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ABSTRACT

This paper describes a narrow-band satellite application for facilitating a Computer-Based Education Utility (CBEU). A review of computer uses in education is presented with an emphasis on interactive computer applied to instructional processes. An example of major use of the CBEU focuses on meeting the educational needs of handicapped children, first by inservice teacher education followed by direct instruction to handicapped children via CBEU. Less than 40 percent of the handicapped children who require special education programs in the United States are receiving an adequate education. A plan is presented to provide a flexible "on-the-job" CBEU with a curriculum enabling inservice elementary teachers to learn how to teach mildly handicapped children. The plan described in this paper would make tested curriculum materials available to inservice teachers through Education Centers established by Regional Sponsoring Agencies. It would also create the opportunity to expand the curriculum for practicing teachers into other needed skill areas and eventually provide direct instructional service to handicapped children. A selected bibliography is also provided. (Author/WBC)

Interactive Computer-Based Education

For Satellite Application

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INTERACTIVE COMPUTER BASED EDUCATION
FOR SATELLITE APPLICATION

by

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Abstract

This paper describes a narrow-band satellite application for facilitating a Computer-Based Education Utility (CBEU). A review of computer uses in education is presented with an emphasis on interactive computers applied to instructional processes. An example of major use of the CBEU focuses on meeting the educational needs of handicapped children, first by inservice teacher education followed by direct instruction to handicapped children via CBEU. Less than 40 per cent of the more than 7,000,000 handicapped children who require special education programs in the United States are receiving an adequate education. Approximately 1.3 million elementary classroom teachers must be prepared to provide appropriate educational experiences for mildly handicapped children when they enter regular classrooms as they inevitably do. Legislation and litigation in all 50 states of the union generally termed "right to education" laws have created a new thrust in basic education making additional training imperative. A plan is presented to provide a flexible "on-the-job" CBEU with a curriculum enabling inservice elementary teachers to learn how to teach mildly handicapped children. Approximately 100 clock hours of individually adaptive computer-based education curriculum have already been used by over 10,000 preservice and inservice teachers to learn

these important skills. The plan described in this paper would make these tested curriculum materials available to inservice teachers through Education Centers established by Regional Sponsoring Agencies. The plan would also create the opportunity to expand the curriculum for practicing teachers into other needed skill areas and eventually to provide direct instructional service to handicapped children.

Statement of Objectives

Objectives of this document are as follows:

To present a workable plan that meets a nationwide need for educational services through the application of computer technology and satellite communication to the instructional process. To define a continuum of instructional activities, instructional processes within those activities, and the technological requirements of computer-based education.

To define the role of a local group in establishing and operating a computer-based education center (CBE Center) (requiring a minimal investment of resources and technological expertise) which can provide educational services to communities of varying sizes.

To summarize the benefits of a CBE Center to a regional sponsoring agency, learners, and to the nation and society.

Overview

The focus of this paper is on the interactive uses of computers in the processes of instruction. Combining computer technology in a interactive mode with satellite technology overcomes many contemporary problems which were experienced when communications technology was applied to an educational situation. Computers used for instruction in an interactive mode provide the advantages of (1) individually scheduled and individually paced instruction, (2) availability of a pool of instructional materials delivered as needed to a given computer terminal, and (3) personalized active participation and high motivation of learners during instruction.

<u>Interactive</u> means that the learner (at a computer display) and the computer display are acting reciprocally to change the behavior of the

learner and the computer display. For example, the computer can present material to a learner and request a response to a question. The specific response that the learner gives to that question will then determine the selection of the next material that is presented by the computer to the learner. The interactive process provides a sequence of instructional events individually tailored to the needs of each learner.

This paper discusses computer concepts and definitions, a continuum of computer uses in instructional activities, the function of the computer in specific instructional processes, computer-based education as an educational utility, satellite application for nationwide computer-based teacher education, long term usefulness of a computer-based education utility, conclusions and recommendations, a glossary of terms, and a bibliography.

Deliberately excluded from this paper are administrative applications of computers, information retrieval systems, and the use of computers as calculators for solving numerical problems. Although each of the excluded applications are extensively used and make important contributions to Education, they are not a part of the direct instruction process and therefore have been excluded here.

Computer Uses in Education

We assume that the reader is more likely to be a specialist in communication technology than a specialist in the use of computers.

Therefore, the first part of this paper develops basic concepts needed to define the potential of computers in the education process. A glossary of common computer terms in education is included at the end (Blum, 1971).

Computer Concepts and Definitions

Computers have three characteristics in common with many other machines found in homes and schools: (a) a mechanism or facility for inputting the problem to be solved or the work to be done, (b) internal facilities for processing the information or solving the problem, and (c) facilities or functions for providing the solution (output) of the problem (Gielow, n.d.). One analogy is the automatic washing machine--the task is to convert dirty clothes into clean clothes. Dirty clothes and solvent are the input; the pre-determined wash, rinse, and spin cycles (or program) built into the machine by the manufacturer is the processing; and the clean clothes are the output. A desk-top calculator is another working machine closely related in function and processing to computers. The inputting facility consists of the keyboard and function keys; the processing is the adding, subtracting, multiplying, and dividing done by the machine at the specific direction of the user; and the solution, or output, is provided to the user on an electronic display or printed on paper.

Similarly, the computer solves problems (by accepting data and performing prescribed operation on those data) and supplies the results of these operations to the user. A computer system is equipped with hardware devices to perform specialized tasks--card reader/punch, line printer, tape drive, disk drive, and central processing unit for receiving, processing, storing, and delivering results to the user. Additional hardware devices are sometimes required to "interface", or connect, all the devices together. A computer program called an operating system is used to schedule and control each hardware component and operate the entire system.[1]

Advantages of using computers in education. The speed of computers is one of their main advantages. For example, a trained person with a desk calculator could in ten seconds add two four-digit numbers. A medium size computer appropriately programmed and fed data could in the same ten seconds add one million four-digit numbers. Stated in another way, an individual with a desk calculator would take one hundred days to do what a computer can do in ten seconds, and that does not include time for sleeping, eating, or pencil sharpening. Such speed makes it possible to provide input and display services never before possible.

Accuracy is another reason for using computers in education. Once a need has been defined and a program written and refined for meeting that

[1]The reader without a technical background in computer science, but wishing more depth than can be provided here is referred to a little book entitled, The Way Things Work--Book of the Computer, 1974, Simon and Schuster, New York, 245 pp.

need, the computer will continue to accurately meet the need each time it is instructed to do so. For example, a computer can, when properly programmed, balance 10,000 checking accounts in ten seconds without error.

A third advantage of using computers is the analytical discipline required for the development of programs that teach. Because a computer can make only one decision at a time based on information provided by the program, one must first analyze the problem and then define the solution in minute, step-by-step detail so that at no point in the solution process is there more than one choice to be made between two options. Then step-by-step instructions must be written to tell the computer specifically what to do at each stage of a processing task. The forced application of such discipline requires the user to analyze his task carefully. Such analysis often sharpens the user's thinking and helps re-define the needed output.

A fourth characteristic of the computer in education is versatility. A computer can receive data through its input devices, store it for later use, manipulate and modify the data in a variety of ways specified by computer programs, and output it to the user upon request (Gielow, n.d.).

Classification of computer use. Available computer technology--both hardware and software can provide a variety of access to the system. Access is minimized when the user submits a deck of punched cards with the appropriate data and program and receives the output from the computer

in the form of printed paper several hours or days later (batch processing). On the other hand, the power of the computer may be instantly and continuously available to the user through a remote terminal located at a distance from the computer system, with a wide variety of capabilities for modifying ongoing processes (real-time processing) in education. Somewhere between these two extremes are numerous input/output devices and a range of "turn-around" times that meet the needs of varying instructional applications. To choose among these alternatives requires an evaluation both of the required "turn-around" time and the cost/benefit relationship.

Batch processing (the only operating method available on early computers) requires similar input items to be grouped for processing during the same machine run. The standard home washing machine operates in a batch processing mode, i.e., all of the similar items, say, dark clothes, are grouped together for washing (processing) and the light, delicate fabrics are grouped in a similar way for a different wash cycle (program) at a later time. With computers the necessary batch data are either punched on cards and physically delivered to the machine or transmitted to the computer through a communications unit and stored for later processing. In a similar fashion, the output from batch processing is usually printed on paper and physically delivered back to the user.

Time sharing is a method of operation in which a computer facility is shared by several users for different purposes at (apparently) the same time. Although the computer actually serves each user in sequence, its speed makes it appear that the separate users are all served simultaneously. Time-sharing supplemented by communication links distributes computing power to users in a wide geographic area, provides potential for extended use of computing power, and makes available a whole new range of applications for computers.

The concept of real-time computer use is an extension and refinement of the time-sharing concept. The critical additional characteristic of real-time operation is that computing on decision-making takes place concurrently with another process such as instruction so that the computing results can be used to guide the operation of the instructional process. The computer and instruction activity are interacting with each other--each modifying the other.

Computer-Based Education

Real-time computer processing has made possible computer-based education (CBE). It is important to recognize the different applications of computers in teaching which are referred to collectively as computer-based education. The continuum of instructional activities to which computer technology has been applied include the following: (a) management of instruction; (b) tutorial instruction; (c) drill and practice; (d) instructional games; (e) simulation; (f) modeling; and (g) inquiry. Each of these instructional activities employs the computer in a different role and makes differing demands on the power and sophistication of the computer system and terminal devices (Table 1). Computer-managed instruction in its least complex application is relatively simple, relying principally on the recordkeeping and summarizing power of a computer. Frame oriented tutorial instruction presents instructional material to the learner, accepts and judges responses from the learner, and alters the flow of subsequent instructional materials based upon the learner's responses. The frames of material are predetermined and stored in the computer for use according to the algorithms of the instructional program. Drill and practice and instructional games frequently are generated by the computer according to certain rules and algorithms provided by the author. Simulation, modeling, and inquiry are data base oriented and allow students to access and to manipulate pools of data without that access being precisely predetermined by an author or programmer.

The complexity and power of the computer system and terminals parallel the continuum of instructional activities quite closely. Simple instructional activities (management of instruction) can be implemented with simple terminal devices and relatively small uncomplicated computer systems. The more sophisticated applications (simulation, modeling, and inquiry) require extremely sophisticated terminals and sizeable amounts of computer power. Simple computer terminals include teletype devices and computer-driven typewriters. More sophisticated computer terminals include cathode ray tubes (CRTs) which have the advantages of quiet,

Instructional Activity	Management of Instruction	Tutorial Instruction	Drill and Practice	Instructional Games	Simulations	Modeling	Inquiry
Instructional Function	Assess Diagnose Prescribe Monitor	Present Evaluate Feedback Branch	Consolidate Learning Enhance Retention	Motivate group and cooperative skills	Analyze Synthesize Integrate	Develop Concepts	Discover Hypothesize
Stages of Learning	←—— Acquire	——→	←——	Embed	——→		
					←——	Integrate, test, invent	——→
Locus of Control	←——	Computer	——→				
			←——		Learner		——→
Computer/Terminal Complexity, Power and Sophistication	←——	Simple	——→				
		←——		Medium	——→		
		Sophisticated	——→		←——	Sophisticated	——→
Development Time and Cost	←—— Low	——→					
		←——		Medium	——→		
				←——		High	——→
Student Terminal Time Required	←—— Low	——→					
		←——		High	——→		
					←——	Medium	——→

Table 1. Instructional Characteristics and Requirements of Various Computer-Based Education Techniques.

high-speed display of upper and lower case alphabetical and numerical (alphameric) characters most applicable for drill and practice and instructional games in some content areas. Sophisticated terminals which allow for the display of computer-generated graphics, full-color photographs, and permit the playing of audio messages for the learner under computer control are mandatory for simulation, modeling, and inquiry applications. Tutorial instruction in many content areas also requires sophisticated terminals. As the sophistication of the educational application and the terminal becomes higher, so do the power and complexity required of the computer system. The amount of time that a given student spends at a computer terminal and the amount of effort and resources required for curriculum development also increase as the instructional activity becomes more complex and more sophisticated.

Let us look now in more detail at the integration of computer functions and instructional processes.

Computer Functions and Instructional Processes

Management of instruction. Computer managed instruction can be subdivided into three levels of application (Mitzel, 1974). Level I operates in a batch processing mode and is used to tabulate and accumulate systematic information about marks, attendance, and test performance. The role of the computer is chiefly one of replacing high quality clerical and tabulation services. Level II applications use a batch processing computer with instructor input to accumulate records of student performance and to feedback cumulative records to both the instructor and the student on a scheduled basis. The periodic prescriptive function (feedback) has been introduced at Level II advising students on a differential basis of what they need to do to remove various deficiencies which have been identified by their instructor's evaluation of their performance on learning modules. Level III is characterized by real-time, interactive interface between the learner and the computer and by a diagnostic/prescriptive logic keyed on the student's responses to the material stored in the computer. The power and flexibility of the computer facilitates the instructional processes of assessment, diagnosis, prescription, and monitoring.

Level I applications require simple terminal devices for displaying alphanumeric characters, relatively small amounts of computer power and relatively small amounts of student time "on-line." Level I materials are relatively simple to develop and implement. Since CMI Level I does not provide instruction directly to students, facilities must be provided for on-line testing and off-line work spaces where either individuals or groups of students may receive instruction.

It is important to note that there is a sizeable trade-off for the apparent advantages of CMI. Because CMI depends upon the ability of the learner to provide his own continuity in the assimilation of facts, principles, and concepts from reading and other materials; CMI will be ineffective with learners who do not possess good study skills and habits of concentration. CMI may not work well with the extreme lower portion of the ability distribution in many educational settings.

Tutorial instruction. Computer-based tutorial instruction focuses on the student's acquisition of new facts and concepts and primarily presents new material to the student. Four steps are usually included: (1) stating the item of knowledge that is to be taught; (2) clarifying and elaborating the item in a series of sentences or diagrams; (3) restating the item to improve understanding (frequently requiring the student to apply a rule or generalization); and (4) making a logical transition to the next concept or time to be taught (Rockart and Scott Morton, 1975). Tutorial CBE provides a complex network of individualized instructional pathways through material and can relieve the conventional instructor of the burden of trying to individualize instruction simultaneously for a group of learners. Tutorial CBE requires sophisticated terminals so that graphics, photographs, and audio material can be used in the presentation of the content. Fairly complex response judging capabilities and branching capabilities are required in order to individualize the instruction. Since material new to the learners is being presented for the first time and feedback is provided to the learners in real-time, tutorial CBE requires many hours of student time at the computer terminals.

Experience with tutorial applications show that the time for individual learners varies by a factor of about four to one, depending upon the learner's prior knowledge, study skills, reading speed, and comprehension.

Because the author must plan for a network of multiple individual paths through the instructional material, relatively large amounts of time and resources are required to develop tutorial CBE materials in most subjects. However, since the complete course of tutorial instruction is presented via CBE, student use does not require that a highly qualified instructor be present. It follows from a comparison of CMI and tutorial uses of the computer that some of the continuity in learning that is missing in CMI is present in tutorial CBE. Where the target population of learners includes those with poor study skills or inadequate experience with independent study, tutorial CBE is likely to be more effective than CMI.

Drill and practice. Drill and practice reinforces previously acquired concepts, consolidates learning, and enhances retention and recall. Drill and practice is used extensively where overlearning is required, e.g. mathematic skills, radio code, translation drills for foreign languages, and word matching for pre-readers. Since many of these drills are repetitive in nature, programed algorithms instruct the computer to generate the specific displays presented to the learner. Drill and practice applications which require alphameric displays and alphameric responses can be implemented on simple computer terminals. However, the more sophisticated CRTs provide for silent operation at much faster speeds where speed is important in the drill and practice process. Computer generation of problems and the evaluation of student responses to those problems requires a sophisticated answer processing capability in the computer. Relatively large amounts of student time may be spent at computer terminals, although since the entire instructional process does not take place at the terminal, facilities for individual or group instruction must be provided.

Instructional games. The purpose of instructional games is to motivate students to interact with instructional materials through competition and the motivating force of team play. Instructional games frequently employ secondary reinforcement systems (points, tokens, or candy) which can be useful in developing group and cooperative skills. The terminal requirements for instructional games vary from simple to complex depending upon the content and the display requirements for the game. Obviously, adults require less concrete and more symbolic representations in the displays than children do. The game must be supported by a relatively powerful and sophisticated computer system to provide for all of the contingencies included in the game. Instructional games are relatively complex to develop and usually require a considerable amount of student time on-line. Additional sophistication in both computer and operating systems are required for team games played in real time.

Simulations. Simulations can be used to provide realistic substitutes for natural experiences which might otherwise be impractical, time-consuming, costly, or even dangerous. They can be used to introduce new subject matter or for practicing skills and concepts already learned. Simulations, like modeling, require extremely complex, sophisticated terminals, great amounts of computer power, large amounts of student time on-line, and sizeable quantities of resources to develop the simulations. Military command applications and medical diagnosis and treatment are primary examples of computer based simulations.

Modeling. Modeling is an extreme example of simulation where the model is provided by the student rather than the computer. The student actually controls the rules and structure of the model rather than simply entering values into a pre-existing, unchanging model. The model need not be as realistic or complete as a simulation since the attention of the student is focused on understanding the model situation itself, and not on behaviors which can be directly transferred to a real-world situation. Modeling involves concept learning as opposed to concrete learning and allows the student to develop concepts and natural laws by controlling and manipulating the rules and structure of the model (Dammeyer and Martz, 1976). Modeling requires complex and sophisticated terminals for displaying tabular data, graphs, and charts for the learner. Powerful computer systems are required to process the rules and model changes input by the student, to calculate the effect of the changes on the data and display the results for the learner to view and analyze. Large amounts of resources are required for developing these models and large amounts of terminal time are required by the students in using the models.

Inquiry. Inquiry mode gives a learner direct access to a data base and allows him to ask questions that represent phenomenon he would find in the real world. An example of this application is the "Wooly Mammoth Problem" developed by Szabo and Rhoades (1976). The purpose of the problem is to provide a learning experience in the problem-solving process. The program confronts subjects with tasks requests hypotheses about cause of death of mammoths, and accepts natural language data requests. The requirements for computer/terminal complexity, power, and sophistication; the development time and cost; and the student terminal time required are quite similar to the requirements for simulations and modeling.

Computer-Based Education Utility (CBEU) Via Satellite Communication

We are all familiar with the services and the advantages which are to be gained by relying on general utility companies to meet common needs. Some of these utilities include water, electric, and telephone companies. Metropolitan areas have specialized even more and established utilities for treating waste products and steam companies to provide a central source of heat and power for high-rise apartment and office building complexes. From the user's viewpoint, the large investment in equipment, operational expertise, capital funds, and overhead expenses have been assumed by the utility company.

This paper suggests development of a Computer-Based Education Utility (CBEU) to provide computer power for instructional applications distributed to users via satellite and ground lines. The emphasis is on optimizing the availability of computer-based education to users through the optimum configuration of a central computer, a combination of satellite and land-based communication, and appropriate infra-structures of local, state, and federal agencies. Government subsidy of the CBEU is necessary so that needy users throughout the nation can obtain equal economic access to the utility. The Post Office, airlines and the nationalized railroad are examples of subsidized services. Government subsidy would insure that the cost of the utility is maintained at a reasonable and acceptable level for users. At the same time users pay enough of the cost to provide some control of demand. The commodity provided by the utility company (in this case, computer-based education) must be ready for use at the discretion of the user. The availability of a computer-based education utility (CBEU) distributed by communications satellite would enable each user group to focus its resources on the instructional task and the learner rather than on establishing and running a system of its own.

Great care must be exercised in selecting the central equipment and system for a CBEU just as care is exercised in selecting the central equipment for a telephone or electric utility company. The concept of a utility implies that one utility will provide all of the required services. For example, one electric utility company provides all electrical power whether that current is used for illuminating your living room or driving a steel stamping machine producing the front fender for your new automobile. A single telephone utility is expected to provide service which enables you to communicate with all of your friends who have telephone service whether they are north, south, east, or west of you and whether or not they have a green, white, or blue telephone instrument. Similarly, a computer-based education utility should provide a full range of services to meet different instructional needs -- from sophisticated simulation, modeling, and inquiry modes requiring large amounts of computer power and sophisticated terminals complete with graphics displays, image projection facilities, and audio to the simplest service of instructional management requiring basic terminals and small units of computing power.

A CBEU must be a comprehensive service providing the following applications: (1) management of instruction; (2) tutorial instruction; (3) drill and practice; (4) instructional games; (5) simulations; (6) modeling; and (7) inquiry. The utility should allow a user group to declare its teaching materials as being in the public domain and available to any other user group on the CBEU system or to declare its teaching materials as private and available only to persons designated by the authors. The utility must also provide facilities for users to develop and implement their own instructional materials for the system.

Implementation Plan

Several computer manufacturers provide a computer-based education capability which enables individualized instruction to be offered nationwide via a high-speed computer and long-distance voice-grade communication. Instructional lessons are delivered to students at interactive terminals allowing the student to progress from one unit of a course to another at his own pace. A range of terminals is available from cathode ray tube to sophisticated terminals containing plasma display panels, keyboards, touch sensitive screens, full-color, random-access, microfiche image projection and random access audio playback facilities. Learners respond to questions via keyboards or finger-sensitive panels by touching areas of the display screen.

A single system now available from computer suppliers can provide instruction at 500 terminals simultaneously via satellite communications or long lines throughout the nation. We suggest that modules of four terminals could form a computer-based Education Center which can communicate by means of a single voice-grade communication channel via satellite (or long lines) to a central computer site. Education Centers of

this size can provide over 10,000 clock hours of individualized tutorial instruction per year. The number of individuals to be served depends upon the mode of instruction and the availability of appropriate teaching materials. Several four-terminal modules with additional voice-grade lines could be clustered to form an Education Complex in populated communities. Compatibility of the satellite communications segment with conventional ground lines is assumed in order that the number of sending and receiving stations for satellite communications are minimized into a set of convenient collection points. A single computer system operating 500 terminals simultaneously would support 125 Education Centers providing a total of 1.25 million clock hours of individualized on-line instruction per year.

Regional Sponsoring Agencies (RSA) would be needed to establish and house one or more Education Centers, acquire terminals, recruit and manage students, and coordinate activities with local education institutions to offer appropriate educational credit for the achievement acquired by learners. RSA applies to any group desiring to provide education in a given geographic area. The Appalachian Regional Commission, state directors of special education, federally-sponsored education laboratories and centers, Area Learning Resource Centers, Regional Resource Centers, Native American reservations, intermediate school units, boards of cooperative educational services, local school districts of various sizes, state or federal prisons and hospitals or colleges and universities could all become RSA's to establish and operate Education Centers. Centers should be equipped with an appropriate number of modules to match the needs of their constituent population. RSA's could be located in such geographically dispersed areas as the Rocky Mountains, Hawaii, Puerto Rico, the Pacific Basin, Alaska, and selected urban areas on the continent depending upon the size of a satellite footpad and the number of operational hours per week.

Educational Uses of CBEU

Changing patterns in population growth and an apparent stabilization or reduction of the numbers of youth and adults engaged in full time educational pursuits, suggest that society must, as a whole, look at new educational clientele and new administrative patterns for providing desired educational services to the American people (Vermilye, 1974; Carnegie Commission, 1973, and Cross, 1971). There is a sizeable and growing potential student market to be developed among those who are not traditionally considered to be in the college student pool. The new market includes the fully employed seeking upward job mobility (Flexible Learning System for the Registered Nurse, 1975; Catalog of Available Courseware, 1976; Pondy, 1976); individuals who are geographically, socially, culturally, and educationally isolated; handicapped individuals (Cartwright and Hall, 1974); incarcerated individuals; and learners in our traditional educational environment who are educationally disadvantaged in the basic skills of language (Obertino, 1974) and mathematics (Dugdale and Kibbey, 1975 and 1976). In fact, any individual of any age who is constrained by time or location from participating in traditional education would be well served by a computer-based education utility.

Just as the parameters which define student clientele are changing, so are the parameters which define the content which should be taught. For example, the following subjects appear to be increasingly important in American society but have not yet been accorded an important place in the primary and secondary education curriculum: environmental education; metrication; drug abuse education; second language learning; consumer education; and career education (Computer-Based Career Guidance and Counselor Administrative Support System, 1976; Application Brief, 1973 and 1975); special training for volunteer community workers including firefighters, civil defense workers, first aid workers, and ambulance drivers and attendants; parents, teachers, nurses, physicians, (Jones and Sorlie, 1976; Osbaldeston, 1974), optometrists, barbers, osteopaths, and attorneys, to name a few. Some available CBE courseware in traditional subject matter areas for traditional learners has been catalogued by Lyman (1974) and includes 38 major curricular areas from elementary school to post baccalaureate professional training.

One area of educational need in the United States will receive special attention here because of the magnitude of the problem and the unique contribution that a CBEU can make toward solving the problem -

the education of the handicapped. As an example, we present a plan for using a CBEU to first train teachers to deal effectively with mildly handicapped children in the regular classroom and then focus the power of a CBEU on the process of direct instruction to handicapped individuals.

Satellite Application for Nationwide Computer-Based Teacher Education

Overview

Less than 40 per cent of the more than 7,000,000 handicapped children who require special education programs in the United States are receiving an adequate education. Approximately 1.3 million elementary classroom teachers must be prepared to provide appropriate educational experiences for mildly handicapped children who enter regular classrooms as they inevitably do. Legislation and litigation in all 50 states of the union (generally termed "right to education" laws) have created a new thrust in basic education making additional training imperative. Recent legislation passed by the Congress as PL94-142 puts new resources at the disposal of state and local educators.

This section of the paper proposes a plan to provide a flexible, "on-the-job" instruction delivery system with a curriculum enabling inservice elementary teachers to learn how to teach mildly handicapped children. Approximately 100 clock hours of individually adaptive CBE curriculum have already been used by over 10,000 preservice and inservice teachers to learn these various skills. The plan described in this paper would make these tested curriculum materials available to inservice teachers through Education Centers established by Regional Sponsoring Agencies. The plan would also create the opportunity to expand the curriculum for practicing teachers into other needed skill areas.

Need

Although the seven million handicapped children who require special education programs in the United States represent approximately twelve per cent of the school population, less than forty per cent of them are receiving an education adequate to their needs. Using some of the strongest language to come from the Federal Government on "mainstreaming" of the handicapped, HEW's Office for Civil Rights (OCR) told state and local education agencies (August, 1975) that separate schooling or removal of exceptional children from the regular education environment should occur only when the nature or severity of their exceptionality is such that they cannot be educated in regular classes. Approximately 1.3 million elementary classroom teachers must be prepared to provide appropriate educational experiences for mildly handicapped children when they enter regular classrooms, as a consequence of legislation and litigation in all fifty states of the union. Assuming normal attrition and replacement rates there will be approximately 800,000 teachers nationwide during the next ten years who lack sufficient skills in dealing with mildly handicapped children. Additionally, approximately 200,000 administrators and auxiliary personnel who would benefit from such training will be serving in schools. Allowing for other in-place programs to provide these skills, (e.g. recent federal focus on having all new teachers trained in special education skills), there are approximately 500,000 educators who need training to meet the needs of mildly handicapped children in regular classrooms. The plan proposed in this brief paper would train 500,000 educators over ten years assuming the availability of one or more CBEU's.

The need for retraining of inservice elementary teachers is exacerbated by the current financial "crunch" currently being experienced by school districts. The inelasticity of tax resources is forcing most schools to eliminate services and support programs which were developed to aid teachers in the education of the handicapped. As speech teachers, guidance counselors, and resource rooms are withdrawn from school programs, more and more of the services for handicapped will have to be provided by the regular classroom teachers.

The strategy incorporated into this paper is to provide a flexible "on-the-job" instruction delivery system with an appropriate curriculum making it possible for inservice elementary teachers to learn how to teach mildly handicapped children.

The Curriculum

Under grant support from the Bureau of Education for the Handicapped, USOE, teams of researchers and curriculum specialists led by Professors

G. P. Cartwright, C. A. Cartwright, and M. E. Ward at Penn State University have developed a series of courses to meet this need. The series of self-contained, college-level, CBE courses called CARE: Computer Assisted Renewal Education, helps regular classroom teachers develop clinical sensitivity and diagnostic awareness of the strengths and weaknesses of handicapped and normal children. CARE is principally oriented toward preschool and primary-level elementary teachers because unrecognized problems and resulting lack of remedial treatment at this stage in a child's development may cause the child to be academically retarded by the age of 9 or 10 years, hence the emphasis is on early diagnosis and treatment. However, CARE is also of interest to secondary teachers, principals, administrators, special class supervisors, special education teachers, school nurses, pyschologists, aides, special service personnel, and day care workers. The content of CARE is especially relevant to education personnel who either supervise or cooperate regularly with elementary teachers in groups. Greatest benefit is probably derived from the CARE curriculum when the program is used to "saturate" the staff of a building or of a district. In this instance all of the professionals providing service to young children have a common base of knowledge and procedure.

<u>CARE 1: Early Identification of Handicapped Children</u>. For the purpose of CARE, handicapped children are defined as those children who normally will display deviations from normal behavior in the cognitive,

affective, and/or psychomotor responses. Principal emphasis is directed toward those atypical conditions or characteristics which have relevance for teaching.

The philosophy behind the course is such that teachers are encouraged to look at children as individuals. Course material has been designed to illustrate that the most fruitful approach for improving education is for teachers to deal with the observable behaviors of children. The use of traditional categories is minimal; however, certain terms and concepts related to handicapping conditions are taught so that persons who take the course are better able to communicate with other professionals concerned with handicapped children.

Upon completion of the course, it is expected that participants will:

1. Know the characteristics of handicapped children and be aware of symptoms which are indicative of potential learning problems.
2. Be able to screen all children in regular classroom programs for deviations and determine the extent of their inter-individual differences.
3. Be able to select and use for those children with deviations the appropriate commercial and teacher-constructed appraisal and diagnostic procedures in order to obtain more precise information as to the nature of the deviation.

4. Be able to synthesize information by preparing individual profiles of each child's strengths and weaknesses on educationally relevant variables.
5. Be able to evaluate the adequacy of the information available in order to make appropriate decisions about referral to specialists.
6. Be able to prepare adequate documentation for the case if the decision to refer is affirmative.

It is expected that teachers who exhibit the competencies described in these objectives will systematically evaluate children's learning potential and formulate appropriate educational plans according to the Decision Model for the Identification of Handicapped Children (Figure 1) developed for Care 1.

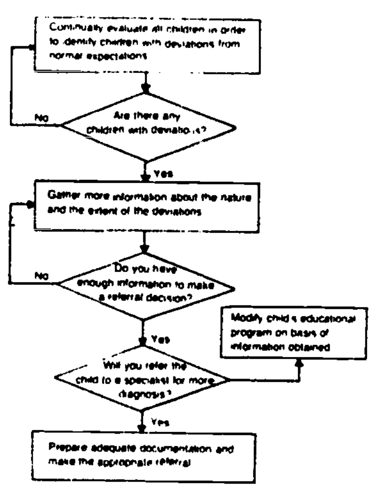


Fig. 1. Decision Model for the Identification of Handicapped Children.

<u>CARE 2 and CARE 3: Diagnostic Prescriptive Teaching of Preschool and Primary Children</u>. CARE 2 and CARE 3 are designed to prepare teachers of preschool children (CARE 2) and teachers of primary grade children (CARE 3) as well as child care workers to work effectively with children who may be experiencing learning difficulties. An important component of the CARE 2 and CARE 3 courses is the Diagnostic-Teaching Model (Figure 2) which provides teaching personnel with an outline of procedures to follow as they deal with children's learning problem both in affective and cognitive areas of the curriculum.

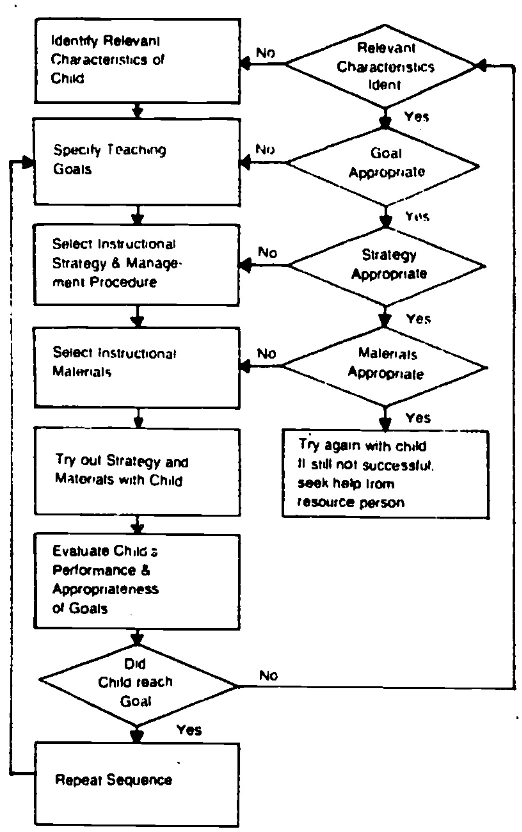
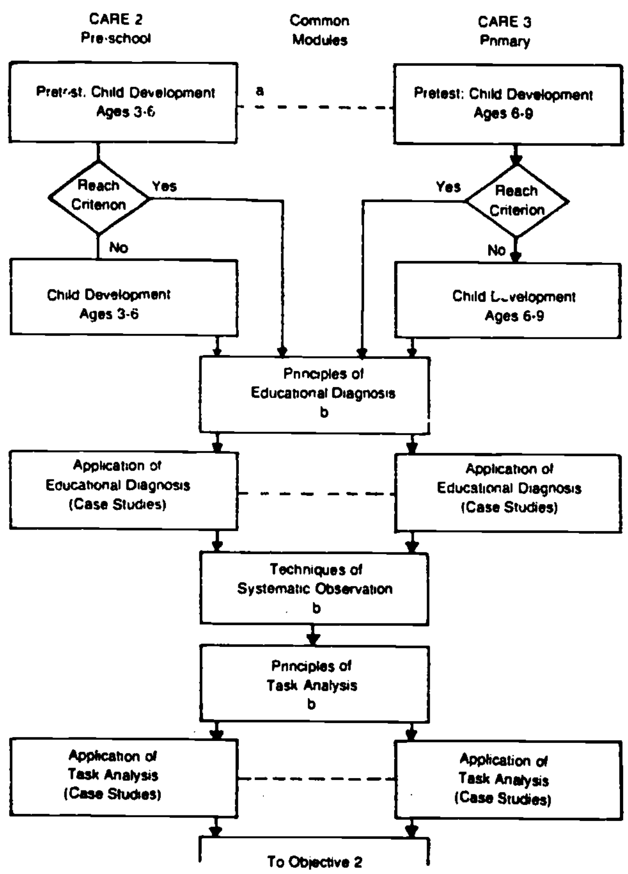


Fig. 2. Decision Model for Diagnostic Teaching

The Diagnostic Teaching Model is applicable to both preservice and inservice training of special educators and regular elementary teachers. The following eight objectives delineate the basic set of global competencies that are required to carry out the model:

1. Identify characteristics of individual children that indicate special teaching or management procedures are required.
2. Specify relevant educational objectives for individual children.
3. Select techniques for effective classroom management.
4. Choose and use specialized teaching strategies for reaching specific objectives for children with varying behavioral and learning characteristics.
5. Choose and use special materials in association with specific strategies.
6. Identify and use appropriate evaluation procedures.
7. Draw upon existing sources of information regarding specialized strategies and materials.
8. Consult with available resource persons for assistance.

A modular approach, illustrated in Figure 5, was used in the development of CARE 2 and CARE 3. Both courses share a core of objectives, information, procedures, and strategies. The examples and simulated case studies in which the students apply the principles, however, are appropriate for the age-group of children to which each is directed.



[a] Dashed line indicates that the same format is used for both courses, teaching strategy (and programing) are the same but content differs.

[b] Basic content and strategies are the same for both.

Fig. 3. Relationship Between CARE 2 and CARE 3 Modules.

CARE 4: Education of Visually Handicapped Children. CARE 4, or Education of Visually Handicapped Children, focuses on teaching children who are partially seeing or blind. The purpose of the course is to equip elementary and secondary classroom teachers and other school personnel with the knowledge and skills necessary to work effectively with visually handicapped children in their regular classes. Content is appropriate for both inservice and preservice teachers.

The course objectives for CARE 4 enable the student to apply the Diagnostic Teaching Model developed for CARE 2 and CARE 3 to the teaching of children with limited vision.

Students who complete CARE 4 are expected to:

1. Identify educationally relevant characteristics of visually handicapped children.
2. Construct instructional objectives for these children.
3. Select suitable media and materials for instruction.
4. Arrange proper classroom environmental conditions.
5. Design instructional procedures to facilitate learning.
6. Utilize appropriate techniques for evaluating performance.

The CARE curriculum is only one aspect of badly needed career inservice teacher education. Other instructional materials at the graduate level could be developed and offered in career education, health education, teaching of reading, energy education, environmental education, drug addiction prevention, nutrition, and adult education. As additional materials become available the system can be used not only for teacher education but for experimentation with direct instruction of handicapped children in the public and private schools of the nation.

Since 1970, CARE courses for preservice and inservice teachers have been delivered by a fleet of mobile vans. These vehicles are self-contained in that both the computer and the student stations are on board. Their use has enabled us to learn a great deal about the target population and about student responses to the curriculum material.

Cost of Computer-Based Education For Inservice Teachers of the Handicapped

At the present time it is impossible to determine an accurate dollar figure for the complete cost of the CBEU envisioned in this paper. However, because a sizeable portion of the costs of delivering an hour of computer-based education to a learner is determined by the communication costs, we believe that an education-dedicated satellite can effectively reduce overall costs and bring major benefits to people in remote areas of the country.

Assuming year-round operation of 125 Education Centers with 500 terminals at maximum enrollment, the proposed system will deliver approximately 1.25 million clock hours of instructional computing per year. Amortized (10 years) annual operating costs (including maintenance) for

computer hardware and central communications gear is estimated to be approximately $520,000. Computer operations and curriculum maintenance are estimated at about $80,000 per year.

Field costs are of two principle types, the initial cost of 500 terminals and their maintenance amortized over a 10 year period estimated at $1,500,000 and the cost of long distance communications which vary, primarily depending upon distance from terminal to central computer. It is these costs which we believe can be significantly reduced by a satellite application. Because it is not anticipated that personnel staffs in Education Centers would be augmented by this program, no additional cost estimates for personnel have been included. Table 2 summarizes the estimated gross costs for 1.25 million hours of instruction comparing long lines and satellite communication facilities.

There is undoubtedly a lower limit in distance between the Education Center and the Central Processor where the satellite ceases to provide a viable cost saving over telephone long lines. We estimate this critical point is between 100-200 miles, but there is no way to pinpoint it without the availability of detailed cost estimates.

Table 2
Estimated Annual Operating Costs
for 1.25 Million Hours of
Instructional Computing Using Two
Different Communications Modes
(Amortized over 10 years)

Cost Category	Long Lines @ Commerical Rates (Tel Pac) Average Distance, 1,000 mi.	Satellite Communication
Central Costs borne by federal subsidy		
Central Processor Equip. and Equip. Maintenance	$ 520,000	$ 520,000
Operating Staff and Curriculum Revision	$ 80,000	$ 80,000
Totals	$ 600,000	$ 600,000
Field Costs borne by RSA's		
500 Student Stations, Communications Equipment, and Maintenance	$1,500,000	$ 1,500,000
Communications	$ 625,000	?
Totals	$2,125,000	?

Long-Term Usefulness of a Computer-Based Education Utility

We have projected a ten-year program for using a CBEU to meet a critical national need: that of the inservice education of teachers and other educators. A question might be posed as follows: "Suppose a half million educators were retrained to provide an adequate education for the handicapped by 1988, what capability beyond 1988 does the CBEU then possess?"

As we see it, the critical need for an inservice teacher education utility would taper off by 1988, but the CBEU could by that time have the capability of providing personalized instruction materials to handicapped children in schools, in institutions, and in their homes. Considerable effort would be required to construct and test carefully articulated curriculum materials for the handicapped. However, gradual phasing down of inservice teacher education would permit gradual phasing up of a major program of instruction for handicapped youngsters. Because the basic CBE curriculum for teachers is already in hand, a 1977-78 start of a CBEU is entirely feasible. Meanwhile as resources become available materials for handicapped persons could be constructed and tested for future implementation. The demand for high quality instructional services for the handicapped will apparently be with us in perpetuity.

Recommendations

We believe that "state of the art" in computer-based education and the growing national need for inservice education of teachers of the handicapped can be brought together in a cost feasible way with an education satellite application. There are, of course, numerous unanswered questions which cannot be answered without extensive studies that go beyond this concept paper. Some examples of questions of interest are:

1. Will Regional Sponsoring Agencies develop the recruiting, credit granting, and administrative support needed to maintain full utilization and cost effectiveness of a CBEU?
2. Can satellite communication channels be subdivided into a sufficient number of non-overlapping voice-grade sub-channels to meet the interactive computing needs of 125 Computer-Based Education Centers?
3. What special buffering equipment is required in order to adapt a computer operating system to the "fractional second" time delays inherent in satellite communications?
4. Would special communication equipment be required to transmit computing services between an Education Center and an earth station or signal receiver/transmitter?
5. Is it feasible to position a satellite in geocentric orbit such that it is possible to

serve Hawaii, Alaska, Puerto Rico, and all of the continental U. S. simultaneously with at least 125 voice grade channels?

6. Would it be desirable to develop curriculum materials for some audiences which employed a combination of video and computer media delivered via satellite?
7. What is the probability and cost of being able technically to expand the systems to 1,000 terminals and then to 10,000 terminals?

Conclusions

An analysis of the proposed plan shows the following potential benefits:

Benefits to Regional Sponsoring Agencies

1. Uniform high quality of educational experiences to prepare regular classroom teachers for mainstreaming mildly handicapped children.
2. An educational facility for continuing the education of teachers year after year.
3. Capability of tailoring educational experiences to meet the needs of local teachers.

4. Growth potential for developing new instructional materials for inservice teachers to meet presently unrecognized needs.
5. Growth potential for developing, testing, and delivering instructional materials for handicapped school-age children.
6. Capability for using sophisticated computer-based education without the requirement and expense of establishing a local technical center, hiring a technical staff and administrative personnel.

Benefits to Learners

1. Flexibly scheduled instruction at locations convenient to home and work.
2. Individually planned instruction that can be varied according to time preferences and tastes.
3. Instruction when and where qualified personnel are not now readily available.
4. Adaptation of instruction which can include variations in:
    a. speed with which courses are completed.
    b. instructional method - tutorial, drill, or simulation.

c. depth of interest on the part of the learner.

d. remedial choices and enrichment excursions.

e. diagnosis of individual errors and assignment of remediation.

f. immediate feedback.

g. modification of instructional strategies to match learner competencies.

5. Increased opportunities for independent, self-paced study.

6. Rich variety of courses and styles of instruction.

7. Improved job performance and better relationships with handicapped learners.

Benefits to the Nation and Society

1. Retrain approximately one-half of the nation's elementary teachers with mid-career needs in the teaching of handicapped children.

2. Decrease in the time required by teacher/students to learn specific modules of information.

3. Capitalize on the capabilities of available technology.

4. Release faculty time from rote instruction for curriculum development, individual advising and counseling of students.

5. Utilize quality instructional programs which deliver a uniform product.
6. Integration of available technology to produce desired objectives.
7. Enlarge the market for instructional materials and instructional media.
8. Advance productivity in teaching and thereby increase cost effectiveness.
9. Support research and development on CBE that will enhance progress in other segments of education.

GLOSSARY

(Blum, 1971)

For additional information the reader is referred to the following:

USA Standard Vocabulary for Information Processing, American Standards Association Institute, New York, 1966.
Automatic Data Processing Glossary, Bureau of the Budget, U.S. Government Printing Office, Washington, D. C., 1964. PREX 2.2:AU8/2.

Batch processing: A method of processing in which a number of similar input items or programs are accumulated and processed together.

Branching: Altering the sequence of a program when some predesignated event occurs. Providing a change in instructional procedure as a result of an individual's performance.

CAI: Computer-Assisted Instruction; computer-aided instruction; computer-augmented instruction. Narrowly defined, it refers to tutorial or programmed instruction; defined broadly, it encompasses all instructional computer usage.

CMI: Computer-Managed Instruction. Computer administration of instructional activities. Includes grading, assignment of individual student study programs, and clerical chores.

Core: The rapid-access memory of a central processing unit; usually made up of many small rings (cores) of magnetic material, which may be in either of two states of magnetic polarization.

CPU: Central Processing Unit. The central section of a computer, including control, arithmetic, and memory units.

CRT: Cathode-Ray-Tube. In common use as a display device.

Debug: To locate and correct errors in a computer program.

Dialogue: Tutorial mode usage in which the student assumes greater control over the selection and sequencing of messages that make up the conversation. Program files and algorithms must anticipate and respond to student queries.

Digital Computer: A device that uses digits to express numbers and special symbols in calculations and other information processing. The most common type of computer.

Disk: A storage device resembling a phonograph record and coated with magnetic material for retention of information. Bits can be stored upon it and read while revolving at high speeds.

Down-Time: Time when a machine is not available for operation because of machine failure.

Drum: A cylinder coated with magnetic materials for the storage of information. Bits can be stored upon and recovered from it while it is revolving at high speeds. Data transfer is usually faster than with tapes or disks.

EDP: Electronic Data Processing.

Execution time: Time during which the computer is actively processing the user's job. Roughly equal to "connect-time" in batch-processing, it is only a small fraction of it in multiprocessing.

File: Any collection of similar items of information, whether stored on tape, disk, drum, cards, or in core.

Flowchart, or flow diagram: A graphical representation of the sequence of operations in a computer program by means of a block diagram.

Hardware: Computer components and equipment.

High-speed: Input/output devices whose read/write speed is compatible with the speed of data processing by the computer and can be used on-line.

Information retrieval: A branch of computer science which deals with storing and searching large quantities of information.

Input device: One that brings data to be processed into the computer, such as a card reader, tape reader, keyboard, etc.

Interactive mode: Computer use in which particular attention is given to the interaction between the user and program (or system). The user's responses select various branches in the program while it remains active in the computer. For effective use response times of ten seconds or less are necessary.

Interface: A shared boundary; for example, the boundary between two subsystems or two devices. An interface unit in a remote terminal computer system is a hardware component which "matches" devices to each other; for instance, a computer to several telephone lines from remote terminals or a remote station to a telephone line. The unit may contain buffer memory, switching logic, and/or multiplexing facilities.

I/O: Input/output of information to and from computers. Usually refers to devices such as electric typewriter, card reader and punch, paper tape reader and punch, etc.

Language: A set of symbols, characters and words; their definitions and rules for usage in communicating with the computer to perform desired operations.

Latency: In a serial storage device, the time required to find the first bit in a given location. Can also refer to the elapsed time from the display of an instructional stimulus to the start (or completion) of a student's response. Frequently used as a measure of student performance in educational research.

Library: A collection of programs and routines, usually tested and applicable to many varied uses. Every well-equipped computer center has one.

Light Pen: A photosensitive device used for communication with a computer. When held against the face of a cathode-ray-tube, its position can be sensed. For instance, if the computer is suitably programmed, the position of the light pen can be interpreted in terms of a coordinate grid. The device can be used in this way to enter arbitrary graphical information, sketched by the operator on the CRT, into the computer memory in digital form.

Machine language: A combination of binary digits which can be read directly by the computer without further processing and signifying basic operations such as add, compare, store, etc.

Magnetic core: See "core."

Monitor: The program to control the operation of the routines that comprise the schedule of machine runs in order to use computer time most efficiently.

Off-line: Processes or devices not under the control of the CPU or when used independently of the CPU.

On-line: Devices connected directly to the CPU or processes performed under its control.

Operating system: The collection of programs that direct or supervise the utilization of processing components and the execution of other programs. (See "software".)

Output device: One that translates data stored in the computer into usable information, such as card and tape punches, tape recorders, and line printers.

Plasma panel: A flat, gas-filled panel for graphic display by computer-activated gas discharges.

Processor: CPU. Also a program that will compile, assemble and execute a source program.

Program: A plan or procedure for the automatic solution of a problem by the computer. Also the list of instructions that accomplishes this.

Programming language: Any system of instructions for presenting programs to the computer. (See "language.")

Random access: Access to storage in which the next location from which data are obtained is independent of all previous locations accessed. Storage for which access-time is approximately the same for all locations.

Real-time: Performance of data processing during the actual time the physical process producing the data takes place, in order that results of the computation can be used to guide the physical process.

Remote access: Use of a computer through I/O equipment distant from the CPU, generally through the medium of a telephone line or microwave link.

Simulation: Computer usage in which the output simulates experimental results, random processes, etc.

Software, computer: Computer programs, as contrasted to hardware.

Software, instructional: Curriculum materials as contrasted with educational facilities.

Station: One of the input or output points on a communications system.

Storage: The capacity of a computer to save information for future use. Also the devices that save the information.

Student station: I/O equipment designed for student use, to permit the student to interact with the computer.

Teaching logic: Pattern or strategy for instruction; each author language usually implies another logic.

Teleprocessing: A form of information handling in which a data-processing system utilizes communication lines between stations and the processing unit (computer).

Terminal: A device attached directly to a computer through telephone lines, cables, or other communications links, and designed for user-computer interaction. Terminals may be located adjacent to the computer or at a remote location.

Time-sharing: A method of operation in which a computer facility is shared by several users for different purposes at (apparently) the same time. Although the computer actually services each user in sequence, its speed makes it appear that the users are all handled simultaneously.

Translator: A program that accepts statements or instructions written in one language and produces statements written in another language, or produces direct instructions to the computer for execution.

Turn-around time: The time required for completion of a job from submission to receipt of final results.

Tutorial mode: Instructional computer usage in which the machine converses with the student. More narrowly, that usage in which the author maintains the initiative by defining objectives and describing the subject matter in detail.

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