their teacher can monitor performance and spot and resolve problems.

What introductory and follow-up activities are needed that will integrate this material into the total instructional program? Supplementary materials may be needed to introduce the materials and to follow them up. The designer should include these, or a list of resources in the materials.

[11] Peters and Johnson, *op. cit.*, pp. 25-26.

In addition, the extent to which the material relates to other parts of the instructional program should be described.

Develop the Product

The design phase is a decision-making phase in which determinations of content, scope, appearance, and methodology are made. The development phase is a phase in which design decisions are implemented. The outcome of this phase is a product.

As material is being developed, designers should test their material against standards which they or materials screening and selection teams in their school or district have established. A list of such criteria might include the following (described above as evaluation criteria):

Have I defined the purpose of the materials?

Are the materials significant vis-a-vis my or the school's educational goals?

Are they compatible with the instructional goals?

Is the content accurate?

Have I avoided bias and stereotyping?

Are the directions clear and concise?

Is positive and frequent response to student input provided?

Is it easy for teachers and, if appropriate, students to use?

Is it physically attractive?

Is it adaptable for use by more than one group of students or for more than one purpose?

Is it durable?

Does it lack mechanical or technical error?

Test the Materials and Revise as Necessary

Pilot testing should be an integral part of the design and development process, especially for material intended to be used by teachers other than the designer. Even the designer/teacher who believes that his or her material has limited use might consider its first use a pilot test.

Materials should be validated with a sufficient number of students to be representative of the population for whom the materials are designed. The pilot test group should work through the whole materials package and be tested on their performance in meeting the interim objectives and their achievement of the goal. Completion times should be recorded.

Opinions of student-users as well as teacher-users about the materials, their clarity, accuracy, and ease of use should be solicited.

Complete the Documentation

After pilot testing and revising the materials, the designer should make sure that the documentation about the materials is accurate and complete. The information that might be included in the documentation is listed in Exhibit 3, which shows the items of information associated with design tasks.

The documentation should also include brief descriptions of any features that are unusual about the material, e.g., use of graphics or sound, alternative delivery media, or teacher preparation requirements.

Implementation and Evaluation

Use in a classroom setting may persuade a designer/teacher to make additional changes in the material. For this reason, on-going evaluation is a critical ingredient in the continued success of the materials. The designer should solicit evaluations from students as well as teachers. If changes are made, the documentation should be revised to reflect them.

Exhibit 3. Documentation Items Associated with Design Tasks

DESIGN TASKS	DOCUMENTATION REQUIREMENT
Analysis of the situation	
Identification of content area or skill	Content area
Intended student audience	Appropriate grade or ability level
	Prerequisite skills
Required teacher skills	—
Available equipment	—
Time for use	Estimated time for average use (confirmed in Task 5)
Development plan and schedule	—
Design of product	
Instructional goal	Purpose of materials
Interim objectives	Purpose of materials
Instructional technique	Instructional technique
Other design considerations	May be described as special characteristics
Instructional group	Instructional group size
Medium of instruction	Equipment requirements
Measurement of prerequisite skills	Introductory activities recommended or required
Monitoring and evaluation of student performance	—
Methods for integrating material into total instructional program	Introductory and follow-up activities
	Additional materials
Development of Product	—
Testing of Product	Validation information

Copyright Issues

Few teachers can resist altering materials to fit their students' needs, their own instructional styles, scheduling constraints, or preferences in formatting or design. Thus, material in textbooks may be studied out of sequence; existing graphics may be replaced by new ones; more current information may be added. So long as the overall concept and design remains unaltered, there *may* not be copyright problems. Substantial alterations will involve copyright law. It is not always easy to define the line between insubstantial and substantial alterations, which suggests that the copyright holder be consulted in any case of doubt.

Copyright law extends to the right to duplicate material[12] and may prohibit duplication of specific kinds of materials for preview, evalution, scheduling convenience or any other reason. Before recording or copying anything, school personnel should find out what limitations the copyright on that item imposes. For example, with respect to recording an instructional television program or radio broadcast off the air for later use in teaching, there are a number of restrictions that might be placed depending on the particular program.[13] These include:

- *No recording rights.* Such 1980-81 programs as *Once Upon a Classic* and *BBC Shakespeare Plays* cannot be recorded under any circumstances.
- *Year-long recording rights.* Programs may be recorded and used within the current year (or another specified number of years) and then tapes must be erased.
- *Seven-day recording rights.* Tapes of programs must be erased within seven days of their broadcast.
- *Permanent recording rights or rights in perpetuity.* No restrictions.

Television programs funded by the U.S. Department of Education, Division of Educational Technology have similar restrictions, as illustrated in Exhibit 4. To learn more about the rules that pertain in a specific state, it is recommended that school personnel contact the department in their state education agency that deals with instructional television.

Generally, network television programs carry with them a prohibition against recording for any purpose. The "fair use doctrine" in the U.S. Copyright Law offers an exception. This doctrine allows teachers, librarians, and specified others to use copyrighted works under certain circumstances. Generally, the circumstances to be considered in determining whether the use is fair[14] include:

- Purpose or intended use of the material; e.g., copying material with the purpose of avoiding purchase is prohibited.
- Nature of the copyrighted material, e.g., workbooks, exercises, published tests, and other material considered to be consumable in the course of study or teaching can not be duplicated.
- Amount and substantiality of the portion copied in relation to the copyrighted work as a whole, e.g., one chart may be copied from a book but not more.

These rules pertain to any copying including copying 16mm films onto video cassettes or copying graphs or charts onto overhead transparencies.

Just as the law regarding alteration and modification is complex, so is the law regarding duplication, particularly with respect to materials associated with technology. Again, the authors recommend consultation with the state education agency, the copyright holder, or the television station before recording or copying any material.

[12]For guidance in matters of duplication, the authors rely on *The New Copyright Law: Questions Teachers and Librarians Ask*, Washington, D.C.; National Education Association, 1977.

[13]Described in the Massachusetts Educational Television program guide for the 1980-1981 school year.

[14]From the Copyright Law (P. L. 94-553) and the text of the agreement reached by educators, authors and publishers included in the House Judiciary Committee report. Cited in NEA, *supra.*, pp. 18-24.

Exhibit 4.

Programs Funded by the U.S. Department of Education

Award-winning television programs that have been funded by the U.S. Department of Education, Office of Educational Research and Improvement, Division of Educational Technology may be taped off-the-air for educational use without charge. Most of the programs are available for showing over public, commercial, or cable television. Contact your local television station to find out dates/times when any of the listed series may be scheduled for showing in your area. All programs will have closed captions. These programs have educational objectives and accompanying teacher, student, or home viewer guides. For information on how to obtain guides, write to:

U.S. Department of Education
Office of Educational Research and Improvement
Division of Educational Technology
400 Maryland Avenue, S.W.
Washington, D.C. 20202-3117

Educational Rights in Perpetuity

As We See It (S, A)
Bean Sprouts (E, M)
*Carrascolendas (E)
Dial A-L-C-O-H-O-L (S, A)
Footsteps (S, A)
Forest Spirits (S, A)
*Franco File (E, M)
Getting Over (S)
Getting to Know Me (E, M)
Jackson Junior High (M, S, A)
*La Bonne Adventure (P, E)
*La Esquina (M, S)
Mundo Real (E)
Music... Is (M)
Pacific Bridges (E, M)
Pearls (S, A)
People of the First Light (E, M)
Powerhouse-fall, 1981 (E, M)
*Que Pasa, USA? (S, A)
*Nation Builders (S)
Rainbow Movie of the Week-fall, 1981 (E, M)
Reflections (E, M)
Rebop (E, M)
Checking it Out-fall, 1981 (M, S)
*Sonrisas (E)
South by Northwest (E, M, S, A)
The New Americans (E, M)
The Real People (E, M)
Vegetable Soup (P, E)

Retain tapes for 12 years

*Villa Alegre (P, E)
Infinity Factory (E, M)
Watch Your Mouth (S)
Up and Coming (S, A)
From Jumpstreet (S, A)
The New Voice (S, A)

Retain tapes for 3 years

3-2-1 Contact (M)
Sesame Street (P, E)
The Electric Company (E)

*Bilingual

Audience level:
A - Adult
E - Elementary
P - Preschool
M - Middle school
S - Secondary

VII. Acquiring Media

In considering the acquisition of media, schools and school districts are concerned with the extent to which media can contribute to the learning of a new skill, the enhancement of curricula, the achievement of new educational goals, or the teaching of students who otherwise might not receive educational benefits. Once decision-makers have identified their educational goals and determined, if only tentatively, that media might help them reach those goals, they should prepare cost estimates for alternative media systems[1] This chapter begins by describing the elements that need to be considered in determining costs.

Cost estimation is only one step in planning. Later in the chapter we examine another step, that of weighing the educational value of alternative media systems against their costs. A cost-benefit analysis can help a decision-maker assess the extent to which various systems can achieve the school's or district's objectives and, if so, what the difference in cost among the assessed systems means to the school's or district's budget[2]

Yet another step that should be considered is the extent to which the media systems being assessed can contribute to long-range goals, such as preparing students for working and living in an information age. Educational decision-makers may agree with those parents cited in Chapter II that that kind of investment in the future is worth paying for.

At the end of the chapter we describe the kinds of specifications that should be developed in requesting price quotations from potential vendors.

[1]In this chapter we are using the phrase "media system" to describe equipment, buildings, instructional materials, personnel costs, and all other elements involved in the use of technology.

[2]Robert J. Seidel, *It's 1980: Do You Know Where Your Computer Is?*, Alexandria, Virginia: Human Resources Research Organization, March 1980, p. 9. Seidel calls this a "tolerable cost analysis."

Cost Analysis

Installing and using educational media has an impact far beyond the purchase price of equipment. In previous chapters we have examined the changes and alterations that technological innovation may impose on teachers, administrators, and physical facilities. In this section we look at these effects in terms of their costs and suggest a method for assessing the direct and associated, or hidden, costs involved in using media.

The cost components associated with the installation and use of media can be described as capital costs, i.e., one-time expenditure of funds for items which are expected to be used for more than one year, and operating costs, i.e., costs which are expected to vary from year to year depending on how much the system is used[3] and how much the medium is available and not used, i.e., the financial effects of down time.

Capital cost items include:

- **Equipment.** Equipment includes projectors, radios, recorders and players, computer terminals, microcomputers, television receivers, cameras, monitors, and the like. Includes peripheral equipment used to expand the capabilities of computers, e.g., disk drive, modems, printers, and light pens. Also includes programs, routines, and manuals, or system software, which are essential to the operation of equipment.

- **Transmission and/or reception.** Includes the cost of the device plus the cost of installation of telephone lines, electric lines, coaxial cables, antennas, microwave "dishes" or receivers, and outlets.

- **Facilities.** Includes expansion and renovation costs required to store and use media. For example, learning laboratories, auditoriums for showing films, film libraries, computer tape storage areas.

- **Instructional materials.** Includes the cost of books, film, computer courseware, television programs, and other material which is used for the purpose of instruction. The major cost of developing materials in-house is for personnel, measured in terms of hours of design and development. Whether developed by faculty or

[3]Wilbur Schramm, *Big Media, Little Media*, Beverly Hills: Sage 1977, pp. 106-107.

purchased, materials may be the single most expensive item in installing a media system.

In determining the cost of materials, the administrator should consider their life span. For those materials likely to wear out or become obsolete sooner than equipment, replacement costs should be estimated in long term planning.

Operating cost items, for initial start-up and subsequent operation, include:

- **Salaries.** The total cost, including salaries and fringe benefits, associated with personnel who install the system, train teachers and others in its use, develop instructional material, manage the system and repair it. If teachers are to receive training during the school year, then their lost services should be accounted for or the cost of their replacement by substitute teachers should be added.

- **Utilities.** The cost of heating or cooling the system, electricity, and telephone services should be included.

- **Maintenance and repair of materials and equipment.**

- **Expendable supplies.** Includes paper, pencils, printed training materials, and other supplies that have a single-use or short life span.

- **Other costs.** Includes travel and per diem of school personnel for training, trainer travel and per diem, and consultants' fees.

Another way of looking at the cost of media is to assess the initial capital costs against operating costs. Some media systems, such as those that rely on satellites for program delivery, may have high initial costs. Others have lower initial costs but operating expenses are high enough to make them unattractive to educational buyers. These figures vary not only between different types of media but also between the same type. For example, one brand of microcomputer may have high repair costs while another may be very reliable and need relatively little maintenance. The wise administrator will request figures pertaining to operating costs from manufacturers. In addition, it is strongly recommended that administrators talk to their colleagues who use a medium under consideration about their experiences.

In some schools, administrators may be considering an expansion of their existing media system through the purchase of additional pieces of equipment. There are a number of ways to compute the cost of expansion. For example, Schramm[4] suggests this formula that depends on making a distinction between fixed (e.g., facilities rental) and variable costs (e.g., instructional materials): $TC(N) = F + VN$, where the total cost (TC) of a media system serving a certain number of students (N) equals the sum of all fixed costs (F) plus the variable costs per student (V) times the number of students at the optimal schedule. Such a computation can give an administrator a rough estimate of the cost of system expansion when student users are added.

Another formula for roughly assessing the effect of expanding enrollment is: $D \times H \times P \times U = N$, where the number of days of utilization per week (D) is multiplied by the number of hours of utilization per week (H), times the number of 30-minute periods of use per week (P), times the percent of usage expected (U) equals the number of students (N) that can be served by one piece of equipment for a specific purpose. For example:

D = 5 days
H = 6 hours
P = 2 30-minute periods
U = 80%

$5 \times 6 \times 2 \times .8 = 48$ students

The high cost of discontinuing the use of a media system is in itself a persuasive argument for making decisions to purchase carefully. A system that is never used is a total financial loss unless some money can be recovered from selling components of the system. Although the longer a system is used the lower the loss will be, schools and school districts usually cannot recover any of the remaining assets. For this reason it makes sense to investigate systems that can accommodate new features and that will not readily become obsolete.

Cost-Benefit Analysis

School administrators may believe that the cost associated with the acquisition and use of a specific medium is tolerable because they anticipate high gain.

[4]Schramm, *supra.*, p. 107.

Such decisions are usually made when the school district has newly established purposes it seeks to achieve, new teaching methodologies to install, new student populations to reach, or perhaps even when their equipment/materials budgets increase. Administrators in such districts may simply ask themselves whether the district can afford to pay for the value which the proposed system will contribute to meeting their educational goals.

It is largely a matter of individual judgment to declare that one media system contributes more to the quality of learning than another. In our attempts to define the characteristics of a good learning situation in Chapter III and to apply it in Chapters IV and V, we have seen that different media offer different capabilities each of which may have more or less value to a decision-maker.

Because of the difficulty in reaching agreement on the definition of quality, many decision-makers use other measurements in comparing the effectiveness of one medium over another. Such criteria measure quantity, for example, the ability of a media system to provide instruction to more students at one time than another system or the reduction in number of hours necessary to complete a course or curriculum module or to reach an instructional objective. Other quantitative effectiveness measures include:[5]

- Attendance rates or, conversely, absenteeism and attrition rates.
- Test scores.
- Repeater rates, i.e., number of students who repeat a course or part of a course.
- Number of additional courses offered.
- Amount of individual attention provided each student either directly through the medium or through the teacher.

Two other measures might also be used in comparing the cost-effectiveness of media. The first of these, cost avoidance, depends on the intended use of a media system. If it is to be used as a substitute for or to replace media or human resources, then the district may be able to avoid costs. For example, a microcomputer which includes a two-way communication capability is loaned to a homebound student thus avoiding the need for a teacher to provide instruction to the student at home. On the other hand, if a media system, such as a fully equipped television studio, is intended to be used in a new elective course, it is an added-on cost. The studio, in this example, is not a substitute for another medium or a teacher; it is an added cost. Administrators, educators, parents and others may agree that the capacity to provide students training in television programming is an important addition to their oral and written communication courses and thus is worth the added cost.

Cost per student hour is another valid unit for comparison although care should be used with this measure. (What is the cost per student hour when the student is reading a book?) Such an analysis favors media that have a number of uses and are appropriate for different ages and levels of students, since the greater number of students that can use the medium the lower the per student hour cost. It also favors media that can be used 24 hours a day, seven days a week since that capability opens up use to other learners or users in addition to students in school. Neither of these benefits can be realized without careful scheduling.

No matter what the measures used to conduct a cost-benefit analysis, the key question must be, "Compared to what?":[6]

- What is the cost per student hour of computer-based instruction *compared to* the cost per student hour of reading a book?
- What is the cost of a week of a computerized tutorial *compared to* a week of teacher-student one-on-one instruction? And, how do test scores compare for each method?
- How many more courses can we offer using intelligent videodiscs *compared to* conventional classroom teaching?

One research study[7] on costs per student hour of compared an instructional television program to a textbook, film and classroom teacher. The findings were:

[5]Robert J. Seidel and Harold Wagner, *Cost-Effectiveness Specification for Computer-Based Training Systems*, Alexandria, Va.: Human Resources Research Organization, 1977, Vol. III, pp. 71-76.

[6]Glenn Head, "A Cost Benefit Analysis of Individualized, Criterion-Referenced, Computer-Based Training," Denver: Instructional Communications, Inc., 1980.

[7]Robert Carlisle, "Investment in ITV: Hunt for the Wiser Answer," *Patterns of Performance: Public Broadcasting and Education 1974-1976*, Washington, DC: Corporation for Public Broadcasting, 1978, p. 145.

Mode	Cost Per Student Hour of Instruction
Television program	$00.008
Textbook	00.014
Film (owned)	00.072
Teacher	00.290

Finally, administrators might consider the impact of media on their long-range goals for their schools and school districts. For example, a school district may want to prepare its students to be able to cope with the age of information. Believing that computer illiteracy will be as damaging to individuals ten years from now as the inability to read and write is today, decision-makers may feel compelled to install and use computers as an object of instruction as well as an instructional tool. Thus, in terms of their cost-benefits, computers may be of higher value than other media, and their cost may be considered low when measured against the benefits they can provide to the adults of the future.

Preparation for the Acquisition of Media Systems

School administrators who have considered the cost of a number of different media systems will want to specify their requirements for a selected type before beginning a bid solicitation process. The necessary precedent to this phase of the acquisition process is, of course, to identify the type of medium that will best fit the educational needs of the school's students. This deceptively simple issue has been the subject matter of this guide. Its answer depends on student and teacher needs, instructional materials available, other resources available, environmental and budgetary constraints, and school goals which must be determined before steps are taken. A process for answering these is provided in Chapter VIII.

Development of Specifications for Computer Systems

Because specifications for the purchase of equipment must be developed in conformance with state and local law and policy regarding bidding procedures, requests for proposals will vary in content and format. Nevertheless, certain categories of information are helpful for both buyers and prospective vendors and are thus likely to appear in every set of specifications. These categories are described below.*

Introduction or Overview

A summary statement of what is to be purchased and what it will be used for. A brief description of the school and school district.

General Information and Requirements

Information on the bidding process, including requests for demonstrations of equipment, description of the buyer's method of financing, requirements for the format of the bid. Evidence that a system has been in continuous use by a user for a designated time, e.g., three months, should be required.

Equipment Requirements

A list of all performance specifications which the equipment is expected to meet along with the quantity desired.

In addition to the equipment itself (e.g., video screen, film projector, microcomputer), hardware specifications might include:

*An interesting model is the Request for Quotation developed by the Region IV Education Service Center in Houston, Texas, for its purchase of 600 microcomputers in 1980. The Invitation to Bid model in the Minnesota Educational Computing Consortium (MECC), *1979-80 Microcomputer Report*, Lauderdale, Minn.: MECC Instructional Services Division, July, 1979, is also very helpful. See pp 59-83.

- Specifications of Peripherals.
- Power Supply Requirements.
- Service and Sales.
- Performance Requirements (e.g., ability of the system to run a specified program within a specified time limit).
- Future Enhancements (ability of the bidder to ensure that hardware devices developed in the future will be available to the buyer).

Instructional Materials/ Courseware Requirements

A description of materials or courseware that are available to be used with the equipment. The buyer may request a list of all materials or a selected list of materials (e.g., basic skills materials), and should ask that they be described in terms of their instructional objectives, intended audience, or other specified characteristics, as described in the section on documentation in Chapter VI. Because the availability of useful materials is a critically important consideration in selecting equipment for purchase, some writers recommend that equipment be selected on the basis of availability of compatible materials.

Evaluation Criteria

A list of the criteria and the weight given to each to be used by the buyer in making an award. These might include[9]:

- The availability of instructional materials.
- The quality, availability and adaptability of equipment relative to the buyer's required use or uses.
- The ability of the bidder to maintain and service the equipment.
- The experience and reputation of the bidder.
- The ability of the bidder to perform the contract, including the bidder's financial resources.
- The ability of the bidder to provide training to teachers and staff.
- The capability of the bidder to meet future needs.
- The proposed cost relative to other bidders.

Cost Items

- Equipment.
- Software.
- Instructional Materials.
- Training.
- Installation.
- Maintenance and Service.

Additional Requirements

All bidders should be requested to:

- Document any exceptions to the specifications listed in the bid.
- Provide a warrant on all equipment parts and labor for not less than (a specified period of time) after acceptance of the installation.
- State a delivery date and a date for completion of installation.
- Identify the party responsible for making electrical and environmental changes.
- Deliver a specified number of manuals with their bids, as well as model maintenance and service contracts.

Other considerations that may affect the solicitation process include the following:

- Alterations that would reduce vandalism or loss may have price implications.
- Modulators, connectors, and other electronic interfaces needed to connect with existing equipment may be included in the bid specifications.
- Energy consumption costs estimated by bidders may affect the final decision.
- If in-service training is not provided by the seller, the school will have to provide it. The additional cost to the school may affect the final decision.
- As we are all aware, first year models often have "bugs" or "gremlins" which only become apparent with use in the field. To minimize loss for the school

[9]Region VI Education Service Center, *op cit.*, pp 28-30.

district, the vendor of a new model should agree to replace or repair the equipment or its parts should defects be found in operation. Most vendors are willing to make such an agreement since it is not in their best interest, or the school's, to wait for a perfect model!

Once the bids have been received, the school or school district should review them carefully, following state and local requirements in making an award and writing the contract.

VIII. A Decision-Making Process for the Use of Technology in Basic Skills Education*

The preceding chapters of this guide have provided information about technology and the possible effect its use will have on the improvement of basic skills, on the administration of schools, and on school personnel. A number of issues, such as the factors to be considered in comparing the costs of media systems and the effect of future developments on present-day decisions, have been raised and discussed. Throughout the text, questions that should be answered by school administrators before they recommend the use of a particular medium have been raised. This chapter presents those questions in terms of steps in a planning process, which is summarized in Exhibit 5.

The authors recognize that decisions to acquire and use media systems are not always the result of a careful, logical plan as described in this chapter, but may be the result of a fortuitous event, such as a foundation gift, or of decisions made at a different level of the state or local education agency hierarchy. Thus, for example, an administrator or teacher may be asked to do something with the thirty microcomputers that suddenly become school property. The decision-making process suggested in these pages may be useful in rationalizing such an occurrence and ensuring that those microcomputers are used to their fullest capacity. The needs of students and the capabilities of the microcomputers both need to be assessed, instructional material selected or developed, teachers trained, and use organized in the same ways that are summarized in this chapter and described throughout this guide. Clarity of purpose and careful planning, even if it occurs after a media system is available, will help to ensure effective and efficient use.

*This chapter was developed in part by **Frank DiGiammarino**, Ph.D., Director of Planning and Computer Services, Lexington Public Schools, Massachusetts.

1. Setting Basic Skills Goals

The goal-setting step is a necessary precondition of all that follows since it demands that a school or district define what it means by basic skills. In Chapter III we saw that there is little agreement about what the basic skills are beyond reading, writing and computation, and perhaps this is as it should be in a pluralistic society. Nevertheless, a community's parents, teachers, administrators and other taxpayers need to come to some consensus regarding basic skills goals for their student population if education is to be effective and educators held accountable for the learning of their students. Consensus should be community-inspired. The community should determine what outcomes it wishes even when educators and school administrators initiate the goal-setting process.

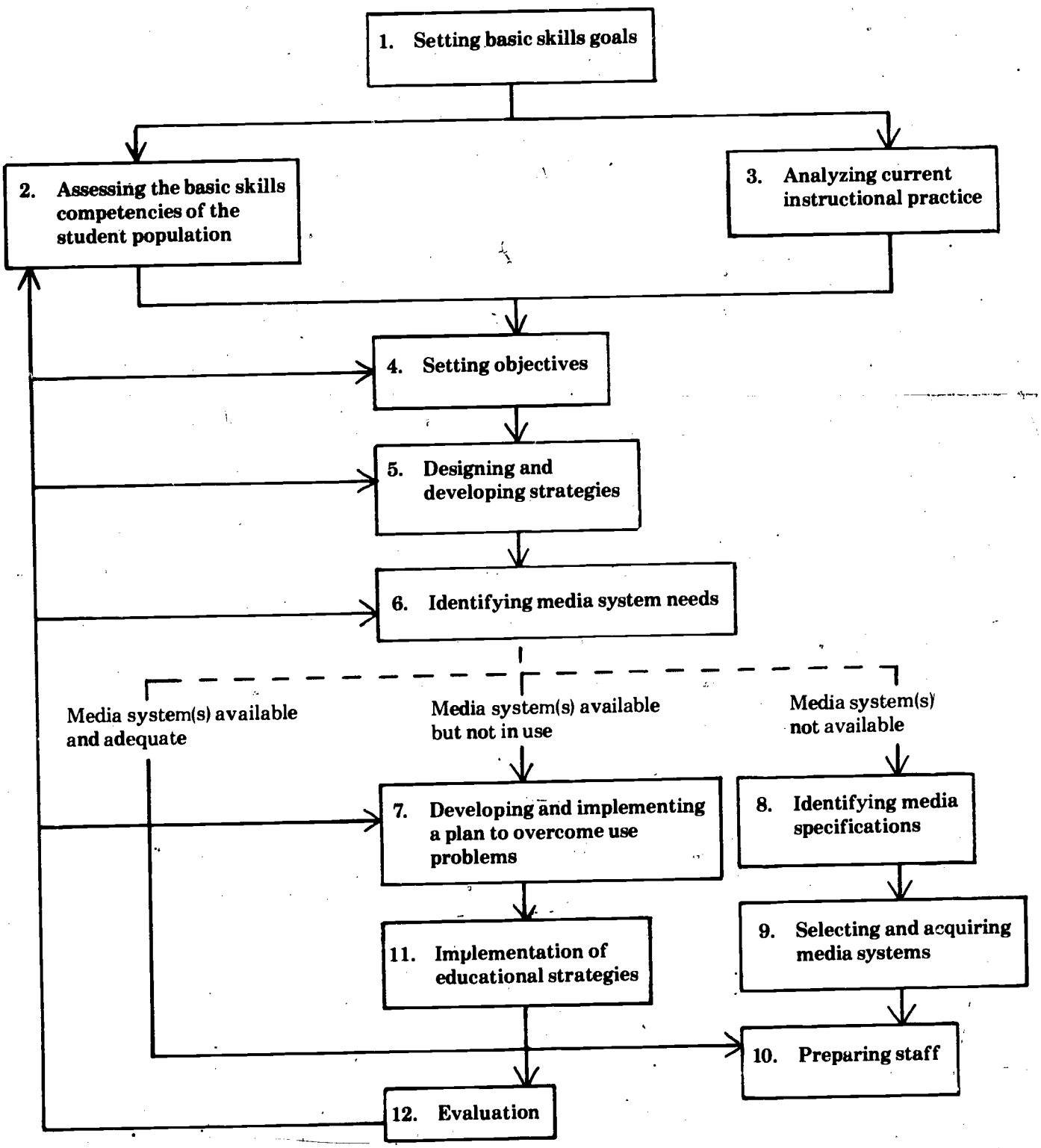
2. Assessing the Basic Skill Competencies of the Student Population

The basic skill competencies and weaknesses of the student population should be measured against the community's goals established in Step 1. Results of the assessment should answer the question: is there a need to improve the basic skills of the students in this system? Although it is unlikely, the answer might be "no"; the school may find that it is meeting basic skills goals, in which case it may choose to continue its program without alteration.

Assessment may be formal, through testing, review of grades, or some other analysis of educational performance, or through teacher, student, parent, or other feedback.

The step is a key one since the needs of students should determine educational strategies, curricula, and media usage.

Exhibit 5. A Decision-Making Process for the Use of Media



3. Analyzing Current Instructional Practice

At the same time as student competencies are being assessed, current instructional practice in the school or district should be evaluated. Decision-makers need to know which of its practices are effective and which are not. Practices that are contributing to the achievement of the community's basic skill goals should be continued. Those that are not must be changed. It is also possible that a current practice which meets limited purposes does not address a school system's broader educational goals, such as enhancing students' critical thinking capabilities or increasing student contact with learning resources. A review of current practice, which can be based on the experience and observations of teachers, administrators and parents, will let decision-makers know what the school is doing to meet community goals, the needs of students and what gaps remain.

4. Setting Objectives

Planning objectives are statements of intent, describing the events that must take place in order to meet a goal. Stated negatively, they describe problems or gaps between what is and what ought to be. The achievement of objectives should mean that a community has moved nearer to goal attainment. For example, a community may agree that all students should attain the knowledge, skills, and understanding necessary for them to function in a computer-based society. Events that must take place to meet this goal might include:

- All students must know about the growing economic, social, and psychological impact of computers on society.
- All students must know about the use of computers for personal, educational, and job-related purposes.
- All graduating students must be skilled in reading, evaluating and adapting computer programs.

5. Designing and Developing Strategies

Strategies are plans for meeting objectives which take into account the physical environment, the number and type of student population to be served, the interests and needs of the faculty, and available facilities, materials and equipment. A plan for meeting objectives will include teaching strategies, e.g., how to teach students about the impact of computers on society, and facilitative strategies, e.g., how to prepare teachers for this task. The repertoire of teaching strategies proposed for meeting an objective should be limited only by the human and financial resources available. Thus, for example, strategies for teaching critical thinking include: 1) integrating critical thinking into one course; 2) into all parts of the curriculum; or 3) developing a separate course on critical TV viewing. Critical thinking may be taught by lecture, discussion, programmed instruction packages, computer programs, or a combination of these.

6. Identifying Media Needs

This step involves two operations: first, identifying the media systems that might be needed to implement the teaching strategies selected and second, evaluating the media systems that are available in the school or district to determine whether any can be used to implement the strategies. All media should be considered in this process, including textbooks, workbooks, film strips, slides, instructional television programs, calculators, and computer courseware. If available media is not being used, an assessment should be undertaken to find out why. Typical reasons are:

- Appropriate materials are lacking.
- Some part of the system is in disrepair.
- Teachers resist use. For example, teachers may feel that calculators should not be used in teaching basic arithmetic.

One of three possible actions will result from media needs identification:

1. If the decision-makers determine that the available media systems are adequate to meet student needs, then implementation of the educational strategies, Step 11, is the next action.

2. If equipment is available but not in use, then decision-makers must identify the factors mitigating against its use and develop and implement a plan for overcoming the problems, as described in Step 7.

3. If equipment is not available, then another series of actions must be taken as described in Steps 8, 9 and 10.

7. Developing and Implementing a Plan to Overcome Use Problems

Of the three most common problems which limit the use of media, it is simplest to resolve the problem of malfunctioning equipment or damaged materials. Even in this case, however, funds may not be immediately available for repair or replacement. Teacher attitude and the lack of appropriate materials demand more complex solutions.

Much equipment goes unused in schools because teachers do not want to, or do not know how to, use it. Since educational strategies which involve media are likely to fail if teachers are not committed to their use, it is in the best interest of decision-makers to involve teachers in planning and to teach them how to use the medium in teaching.

Lack of materials is another, and usually the major, reason why equipment is not used. Although some teachers will develop their own materials, from overhead transparencies to computer programs, most teachers rely on commercially available materials. The quality of such materials is uneven but even more problematic is the lack of criteria for teachers, curriculum coordinators and screening committees to use in evaluating materials. Criteria, such as those described in Chapter VI, will help ensure that the materials selected are appropriate to student and school needs.

8. Identifying Media Specifications

Assuming that the desired media are not on the school premises, specifications for the medium or media to be purchased should be established. Some of the more important specifications include:

Identification of users. The kinds of users should be determined and their approximate numbers estimated. Users might include students, teachers, school administrators, other school staff, town or city government officials, business people, and individual members of the community. If potential users include students, then it must be determined whether they can use the system independently or whether continuing assistance must be provided by an adult. The variety, types and numbers of users will have implications for decisions about requirements for equipment durability, location, and the number of pieces of equipment to be acquired. The answers will have implications regarding the hiring of personnel to aid students and to maintain the system.

Assessment of frequency of use. An estimate of the number of users and the duration of each use should give daily (including non-school hours), weekly (including weekends), monthly, and annual (including school vacations) usage rates. A plan including a schedule for optimal use, with no or limited down-time should be made. Frequent usage by a single student or a number of students will increase durability requirements but can reduce per student hour costs.

Determination of location. The system's location will affect numbers of equipment desired, installation costs, and facility renovation. Therefore, it should be determined whether the equipment will be located in:

- One room, one building;
- More than one room, one building;
- More than one room, more than one building; or
- Perhaps even the homes of faculty and/or students.

School administrators should decide whether portable equipment is desirable or whether the equipment will be fixed in one place. This decision will also have an effect on durability requirements.

Identification of environmental changes. Requirements placed by equipment on the physical plant include:

- Changed or increased electrical power which in turn may require the installation of new power lines or a separate service box. Voltage surges can destroy a computer's memory.
- Modification of walls, ceilings or floors to increase a room's capacity to hold heavy equipment, to install power lines, or to install air conditioning. Heat can destroy the memory in a computer program.
- Installation of coaxial cables and outlets or new telephone lines.

- Installation of some means of discharging static electricity.
- Construction of secure and clean storage areas.

Determination of needs for equipment and material maintenance and repair. All types of equipment need maintenance and repair from time to time, although for some types servicing is more complicated and expensive. Several service contract options are available which should be examined prior to developing formal contract specifications. These are described in detail in Chapter V. Whichever option is selected, a preventive maintenance program should be planned and its cost estimated. Such a program should include covering equipment when not in use; storing electronic equipment in a dust-free environment; and training all potential users, including students and teachers, in careful and safe use. For example, users should be taught to turn the power off when the equipment is not in use. Before requesting service, they should check the following:

- That the equipment is plugged in.
- That the switch is on.
- That the reset button is in the correct position.
- That fuses do not need to be replaced.

9. Selecting and Acquiring Media Systems

If appropriate media systems are not available in the school or district, then decision-makers must set in motion a process to select and acquire the system or systems which have the most value immediately and in the long range. The selection process should include the actions described below.

Identification of available media systems. Some administrators assess the capacity of equipment first and base their decisions on that assessment. Others evaluate available instructional materials first and select equipment that is most compatible with the best materials.

Identification of each system's educational and management uses. This information, as well as that described in the next paragraph, should be found in the system documentation.

Identification of the technical characteristics of each system. Characteristics should include the number of students that can have access to it at one time or over a number of hours, the demand it places on facilities and utilities (i.e., space, electricity, telephone lines, and the like), and the teaching and management resources that each requires.

Identification and evaluation of related materials. Materials that can be used with the equipment should be identified and evaluated.

Determination of costs. All costs associated with each media system's operation should be determined, as described in Chapter VII.

Comparison of benefits and costs. The benefits of each system should be weighed against its costs.

Selection of the system. In selecting the system or systems, consider which one(s) add(s) the most value to the educational program.

10. Preparing the Staff

Although staff development activities may have preceded the acquisition of a new media system, teachers and media specialists should receive in-service training in the use of the equipment and materials after installation as well. Some vendors include staff training as part of the purchase contract, although the quality and usefulness of vendor-provided training should be assessed carefully since it is not always appropriate. It may be advisable to substitute or to expand on this training by encouraging staff participation in local or state user associations.

11. Implementation of Educational Strategies

Once the system has been installed and is available for use in the instructional program, schedules for the use and maintenance of the equipment and materials should be set up. A procedure for monitoring its use and evaluating its effectiveness should also be established.

12. Evaluation

Evaluation can serve a number of purposes, including:

- Determining whether the system is being used for the purposes and to the extent intended and if not, why not.
- Identifying unintended, but new and effective, applications and to document and publicize these.
- Collecting information on the effects of the system in relation to student enrollment, student achievement, cost avoidance, usage by non-school individuals or organizations.

Such information can be used to increase the effective use of the system within the schools, to justify the acquisition of additional equipment, to justify the replacement of ineffective equipment, to improve the design and development of new instructional materials, and to help users and potential users in other schools or districts.

Monitoring and evaluation may also provide a rationale for expanding a school's goals or changing student objectives if it is found that a system offers more opportunities for learning than initially supposed. Student achievement and attitudes, teacher and administrator reactions, and community responses are all resources for making this determination.

Many resources available to educators today can be brought to bear on the serious task of preparing our young people to function in the age of information. In this guide we have focused on just one of these resources, educational technology. We have described the way in which products of technology can be used to instruct, the limitations of those products, and their effect on the learning environment. Throughout the guide we have emphasized the importance of human resources in learning. It is our belief that without the involvement of those human resources in planning, in sharing experiences, in stimulating ideas, and in developing judgment our schools will fail and technology will have been only an empty promise. With the participation of parents, teachers, other school staff, and students, we can begin to realize the full benefits of an educated citizenry.

Appendices

Appendix A: Glossary

Algorithm. Mechanical computational procedure or a computational procedure which uses a formula to determine each term of a mathematical expression.

Authoring System. Software designed to help authors, such as teachers, develop instructional materials for computers. BASIC and FORTRAN are the most generally used authoring languages because they can accommodate a number of instructional techniques.

Bit/Byte. A bit is the smallest measure of computer information. Eight bits make a byte which is the measure used to express the amount of information a computer can store. Thus, 8K means that a computer can store 8,000 bytes.

Cable.* A system that delivers television signals by wire, rather than through the air, thereby eliminating problems of poor reception.

Computer-Assisted Instruction (CAI). Process of teaching in which instructional material is presented on a terminal under computer control and student responses are processed and fed back to the student by the computer. Also called Computer Based Education (CBE).

Computer-Managed Instruction (CMI). Use of the computer to select materials, schedule, test, prescribe, and maintain student records.

Computer Literacy. The ability to control and program a computer for academic, professional and personal uses; to assess the technical qualities and substantive strengths and weaknesses of hardware, software and courseware; and to understand the impact of computers on society, work and education.

Conventional Instruction. Instruction characterized by minimal use of technology and maximal involvement of the teacher, chalkboard and text.

Courseware. Originally designating instructional materials for computer-assisted instruction only; now includes instructional materials for any medium.

Download. Process of relaying data stored in a main frame to a microcomputer, thereby expanding its capabilities.

Educational Technology. 1. The media which are products of the application of science to educational problems.
2.** A systematic approach to solving problems of teaching and learning which includes the development of instructional systems, identification of resources, delivery of resources to learners, and management.

Equipment.** Nonexpendable devices with mechanical parts or electric or electronic circuits that are used in the process of instruction.

Hardware.** Originating in the computer field, now used to refer to all mechanical, electrical or electronic equipment used in delivering instruction.

Individualized Education. Educational objectives and activities designed to meet the needs, interests and abilities of an individual student.

*Definitions from *Electronic Media Directory*, Batten, Barton, Durstine and Osborn, Inc., New York, N.Y., 1981.

**Definitions from Ivan N. Siebert, *A Handbook of Standard Terminology and a Guide for Recording and Reporting Information About Educational Technology* ("Handbook 10"), Washington, D.C.: National Center for Educational Statistics, 1975.

Interaction. Communication between two people or between a person and some sort of technology.

Interactive Media. Media that have the capability to involve the student actively in the program of instruction, the student actively responding to a medium, the medium actively responding to the student.

Main Frame. Computers with the most power and largest memory capacity of any of the types of computers.

Materials.** Resources used in the process of instruction. These resources are usually consumable and, in our usage in this guide, require equipment for viewing, hearing, or using in other ways.

Media. The means by which instruction is displayed or communicated to the student. The term includes equipment and materials.

Memory. The capability of a computer to store and retrieve information. Varies by computer size and type. *Read Only Memory* (ROM). Capability that is limited to storage and retrieval.

Microcomputer. The smallest of computers and often the type preferred by schools. Self-contained and light in weight, they have smaller memory capabilities and less power than other computers.

Minicomputer. Smaller version of the main frame.

Modem. A device that allows terminal-computer and computer-computer communication over a telephone for the purpose of moving information from one place to another.

Networks. 1.* A group of stations or cable systems linked together regionally or nationally by telephone lines, coaxial cables, microwave relay, or satellite transmission.
2. Two or more microcomputers that are linked together for the purpose of sharing data and devices such as printers.

Peripherals. Devices that can send or receive information when connected to a computer, thus adding to the computer's capabilities.

Program. Instructions, presented in a language a specific computer can understand, the purpose of which is to describe the process the computer is to perform. Programming languages include PILOT, BASIC, Pascal and FORTRAN.

Programmed Instruction. Technique of presenting instruction in short, sequential segments. Media used is generally print, although computers and other media also use this technique. *Branching Programmed Instruction.* Technique which addresses the particular response of the learner by referring him or her to next segment or to a remedial segment.

Satellite.* An electronic transmission vehicle located in fixed orbit in space. Used by the Public Broadcasting Service network, cable television, and others to distribute programs to large national audiences.

Software. Originally used in the computer field to mean the programs required for operating computers; now used interchangeably with *courseware* to connote instructional materials used with any equipment or hardware.

Technology. (See Educational Technology above.)

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Appendix C: Resources*

Sources of Instructional Material

COMPUTER SOFTWARE

School Microware - a directory of educational microcomputer software.

School Microware Reviews - a review of software by educators.
P.O. Box 246, Dresden, Maine 04342

Robert Purser's Quarterly Magazine
P.O. Box 466, El Dorado, Cal. 95623

Datapro Research Corporation
1805 Underwood Blvd., Debran, N.J. 08075

INSTRUCTIONAL TELEVISION PROGRAMS

Most of the instructional television that is produced in this country is distributed by:

Agency for Instructional Television (AIT)
Box A, Bloomington, Ind. 47401

Great Plains National Television Library
Box 80669, Lincoln, Neb. 68501

Children's Television International
Skyline Center, Suite 1207, 5205 Leesburg Pike, Falls Church, Va. 22041

The Director of Instructional Television of local public broadcasting stations is also a good resource.

*The resources listed here are not comprehensive. As educators become increasingly involved with educational technology, new resources become available to meet their needs. The authors recommend that readers maintain contact with their state departments of education, university media departments, and professional associations for the most current information.

AUDIO-VISUAL

Educational Film Locator
R.R. Bowker Co.
1180 Avenue of the Americas, New York, N.Y. 10036

The Audio Visual Equipment Directory
National Audio Visual Association (NAVA)
3150 Spring St., Fairfax, Va. 22301

Index to Filmstrips, Index to Transparencies, and others for almost every type of audio-visual media.
National Information Center for Educational Media (NICEM)
University of Southern California, University Park, Los Angeles, Cal. 90007

Organizations

COMPUTER USERS

Association for Computing Machinery (ACM)
1133 Avenue of the Americas, New York, N.Y. 10036
ACM consists of special interest groups that focus on particular aspects of computing, such as the Special Interest Group on Computer Science Education (SIGCSE), Special Interest Group on Computer Uses in Education (SIGCUE), and ES3, a subcommittee on elementary and secondary schools. Among its task groups are:

Administrators and School Boards
249 High Street, Hartford, Conn. 06103

Microcomputer Groups
Department of Computer Science,
University of Oregon, Eugene, Ore. 97403

Association for the Development of Computer-Based Instruction (ADCIS)
Western Washington State College,
Bellingham, Wash. 98225

Association for Educational Data Systems (AEDS)
1201 16th St., N.W., Washington, D.C. 20036

CONDUIT
P.O. Box 338, Iowa City, Iowa 55240
An information source that also reviews and tests computer-based instructional materials and publishes a newsletter, *Pipeline.*

International Council for Computers in Education (ICCE)
Computer Center, East Oregon State College,
La Grande, Ore. 97850
Publishes *The Computing Teacher* and functions as an umbrella organization for educational users groups such as:

Computer Using Educators (CUE)
Run by teachers on a volunteer basis, it has a resource center and a software swapping library and publishes an informative newsletter.
Membership: Don McKell, Independent High School, 17776 Education Park Drive, San Jose, Cal. 95133
Newsletter: Mountain View High School, Mountain View, Cal. 94001
Softswap exchange: Ann Lathrop, San Mateo Eduational Resources Center Library, 331 Main Street, Redwood City, Cal. 94063

Northwest Council for Computers in Education
(Same address as ICCE)

Ontario Society for Microcomputers in Education
Unit for Computer Science, McMaster University, Hamilton, Ontario, Canada L8S 4K1

Texas Computer Educators Association
7131 Midbury, Dallas, Texas 75230

MACUL
33500 Van Born Road, Wayne, Mich. 48184
An organization of educators interested in the educational application of computers. They produce newsletters and journals and hold several conferences per year.

Microcomputer Education Applications Network (MEAN)
Suite 800, 1030 15th St., N.W., Washington, D.C. 20005
A new organization that plans to develop and disseminate software for educational applications.

Society for Applied Learning Technology (SALT)
50 Culpepper St., Warrenton, Va. 22186

INSTRUCTIONAL TELEVISION

The Corporation for Public Broadcasting
111 16th St., Washington, D.C. 20036

National Association of Educational Broadcasting (NAEB)
1346 Connecticut Ave., N.W., Washington, D.C. 20036

The Public Broadcasting System
475 L'Enfant Plaza, S.W., Washington, D.C. 20024

CALCULATORS

The Calculator Information Center
1200 Chambers Road, Columbus, Ohio 43212
Publishes resource lists ("information bulletins"), guides, reports ("reference bulletins") on the educational use of calculators.

AUDIO-VISUAL MEDIA AND MEDIA IN GENERAL

Association for Educational Communications and Technology (AECT)
1126 16th St., N.W., Washington, D.C. 20036

Library Information Technology Association (A subdivision of the American Library Association)
50 E. Huron St., Chicago, Ill. 60611

National Audio Visual Association (NAVA)
3050 Spring St., Fairfax, Va. 22301

National Information Center for Educational Media (NICEM)
University of Southern California, University Park, Los Angeles, Cal. 90007

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