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ABSTRACT

TO DEFINE THE DOMAIN OF INTERACTIVE USES OF COMPUTERS FOR INSTRUCTION AND TO CHARACTERIZE THE VARIETY OF CURRENT ACTIVITIES IS THE PURPOSE OF THIS GUIDE. DIVIDED INTO SEVEN SECTIONS, THE GUIDE PROVIDES AN INTRODUCTION AND A DEFINITION OF COMPUTER TERMS AS USED WITH INSTRUCTION. ONE SECTION DEALS WITH A VARIETY OF USES, ANOTHER WITH A VARIETY OF LESSONS, SYSTEMS AND LANGUAGES, AND ANOTHER WITH LITERATURE SURVEYS, REVIEWS AND BIBLIOGRAPHIES. THE LAST TWO SECTIONS DEAL WITH SINGLE MEETINGS, CONFERENCES AND SYMPOSIA; PROFESSIONAL ORGANIZATIONS, PUBLISHERS AND COMMERCIAL INFORMATION SERVICES. IT CONCLUDES WITH TWO APPENDICES AND A BIBLIOGRAPHY. (GC)

A GUIDE TO THE LITERATURE ON INTERACTIVE USE OF COMPUTERS FOR INSTRUCTION (SECOND EDITION)

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I. INTRODUCTION

Since the computer may have an important role in any independent study program of the future, it is useful to establish a framework for information about this new technology of teaching and learning, and to provide a list of information sources. This paper defines the domain of interactive uses of computers for instruction (in Section II), and characterizes the variety of current activities (in sections III and IV). However, the reader who wishes a more general introduction might consider the following articles:

> "Special Feature: Computers and Education" (four articles), *Computers and Automation,* Vol. 18, No. 3, March, 1969, pp. 16-34.
>
> "Special Report: Computer-Assisted Instruction," *Nation's Schools,* Vol. 82, No. 4, October 1968, pp. 49-68.
>
> "Computer-Assisted Instruction" (five articles), *Datamation,* Vol. 14, No. 9, September 1968, pp. 22-47.
>
> "Special Report on Technology for Education," *International Science and Technology* (now *Science and Technology*), August 1967, pp. 29-97.
>
> "Information" (an entire issue), *Scientific American,* Vol. 215, No. 3, September 1966. Reprinted by W. H. Freeman & Co.

The field of computer applications in education is now characterized by rapid technological development and continuous change in the state-of-the-art. It is not sufficient to list only current books and articles, as is done in sections V and VI, so some likely sources of future publications also have been included in section VII. For convenient reference, a glossary of terms and a list of typical projects have been added as appendices to this paper.

II. DEFINITION

A. Numerous Acronyms

The uses of the computer as an instructional aid have been represented by a number of acronyms, including CAI, CBI, CMI, CAL and CAE. These different initials and labels associated with various interactive uses of computers for instruction are confusing and can be misleading.

Computer-assisted or computer-aided instruction (CAI), adopted by IBM in their early writing about instructional systems, is probably the most commonly used acronym at this time, while System Development Corporation and later Stanford University and RCA have used the term computer-based instruction (CBI). Computer-assisted learning and computer-augmented learning have been suggested as being more descriptive of the variety of uses intended to aid the student in the learning process; the resulting acronym (CAL), however, introduces further problems due to its use in association with two computer languages, a conversational algorithmic language for interactive computing developed at the Berkeley campus of the University of California and a course-author language for automated instruction developed at the Irvine campus.

Other terms and acronyms, such as computer-assisted education or computer-augmented instructional systems, have been used to imply a broader range of concern. Computer-augmented education (CAE) is the term used by the US Naval Academy. Some of the projects emphasize teacher use of the computer to handle performance records and curriculum files, and use the label "computer-managed instruction" (CMI). This implies that the student does not receive instruction directly from the computer, but that various non-computer media are "managed" or scheduled for him by his teacher with the assistance of automatic data processing.

The Educom Task Force on Educational Systems and Technology on occasion discussed this nomenclature problem but did not produce any satisfactory recommendation for the field. Acronyms tend to become associated with one manufacturer, computer system, or research and development project; it is just as well if they are not used to describe the entire field. This survey considers a variety of applications including computer assistance in the preparation of materials, the management of instruction, the execution of instruction research, individual study or research by the student, and author-directed instruction of the kind usually called CAI.

B. Glossaries

There are many glossaries of terms covering computing and information processing, and some of them can be obtained from computer company representatives. A list of definitions and references is available from the American Standards Association, 10 East 40th Street, New York, N.Y. 10016. A glossary of terms in the area of computing *(Automatic Data Processing Glossary)* was prepared by the Bureau of the Budget in 1962 and is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. for 40¢. It was reprinted in the

Automated Education Handbook in 1965, but a glossary exclusively concerned with interactive use of computers needs to be written. A draft is attached as Appendix A.

C. CAI and PI

One of the frequent questions asked by educators concerns the relation of CAI to programed instruction. One safe answer to such questions would be that it depends a great deal upon the kind of CAI to which one is referring (e.g., testing, computation, or computer-controlled interactive instruction) (Rogers, 1968). In addition, opinion about programed instruction. (PI) suffers from problems which result from casual naming and inadequate definition. If PI is considered a medium, that is, a format for printed instructional materials, then it is distinct from CAI as a medium for presenting materials with an electric typewriter or electronic display screen (cathode ray tube) connected to a computer. However, a large part of the material now available for use with computers confuses this distinction and looks very much like computerized versions of programed texts, slides or audio tape. Only some of the computer-based exercises emphasize dynamic interaction, computation, or other information-processing functions that cannot be readily provided by the lesson author in paper-and-pencil format at much less cost.

On the other hand, if programed instruction is interpreted not as a medium but as a strategy for the development and validation of instructional materials, it is a strategy which may be applied to development of materials in various media such as textbooks, workbooks, laboratories, films, computer-controlled audio-visual materials, simulated environments, and even general-purpose, problem-solving environments. This review provides brief summaries of the various interactive uses of computers, some of which depend on strategies derived from programed instruction (such as frame-by-frame specifications) and others which look like straightforward use of the computer as a tool for computation, information-processing or graphic-manipulation.

III. VARIETY OF USES

Numerous categories have been devised for classification of the interactive uses of computers. The following references represent only a few of the classifications developed to date; it is not necessary to identify the best or most useful classification at this time: Suppes, 1967; Bryan, 1969; Stolurow, 1969; Report of a Working Party, 1969, and Feldhusen and Szabo, 1969. However, clarification of the criteria used for such classification or the underlying assumptions from which the categories have been derived have not been obvious in the literature. Therefore, it seems more useful to identify several dimensions of use (such as program control and author prescription) than to enumerate modes of interactive computer uses; both approaches, however, are used here to represent the great variety of computer uses.

A. Dimensions of Use

Program Control. A significant dimension which should be considered in the selection of curriculum procedures for a particular project is that of control. Computer-based lessons differ in terms of the control the writer has over the student's course of study. At one extreme the student can only follow the program; typically he finds himself more restricted working at a computer terminal than he would be with a textbook or set of drill exercises in hand, because the writer has not provided the computer instructions which would permit the student to look back, review or skip ahead as he does with printed materials. Concealment and control are desirable in some situations, and curriculum designers have used such facility to reduce inappropriate skipping about or other distractions. Such control is also an advantage when the lesson designer is testing his materials and wishes to know exactly what each trial student has seen and when.

Further along this dimension of control, a lesson responds to the student in set ways, but allows for a greater range of input from the student, while also giving him opportunities to change the topic. It is much more difficult for a curriculum writer to be successful with this type of programing, and relatively little has been done in this category.

The other extreme is characterized by almost complete user control. The computer is programed to serve the student as a tool in the management of the information necessary for problem solving. The most common use is as a conversational computer, that is, for calculations and other immediate processing in response to directions from the student. A student also can be given access to large files of information to retrieve and rearrange facts as useful for his study.

Diagnosis and Prescription. Another dimension of computer use concerns the extent of data recording and interpretation in the interactive program structure (e.g., the program's facility to diagnose and prescribe new reasoning activity on the basis of student performance and attitude). At one extreme, the computer follows student instructions for problem solving or simple linear programs for practice exercises without paying any attention to student problem solutions or question responses. At this level there is no interpretation or prescriptive feedback

determined by the author's procedure to be displayed to the student or saved for future use by the procedure itself.

In typical tutorial uses the computer program processes student responses and tries to act upon them during the instruction sequence by selecting for the student appropriate remedial or new materials. Such a program could also give interpretation of response measures directly to the student, such as by telling him why he needs more practice, with or without allowing him control over future action, rather than acting "secretly" upon its diagnosis of the response without informing the student.

Problem solving environments which are otherwise unconstrained also may include interpretation of student actions, such as presentation of the correct form for an ambiguous instruction, suggestion of a solution procedure along a direction already taken by the student, or evaluation of his final solution for efficiency in terms of number of instructions or computer time used.

This dimension of "diagnosis and prescription" may interact in varying degrees with the previously discussed dimension of "program control." For any level of diagnosis and prescription, the extent of control over the direction of instruction may vary from nearly zero (where the student has almost complete control) to maximum control by the computer program. In other words, the program may tell the student why or on what basis he is being led through an exercise, whether or not he is permitted to change it. Similarly, any level of control allows the full range of prescription. However, if the computer is to have a justifiable role when programed to maintain maximum control, it must be acquiring and interpreting information for use in the controlling procedure. Although the author may wish the computer to record and store the maximum amount of relevant information justified by potential use in guiding students, he must design a procedure for diagnosis and prescription which passes along to each student only as much as promotes learning and favorable attitude, avoiding the distraction of too much information or irrelevant items.

Variety of Functions Available to User. The opportunities for a user (whether student or author) in an instructional system may vary from a completely preprogramed and limited exercise to the full capabilities of a richly equipped and general-purpose system. The systems dedicated to "drill and practice" are exemplars of a limited variety of functions available to the user: authors assemble pairs of items for presentation according to preset strategies, and students work on the exercises in sequence and within the interactive capabilities of the system. The system, that is, has preset criteria for "wrong, try again" or "too long, try again."

"Variety" as used in describing a dimension of computer use refers to programing capabilities or functions believed to be worthwhile for the instructional use of a system. A package of drill exercises may include alternative ways to achieve the same performance goals, and the author may write a complicated procedure to select among them on an individual basis, using observed student learning characteristics and current performance. Although drills of limited purpose measure high on "program control," they can also measure high on the dimensions of variety and prescription. Variety is an obvious dimension in consideration of the content utilized in a dialogue, the programing languages available for solving a problem, the alternative models to be used as a basis for a simulation, and the alternative techniques available

to the student to reprogram the model underlying the simulation.

B. Modes of Use

The following five categories represent general groupings or modes of computer use in education. Within any one of these modes, the characteristics of the several dimensions discussed above may be found in varying levels or degrees. The first three categories here are differentiated by the degree of student control over the program, although this is not an essential characteristic of each mode. The last two categories illustrate types of use involving instructors, curriculum authors, and researchers rather than students.

Drill, Author-Controlled Tutorial and "Dialogue" Tutorial. For this kind of computer assistance with student learning, the author typically defines objectives and describes the subject matter in considerable detail. Computerized drill strategies have been used heavily in an experiment with initial reading and math curricula in some of the Palo Alto, California, schools (Atkinson and Hansen, 1966, and Suppes, 1966) and in language laboratory exercises at the State University of New York at Stony Brook (Adams, Morrison and Reddy, 1968). Much of the work done at Penn State and Florida State can be characterized as individualized versions of lecture, text or examination material. This has been called automated tutorial, but the conversation remains very much under the control of the author of the computer program. Computer-based exercises which are characterized here as "dialogue" tutorial appear to encourage additional initiative on the part of the student and to provide suitable rewards. That is, the student may ask questions, direct the discussion to some extent, and construct solutions to problems set for him by the author. Two typical examples of the method concern practice in medical diagnosis (Swets and Feurzeig, 1965) and discussion of problem solutions in college physics (Taylor, 1967).

Simulation and Gaming. These kinds of applications differ from the previous group in that the conversation between the student and program and the results he obtains follow from a general model rather than a frame-by-frame specification. In other words, the designer of the learning exercise may not have anticipated in detail each course of action or outcome. This generality becomes possible if the computer program underlying a game or simulation describes a model designed to provide some appropriate reply no matter what the student should type. Such models can also be used in research to provide artificial situations for initial testing of new hypotheses under favorable conditions of control and observation.

Simulations attempt to model some aspects of the real world for study or research. Computer-based games usually place the student in less realistic situations, provide specific payoffs, and introduce competition with other students. Typical applications of both modes are found in elementary school social studies (Leonard and Wing, 1967), high school career planning (Ellis and Wetherall, 1966) and college chemistry (Lagowski, in press).

Scholarly Aids: Information Handling, Computation and Display. Computer tools for the organization and retrieval of information should be as useful to the student as they are to any scholar working with a broad base of information. A number of experimental systems designed to provide such assistance show considerable promise but are still rather expensive. Apparently, there have been no extensive experiments conducted in typical learning situations.

Computation is such an obvious application that it tends to be overlooked by the planner of a computer-based instructional system. Notable experiments have been conducted by the

Massachusetts public schools (Feurzeig, 1967), the University of California at Santa Barbara (Fried, 1967) and System Development Corporation (Rosenbaum *et al.*, 1967). Prospects for multiple computer uses are encouraged by the development of some fifteen university-based regional computer networks under the sponsorship of the National Science Foundation.

The computer is really a general information processing device and an intellectual aid which can be extended to all aspects of arranging, analyzing and presenting information. An experimental, text-handling system developed at Stanford Research Institute (Englebart, 1968) provides a good demonstration of the range of facilities for handling information which the computer brings to the learner.

Interactive use of computers has potential for problem solving in all areas, including the arts and humanities. Computers are being used increasingly by artists and scholars in connection with musical compositions, creative writing, experimental films and architectural designs. It is especially important that students from these areas outside science and engineering be given access to computing capability through well designed study carrels and readily comprehended programing languages.

Computer aids for instructional management. Public schools probably will be able to provide interactive computer assistance to a few "managers" of instruction sooner than they can to each individual student. Knowledge gained through semi-automated handling of instructional materials and performance records will contribute to effective implementation of other interactive uses of computers by students directly. The Oakleaf school project (Lindvall and Bolvin, 1967) began with much teacher-student contact and a large clerical staff. Gradually the clerical burden is being replaced by computer programs, and routine contact of teachers with students will be replaced by student interaction with computer programs.

John Coulson of System Development Corporation discussed his research efforts in "computer-assisted instructional management" at the 1969 meeting of the American Educational Research Association (Coulson, 1970). In a recent review of the literature, Robert Morgan of Florida State University (Morgan, 1969) has listed several persons working in the area of computer-managed instruction: Harry Silberman of System Development Corporation, working with the Southwest Regional Educational Laboratory and the Los Angeles Public Schools; Robert Glaser of the University of Pittsburgh, working with the Oakleaf School in Pennsylvania; Donald Torr of Sterling Research Institute, Don Tosti of Westinghouse Learning Corporation and Alexander Schure of New York Institute of Technology, all of whom are working with the U.S. Naval Academy; and John Flanagan, working with the American Institute for Research and Westinghouse Learning Corporation.

Computer-Based Tools for the Author and Researcher. Convenient languages are needed for specifying interactive instruction in ways which can be processed by computer programs. A working group established by EDUCOM (Interuniversity Communications Council, see section VII of this paper) has assembled a set of documents which are intended to describe various programing languages and to recommend additional requirements which are not presently met. Some of the systems which are described in the EDUCOM report (Zinn, 1969) provide capability for interactive composition and revision of materials; the author can change his text, diagrams or

learning strategy by typing instructions on a keyboard or by moving a pointer about on a television screen to indicate new arrangements of text or diagrams. Suitable computer programs can also assist with the preparation of a first draft of a testing sequence.

A first approximation of a computer-based learning exercise might be derived from a specially-written text, a set of test papers which have been graded, or a description of objectives for student performance at the end of the exercise. A few projects have demonstrated that computer programs can generate additional materials as needed for each individual student. That is, an additional teaching example or test situation can be assembled from elements and rules provided in advance by the author to describe the subject matter. Finally, computer programs should help with data analysis and decisions in research and modification of instructional packages.

IV. VARIETY OF LESSONS, SYSTEMS AND LANGUAGES

Materials are being written in almost all subject areas and for many age levels. Abstracts of computer programs for instruction are collected by Entelek Incorporated, the University of Wisconsin Instructional Media Laboratory at Milwaukee, and others (see section VII of this paper). The appropriateness and effectiveness of computer assistance in each field depends on characteristics of each instructional objective. Subject experts will determine where and how the computer is used, but the evaluation should be based on records of student performance.

Presumably computers will provide some advantage through increased learning and perhaps through reduced cost. Ways of using computers include: 1) processing and evaluation of responses typed or spoken by the student, 2) complex sequencing or selection rules, or self-modifying strategies of instruction, and 3) generation or assembly of new material. There are also some obvious limitations: it is difficult for a computer to process and evaluate the content of essays, complex physical constructions, and facial expressions.* Nevertheless, some projects are providing computer input from eye movement and head orientation. Probably more limiting than user response is the representation of the topic being studied. Lack of organization of a subject may make computer presentation and student participation difficult where live individual instruction can be reasonably successful.

A number of different kinds of computer systems are being used by current research and development projects. Some small computers have been programed for use by one student at a time for self-testing, computation, simulation, and even design of games (Starkweather, 1965) for another student to play, or for practice of vocal skills (Lane, 1966). Somewhat larger systems, similarly dedicated to a single purpose, have been programed for simultaneous use by from 4 to 32 students; these can be characterized as multiple-user teaching machines. Information can be obtained from IBM, RCA, Philco-Ford, UNIVAC, Technomics and perhaps other manufacturers or from projects in the schools and colleges (see Appendix B). Larger systems have been proposed which would handle from 200 to 4000 students simultaneously using the same or similar teaching programs. Current proposals by Bitzer, Suppes and others named in Appendix B may be of interest to the reader. Other research and development projects have used general-purpose conversational systems, imbedding the conversational instructional applications among other applications available to users. With such an arrangement the student may use the same computer for tutorial, self-testing, simulation, gaming, and problem solving. Examples of uses of campus time-sharing systems for instruction in other than computer science are common now, and a few technical reports describing their applications have been published.

*The reader may want to check some interesting work on evaluation of essays reported by Ellis Page, "Grading Essays by Computer: Progress Report," in *Invitational Conference on Testing Problems*, October 1966 (Princeton: Educational Testing Service, 1967), pp. 87-100. The final report on this project is available as ERIC document ED 028 633.

The current trend in computer use appears to be away from a sequence delivered by the computer under strict control of the author's program. It appears more likely that managers of future systems will make the primary sources of knowledge more available to students through organized files of information and procedures. Students will be given the necessary learning tools for information management, computation and composition. Learning exercises will be characterized by practice in information acquisition and decision-making, and students will take more control over their learning environments.

For certain students and instructional objectives it seems likely that the effectiveness of computerized author-controlled tutorial presentations will be sufficiently greater than non-computer presentation of similar materials to justify the greater cost per unit. For example, children may lack the verbal skills, perceptual discrimination and attention span needed for independent study without the aid of the computer; other students studying written and spoken language at both grade school and college level may benefit from computer assistance for diagnostic self-testing.

Expensive on-line systems will continue to be used for research and materials development, often in the natural environment. From training devices located in public school classrooms, business offices, and engineering shops or laboratories, a central computer and communications system can instruct, record data, and test hypotheses regarding instruction and learning with great detail and over long periods of time. This capability to mix experimental control with real situations should help bridge the gap between contrived laboratory situations and actual application of learning principles in the classroom.

Training exercises have been built into computer operating systems. These efforts to put a computer system to multiple use are significant for two reasons: 1) they increase utilization of the system, which reduces cost per student-hour of use, and 2) they increase the transfer of learned skills from the training to the performance situation, which reduces training time and errors on the job. The general purpose BUIC III designed by System Development Corporation conducts an individualized training program while simultaneously maintaining an operational air defense system on the same equipment which the student will use when the course is completed and he assumes his part in the air defense system.

In cases where the operating system is not available for training purposes, the simulation of complex man-machine systems has become an important instructional technique, particularly in aerospace and military programs. Flight controller teams for mission control and the monitoring of Project Apollo manned-space flights are prepared by intensive training on a complex, computer-driven, real-time simulation system (Shelley and Groom, in press). The simulation of space flight for training purposes is a very expensive operation, requiring extensive computer programing and a high degree of fidelity due to the critical character of the mission itself.

The cost in preparation and use of computer-based exercises will continue to be high (Kopstein and Seidel, 1968) and not readily distributed over a large number of students. However, communication networks will stimulate and technically assist groups of subject experts working cooperatively on computer-based materials for similar courses taught at different institutions. It is likely that materials developed on a cooperative basis will be more relevant and applicable to many different institutions than materials developed through independent ventures.

Guidelines for organization and documentation of computer-based exercises are now being written which will make revision and use easier and more effective at new locations. Computer aids for searching and editing a personal copy could help each other user to explore and modify the materials for better use by his students.

Computer-based networks will distribute interactive information-processing services which individual institutions and community education programs could not afford separately (Brown, Miller and Keenan, 1967). Ultimately, the resources of entire regions will be made available to enrich and individualize the program of each student, no matter what his location.

V. LITERATURE SURVEYS, REVIEWS AND BIBLIOGRAPHIES

There are many ways to organize information about computer-based instruction systems: student levels, subject areas, learning strategies, hardware systems, programing languages, computer functions, and user purposes. Nearly all of these arrangements are represented in the following sample of surveys and reviews arranged alphabetically by author.

Atkinson and Wilson have edited for publication a group of reprinted articles concerned with the role and applications of CAI; educational considerations; and hardware, languages and economics. That collection, *Computer-Assisted Instruction,* has recently been published by Academic Press, Inc.

Barnes selected 113 articles and other works from a wide variety of sources to include in an annotated bibliography on computer-assisted instruction published by Phi Delta Kappa, Inc., Bloomington, Indiana, in September 1968.

A bibliography and KWIK index was published by Engel in 1967 and revised in 1968 and 1969 (Programming Systems Branch, USNWL, Dahlgreen, Va. 22448). It overlaps the Entelek bibliography, but does include some annotations in its published version. The Entelek abstract card file (see section VII) is more extensive and includes longer annotations, but that file is available only by annual subscription.

Gentile circulated a review in 1966 which appeared in *Audiovisual Communications Review,* Spring, 1967. After a brief history he discusses the semantic problem of programed content and strategy, author language convenience, system capability and the effectiveness problem for instructional materials.

A chapter by Hansen in the *Review of Educational Research,* December, 1966, describes psychological experimentation and simulation as well as different applications of computer-assisted instruction. It gives particular attention to research studies (which have been few).

Hickey and Newton published a survey of the literature in 1966, 1967 and again in 1968, drawn from the files of the Entelek indexing and abstracting service (see section VII). The October 1968 version is rather comprehensive and gives appropriate attention to research reports and documentation of instructional materials which have been prepared. In some of the editions there have been a few serious errors, such as the classification of systems and languages in the January 1967 version.

Holznagel publishes periodically a *Computer Education Resource Catalog* for the Computer Instruction NETWORK, 4924 River Road North, Salem, Oregon 97303. The catalog includes a serial bibliographic listing of books, pamphlets and periodicals in general categories according to their major content or purpose, an annotation of certain of the works, and a listing of films and reviews.

In 1969 the Instructional Media Laboratory at the University of Wisconsin-Milwaukee published a comprehensive bibliography which contains over 450 entries and encompasses 37 subject matter areas. Edited by Helen Lekan, the *Index to Computer Assisted Instruction* includes a detailed description of each entry, additional sources to consult, and four major areas of cross references. A second edition should be available early in 1970 through Sterling Institute, Washington, D.C.

The RAND Corporation of Santa Monica, California, is conducting—for the Kerr Commission on Higher Education—a study of the prospects for computer-assisted instruction in higher education. Under the direction of Dr. Roger Levien, the study will review current trends for the instructional use of computers and suggest guidelines for achieving appropriate use of computers in instruction. The report should be completed in 1970.

Molnar and Sherman have compiled a volume of reports, project abstracts, and various appendices related to U.S. Office of Education support of computer activities in instruction and research (January 1969). They wrote a five-page summary of the report for the April 1969 issue of *Educational Technology*.

Publications reviewing the state-of-the-art have recently been written by Robert Morgan and John Feldhusen. Morgan's paper for ERIC at Stanford reviews educational applications of the computer. Feldhusen presents interpretive reviews of recent developments in the field in *Educational Technology* and *Contemporary Education*, both published in April, 1969. A third position paper by Feldhusen on CAI research and development was to be issued by ERIC at Stanford in February 1970.

Stolurow recently wrote a chapter on "Computer Assisted Instruction" for the book *The Schools and the Challenge of Innovation* (McGraw-Hill and the Committee for Economic Development, 1969). In this chapter he elaborates upon the various purposes and unique instructional modes or applications of CAI, the special advantages of a CAI system, and the overall financial costs of computer-assisted instruction.

A book by Uttal *(Real-Time Computers: Technique and Applications in the Psychological Sciences*, Harper and Row, 1967) includes a chapter titled "Computer Teaching Machines." In his discussion of psychological foundations and of types of computer teaching machines, Uttal emphasizes the unique contributions automated information processing systems can make through technology for generation of the steps in a sequence of instruction. In a chapter for a forthcoming book he expands on his ideas for "generative" computer-assisted instruction (Uttal *et al.*, 1969).

Vinsonhaler at the Computing Center of Michigan State University maintains under the sponsorship of MICIS (Michigan Inter-University Committee on Information Systems) a computer listing of an annotated bibliography on computers in education, and publishes new editions twice a year.

In a review circulated in 1965 and published in *The Computer in American Education* (John Wiley, 1967), Zinn described computer contributions to communication among student, teacher, and author in an instructional system. One section lists information arranged by project or computer system, and may be useful when planning visits or phone calls to obtain detailed information about system design, research, applications, and instructional materials under development.

In a chapter in the *Review of Educational Research*, December, 1967, Zinn covered modes of computer assistance for the student, strategies for computer-based learning situations, computer aids for instructional management, computer-based tools for the author and researcher, computer-aided design of learning situations, and trends and projected needs.

Zinn has recently received U.S. Office of Education funds for an "evaluative review of the interactive uses of computers in instruction." Project CLUE (Computer Learning Under Evaluation) will attempt to assess technology, applications, costs, effectiveness and trends for uses of computers in secondary and university instruction. Review efforts are being coordinated with the RAND study discussed earlier in this section. Project CLUE's final report should be available for publication in summer of 1970.

VI. SINGLE MEETINGS, CONFERENCES AND SYMPOSIA (1961-1969, U.S.A.)

The following materials, organized chronologically by date of occurrence, may provide further references for the reader by providing publications and proceedings which were an outcome of the meetings held, and also assist the reader by suggesting where to look for materials resulting from meetings or conferences to be held in the next year or so. Regularly scheduled conferences (FJCC, SJCC, AERA, AEDS, and ACM) are held annually or bi-annually and generally have conference proceedings available (see section VII).

John Coulson of System Development Corporation edited the proceedings of the October 1961 Conference on Application of Digital Computers to Automated Instruction, sponsored by SDC and the Office of Naval Research. The proceedings were published in a book entitled *Programmed Learning and Computer-Based Instruction* (John Wiley, 1962).

A conference was sponsored by AEDS and Stanford University on uses of computers in American education in October of 1965. Sections of two of the presentations appeared in the *Saturday Review of Literature,* 1966, and the conference report was published by John Wiley, June 1967 (*The Computer in American Education,* edited by Don D. Bushnell and Dwight W. Allen).

A conference on the Computer in American Universities was held at the University of California at Irvine in November of 1965. The contributed papers were published in August 1967 with an edited transcript of discussion (*Computers and Education,* edited by Ralph Gerard, McGraw-Hill).

The Commission on College Physics also sponsored a conference in November 1965 at Irvine. The report of that working session, *The Computer in Physics Instruction,* is available from the Commission at the University of Maryland. It is of somewhat lesser scope than the other Irvine conference, but it includes more detail and a number of examples of interest to non-physicists as well as physicists. A revision is under consideration.

In March 1966 the ONR CAI interest group met in Cambridge at Bolt Beranek and Newman and at Harvard University Computation Center. (The Office of Naval Research (ONR) has supported many of the innovative projects in this area, and through Entelek has encouraged meetings to exchange information.) Participants discussed CAI languages for both students and authors. A summary was distributed by Entelek and appeared in *Automated Education Letter.* In July of 1966, Educom established an informal working group in the area of author languages.

During July 1966, Educom assembled a number of experts and representatives of member institutions to discuss and plan a network for communication among colleges and universities in North America. The report of that conference detailed designs and projections of need and probable uses for network services. The report was published in July 1967 by John Wiley and Sons, Inc. (Brown, Miller and Keenan, 1967).

In August of 1966 and 1967, educational technology and special equipment were

described and demonstrated at a conference of the American Management Association (135 W. 50th, New York, N.Y. 10020). The conference programs describe topics and participants; no summary of the sessions has been published. AMA Conferences on Education & Training were held in August 1968 and 1969.

The ONR CAI interest group met at System Development Corporation, Santa Monica, Calif., in September 1966. Various SDC programs exploring computer aids in educational systems were described, and participants discussed issues related to successful implementation of CAI. A summary of these sessions is available from Entelek; sections of the summary appeared in *Automated Education Letter,* January and February, 1967.

The ONR CAI interest group met at Penn State University in April 1967. Research and development activity in technical education using an IBM 1410 and experimental Coursewriter was described. A summary was distributed by Entelek.

The Education Policy Project at George Washington University conducted a "traveling seminar" for the Office of Education during July of 1967. The background papers, briefing sessions and conclusions of the seminar participants are presented in the final report titled *Education in the 70's.* Copies are available from the ERIC Document Reproduction Service, which lists it as document ED 022 361.

An NSF session on computers in chemistry, economics and science education was held in December 1967, and proceedings are available from the Science Teaching Center, University of Maryland.

The meetings of Project ARISTOTLE (Annual Review and Information Symposium on the Technology of Training, Learning and Education) in December of 1967 included a session on use of computers in education under Task Group No. 5 on New Developments in Computers and Communications. Copies of the proceedings are available from the National Security Industrial Association, Suite 800, 1030 15th St., N.W., Washington, D.C. 20005.

An ONR interest group on simulation in instruction met at The University of Texas in Austin, January 1968. Special attention was given to projects of the CAI lab at Texas, and the simulations for testing and training at the manned space flight center in Houston. Notes have been distributed by Entelek, and a longer report is in preparation by C. Victor Bunderson, Director of the CAI Lab at Texas.

An ONR interest group on CAI in medical education met in Cambridge in February 1968. Work in progress at a dozen locations throughout the country was demonstrated by remote teletype and videotape. Proceedings were prepared by Lawrence N. Stolurow, Director of the Harvard CAI Laboratory, and are available through Entelek.

A conference on the use of computers in Medical Education was held at the University of Oklahoma Medical Center in April 1968. Sessions considered computers in undergraduate, clinical, and continuing education, as well as their use in medical libraries. The conference proceedings are available from the University of Oklahoma Medical Center, 800 N.E. 13th Street, Oklahoma City, Okla. 73104.

NATO sponsored a conference on computers and learning in Nice, France, in May 1968. No official proceedings are available, but informal proceedings were distributed by the U.S. Office of Naval Research.

Under sponsorship of the National Science Foundation's Office of Computing Activities, Stanford University, and the University of Illinois, a working conference on systems design for computer-based instruction was held in Colorado in June 1968. Emphasis was directed at discussion of hardware systems (design objectives and criteria), and at languages, teaching strategies, and software for CBI systems. Notes of the conference are available from Dean Daniel Alpert, University of Illinois, Urbana.

Pennsylvania State University held a conference on Computers in Mathematics education in September 1968. The discussions (edited by Ralph Heimer and published by the National Council of Teachers of Mathematics, Inc., 1969) included Uttal's generative computer exercises for analytical geometry and use of the computer as an on-line tool for statistics and as a system for processing and providing graphical aids for college students.

A Conference on "Computer-Assisted Instruction, Testing and Guidance" at the University of Texas, October 20-22, 1968, considered implications of new educational technology for testing and guidance. Specialists discussed the latest research and theoretical developments, the state of computer-based technology, and problems related to the implementation of such technology. (Proceedings were edited by Wayne Holtzman, and are in press for publication by Harper and Row, Winter 1970).

A conference on "Instructional Strategies Appropriate to Computer Assisted Instruction" was held in Washington, D.C., October 29-30, 1968. Topics discussed included the classification and significance of instructional strategies, and operational definitions of individual strategies. (Proceedings were edited by Albert Hickey and published by Entelek as ONR Technical Report No. 9.)

Educom in May 1969, in conjunction with NSF and the University of New Hampshire, sponsored a symposium entitled "The Computer Utility—Implications for Higher Education" in Manchester, New Hampshire. A summary of the symposium's recommendations can be found in the September 1969 Bulletin of the Interuniversity Communications Council (Educom). Proceedings, which are currently in press, will eventually be available from Educom in Boston.

In September 1969 the National Council for Educational Technology, 160 Great Portland Street, London W1, held a symposium at the University of Leeds on Computer Based Learning Systems. Proceedings are expected to be available early in 1970. NCET working papers and a feasibility study for a program for research and development were published in 1969.

The International Federation for Information Processing (IFIP) will hold a World Conference on Computer Education in Amsterdam, The Netherlands, August 24-28, 1970. Held under the auspices of the IFIP Technical Committee for Education and the IFIP Administrative Data Processing Group (IAG), the sessions will include computer aids for instruction as well as instruction about computers. For information contact Secretary General A.A.M. Veenhuis, Stadhouderskade 6, Amsterdam.

VII. PROFESSIONAL ORGANIZATIONS, PUBLISHERS, AND COMMERCIAL INFORMATION SERVICES

Publishers and professional organizations who periodically publish materials relevant to interactive uses of computers in education are listed here. Commercial information services who sponsor workshops and newsletters in addition to computing services also have been included.

American Educational Research Association (AERA), 1201 16th St., N.W., Washington, D.C. 20036. Richard A. Dershimer, Executive Officer. The *Educational Researcher* is the official newsletter of the association and is published about seven times a year. It mentions meetings, new federal programs, and the initiation of major research projects ($2.50 per year). The *American Educational Research Journal,* published quarterly, has an article related to computers in education nearly every issue ($6 per year). The annual AERA meeting in February is likely to include reports of current research and development.

The Review of Educational Research includes in its five issues per year two or three chapters on educational technology and computers ($10 per year). In 1968 the Association established the Special Interest Group on Computer Aids to Instruction (SIG CAI) under the chairmanship of John Coulson (Public Systems Division, Systems Development Corporation Santa Monica, California 90406).

American Federation of Information Processing Societies (AFIPS), 211 E. 43rd St., New York, N.Y. 10017. The Fall Joint Computer Conference (FJCC) and Spring Joint Computer Conference (SJCC) include sessions relevant to instruction, but often under such headings as system design, programing languages, and natural language processing, as well as under computer-assisted instruction. *The Conference Proceedings* of FJCC and SJCC are published by Spartan Books, Thompson or some other independent publisher at the times of the meetings (November and April).

Association for Computing Machinery (ACM), 211 E. 43rd St., New York, N.Y. 10017. A number of the monthly issues of *Communications of the ACM* include articles on use of computers for instruction. Often these are concerned with the training of computer programers, technicians and users. Sections on programing languages and computational linguistics occasionally are relevant to instructional programs ($20 per year). The *Journal* occasionally includes relevant material, and issues of *Computing Reviews* very frequently have abstracts of technical reports and papers from projects using computers for instruction. Annual meetings in August include papers on instructional use of computers.

The Association has established a Special Interest Committee on Computer Assisted Instruction (SICCAI) which distributes a newsletter (INTERFACE, O. Dennis Barnes, Editor, Department of Instructional Technology, School of Education, USC, University Park, Los

Angeles, California 90007) and plans sessions for ACM and AFIPS meetings. The SICCAI Bibliography Subcommittee, under the chairmanship of Gerald Engel, plans to prepare a critical list of existing CAI bibliographies as well as a bibliography of background material in educational psychology relevant to CAI.

Association for the Development of Instructional Systems (ADIS), Keith Hall, Chairman, Pennsylvania State University, 201-202 Chambers Building, University Park, Pa. 16802. *ADIS News Release,* issued periodically, provides for the exchange of system programs and instructional materials among its members. The association, which meets at least twice a year, is presently limited to users of IBM equipment for instruction.

Association for Educational Data Systems (AEDS), 1201 16th St., N.W. Washington, D.C. 20036. *AEDS Monitor,* the magazine of the Association, is published 11 times each year. Most material has been on data processing ($15 per year). *The Journal of the Association of Educational Data Systems,* published four times each year, includes many articles on computers and education ($10 per year). The annual meeting of the Association in March or April always includes sessions on computers and instruction. A series of workshops on educational data processing held at various locations during 1967-68 included sessions on CAI. Proceedings are available from AEDS.

Automated Education Center, P. O. B x 2658, Detroit, Michigan 48213. Frank H. Gille, Publisher. *The Automated Education Handbook* ($35) and two monthly newsletters (*Automated Education* and *Data Processing for Education,* each $18 per year) provide information about programed instruction, audio and visual media, and computer assistance. Most of the material in the letters is selected from news releases and other publications for potential educational users of computers. The *Handbook* includes research reports, discussion of procedures, and summaries of technology and applications.

Berkeley Enterprises, 815 Washington St., Newtonville, Massachusetts 02160. Edmund C. Berkeley, Editor and Publisher. *Computers and Automation* is a monthly journal; articles are usually informal and descriptive. Sometimes information about a new project appears here before it is reported more formally. The March 1969 issue carried a series of articles on "Computers and Education" ($15 per year).

Computer-Assisted Instruction, Inc. (CAI, Inc.), 111 West Monroe Street, Chicago, Illinois 60603, Dr. Robert C. Kyle, President. CAI, Inc. specializes in the design, development, and implementation of training systems. One-day seminars directed to business, industry, government and schools consider the present and future potential for the use of computers in the education and training process. Subscription fees vary.

Datamation, 1830 W. Olympic Blvd., Los Angeles, California 90006. Robert B. Forest, Editor. This monthly trade journal includes occasional articles on the use of computers in instruction. A special issue on computers and education appeared in September of 1968 ($15 per year; some complimentary subscriptions are available).

Educational Systems Corporation, Box 3711, Georgetown Station, Washington, D.C. 20007. *Journal of Educational Data Systems* (quarterly) includes articles on uses of computers

for instruction, especially for the teaching of programers and technicians. The Fall 1967 and Spring 1969 issues are devoted to CAI ($9 per year).

Educational News Service, 456 Sylvan Avenue, Englewood Cliffs, New Jersey 07662. Lawrence Lipsitz, Editor. Every issue of *Educational Technology* (monthly) has one or more articles or notes on instructional use of computers ($12 per year).

Educom (Interuniversity Communications Council), 100 Charles River Plaza, Boston, Mass. 02114. Jordan Baruch, President. The central office distributes a bulletin to the faculty of over 80 member institutions ($10 per year). Needs in the area of computer uses for instruction are reviewed, along with other topics, by panels concerned with technology and applications. A set of documents on programing languages and technical assistance for authors has recently been completed in cooperation with the Center for Research on Learning and Teaching, University of Michigan. Copies of this comparative study of languages, partially funded by the Office of Naval Research, are available from Educom. A pilot network has been developed which will assemble directory and information services, recommend standard practices, and facilitate cost sharing of communication circuits and special computer facilities for remote use or for information exchange.

Entelek, Inc., 42 Pleasant Street, Newburyport, Massachusetts 09150. Albert Hickey, President. Originally contracted for by ONR, Entelek conducts a CAI Information Exchange which periodically distributes abstracts of CAI research documents, summaries of operational CAI programs, and descriptions of individual CAI facilities. Five by eight inch data cards are mailed in multiple copies for cross-indexing and are accompanied by author, subject, KWIC, and bibliographic indexes. ONR originally paid the costs for about 60 institutions active in the CAI field and in the exchange; now all must subscribe at $150 per year.

The CAI program abstract cards have been prepared for publication in the *CAI Guide*, June 1968 ($10). Entelek assists with CAI interest group meetings, publishes summaries, and distributes an occasional newsletter, entitled "News About CAI." The first three editions of *CAI: A Survey of the Literature*, based on data in the information exchange, were published in 1966, 1967, and October 1968.

ERIC Clearinghouse on Educational Media and Technology, Institute for Communication Research, Stanford University, Stanford, California 94305. The current report literature is indexed and abstracted in *Research in Education* ($21 per year, U.S. Government Printing Office, Washington, D.C. 20402), while journal literature is indexed in *Current Index to Journals in Education* ($34 a year, CCM Information Corp., 909 Third Ave., New York, N.Y. 10022). Documents are available from the ERIC Document Reproduction Service in microfiche or photocopy. The clearinghouse occasionally distributes state-of-the-art papers—such as Morgan, 1969—direct from Stanford. Its regular newsletter is free upon request.

Education and Training Consultants (ETC), 815 Moraga Drive, Los Angeles, California 90049. Dr. Leonard C. Silvern, President. Three-day to two-week workshops are presented periodically, and are frequently coordinated with activities of Computer-Assisted Instruction Systems (CAIS), 979 Teakwood Road, Los Angeles, California 90049 (Dr. Gloria M. Silvern,

Vice-President). This commercial organization also issues regular news releases concerning its activities.

The Institute for Advanced Technology (IAT), C-E-I-R, Inc., 5272 River Road, Washington, D.C. 20016. A subsidiary of Control Data Corporation, C-E-I-R regularly presents a number of three-day seminars in different cities. C. Victor Bunderson and Michael D. Clark currently are conducting these seminars, which are designed primarily as an introduction to computer-assisted instruction for educational administrators and personnel and training directors from industry and government. As an extension to the publicly offered program, the Institute sponsors special sessions at the clients' premises or at designated IAT facilities. These special courses may be a replica of the regular program or tailored to meet clients' requirements.

Institute for Computer Assisted Instruction (ICAI), 42 East Court Street, Doylestown, Pennsylvania 18901. Dr. Alex B. Kyle, President. This commercial organization holds a number of conferences, meetings, training workshops for instructional programers, and public one-day briefings each year. It plans to publish an annual state-of-the-art review and also the *CAI Newsletter* (8 issues, $12 per year). Subscription fees for the various services vary.

Institute of Electrical and Electronic Engineers (IEEE), 345 E. 47th St., New York, N.Y. 10017. *Proceedings of the IEEE* occasionally is devoted entirely to computers and related subjects. The last such issue was December 1966, which contained some papers on computer-aided instruction. The November 1967 issue was devoted to computer-aided design ($22 per year, single copy of special issues $4). *IEEE Transactions on Man-Machine Systems* (name changed from *Transactions on Human Factors in Electronics*), *IEEE Transactions on Education* and *IEEE Transactions on Electronic Computers* often include relevant papers. A special issue of the first journal, June 1967, focused on computers and education. Subscription prices vary (single copy $5).

International Federation for Information Processing, Congress Office, 23 Dorset Square, London N.W.I., England. Proceedings of the IFIP tri-annual congresses often contain technical papers related to computer applications in education. Proceedings of the 1962, 1965, and 1968 congresses should be available from the North-Holland Publishing Company, P.O. Box 3489, Amsterdam. Special Meetings are held occasionally, such as the World Conference on Computer Education in Amsterdam, August 24-28, 1970.

The National Association of Secondary School Principals (NASSP), 1201 16th St. N.W., Washington, D.C. 20036. During 1970 the Committee on Computers in Education of the NASSP is offering a series of seminars on potential uses of the computer in various parts of the country. The seminars, which are intended primarily, but not exclusively, for secondary school principals, are conducted in multi-media education centers, where participants are provided access to computer terminals. Registration fees range from $115 to $170 for each two-and-one-half-day session.

System Development Corporation, 2500 Colorado Avenue, Santa Monica, California 90006. The *SDC Magazine* (monthly) occasionally includes articles on uses of computers for instruction, especially uses in systems training projects conducted by System Development Corporation. Available SDC publications are listed each month on the last page of the magazine.

APPENDIX A—GLOSSARY OF TERMS FOR INTERACTIVE USE OF COMPUTERS

Access time—Time required to obtain information from storage (read-time), or to put information away in storage (write time).

Acoustic coupler—A device used in place of a data-set to transfer information from the terminal via an ordinary telephone over telephone lines to the computer and vice versa.

AHI—Augmentation of human intellect. Computer techniques for retrieving, rearranging and manipulating information, usually text, sometimes diagrams, or anything that helps one engage in intellectual activity; computer extension of human abilities to accomplish instructional research, composition or other creative work.

Algorithm—A procedure for solving a problem. When properly applied, an algorithm always produces a solution to the problem. (Compare with "heuristic.")

Analogue computer—Device using voltages, forces, fluid volume or other continuously variable physical quantities to represent numbers in calculations. It is convenient for solving differential equations, simultaneous equations and equilibrium problems. (See "digital computer.")

ASCII—American Standard Code for Information Interchange. Established by the American Standards Association as the standard for representation of numbers in computing machinery.

Bandwidth—The difference, expressed in cycles per second, between the highest and lowest frequencies of a band or part of a channel; a determinant of amount and quality of information which can be passed per second. Bandwidth is measured in cycles or bits per second (cps or bps), kilocycles per second (KC) or megacycles per second (MC).

Batch processing—A method of operation in which a number of similar jobs are accumulated and processed together, usually being done in serial order. (See "time-sharing" for contrast.)

Binary device—Having two states; on-off, or yes-no, or true-false.

Bit (contraction of "binary digit")—A unit of information content; the smallest notation.

Branching—Altering the course of a set of instructions by switching when some predesignated event occurs.

Buffer—A storage device used to compensate for a difference in rate of flow of data, or time of occurrence of events, when transmitting data from one device to another.

Byte—A group of bits (usually six to eight) representing a character.

CAE—Computer-assisted education, computer-augmented education.

CAI—Computer-assisted instruction, Computer-aided instruction, computer-augmented instruction. Defined narrowly, it refers to tutorial exercises or computerized programed instruction; defined broadly, it encompasses the entire field of computer uses for instruction in which there is an interaction between student and machine (e.g., drill, tutorial, simulation, problem solving, and scholarly aids).

CAL—Computer-assisted learning; also the name of an on-line computation language developed at Berkeley, and a coursewriting language developed at the Irvine campus of the University of California.

CBI—Computer-based instruction.

CBL—Computer-based learning.

Channel—A path for electrical transmission between two or more points. Also called a circuit, facility, line, link or path.

Character—A digit, letter or other symbol, usually requiring six or eight bits for representation in digital computers.

CMI—Computer-managed instruction. The main function of the computer is to assist the teacher in planning instructional sequences. The actual instruction may or may not involve the computer.

Compiler—Computer program for translation of instructions expressed in a user language (e.g., algebraic formulas, logical expressions or transfers of control) into a machine language (e.g., binary numbers signifying basic operations such as add, compare, store and jump).

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

Course—Used rather loosely to mean any instructional sequence or computer-based learning exercise.

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 television-like display device for drawings and text.

Cursor—A point or line of light displayed on the CRT and under the control of either the user or the computer to indicate the point at which the next display or editing operation is to occur.

Data-phone--A trade mark for the data sets manufactured and supplied by the Bell System; a method of transmitting data over the regular telephone network (DATA-PHONE Service).
Data-set--A device for transmission of data over the regular telephone network.
Debug--To search for and correct errors ("bugs") in a computer program.
Diskpack (also disc)--A stack of disk-like plates coated with magnetic material for the storage of information; bits can be stored upon and read from the surface while the pack revolves at high speeds, somewhat like a stack of phonograph records crossed with a tape recorder.
Down-time--Time when a computer is not available for operation, usually because of a failure in the equipment.
Drum--A cylindrical drum coated with magnetic material for the storage of information. Bits can be stored upon and read from the surface while it revolves at high speeds.
Duplex--In communications, pertaining to a simultaneous two-way and independent transmission in both directions (sometimes referred to as "full duplex"). (Contrast with "half-duplex.")
Facsimile (FAX)--Transmission of pictures, maps, diagrams, etc. The image is scanned at the transmitter, reconstructed at the receiving station and duplicated on some form of paper.
Feedback--In programed instruction, providing the student with information on correctness of his last output or response. The feedback may be designed to correct a student's incorrect response.
Flag--An error message found on the compile listing.
Flow diagram--A schematic or block representation of programing strategy.
Frame--The smallest unit of programed instruction. It usually consists of information and/or a question, an opportunity for an answer, and some provision for checking the answer.
Generative techniques--Standard patterns or procedures, or algorithms applied to curriculum files for the generation or assembly of sequences of instructional materials; an alternative to frame-by-frame programing.
Half-duplex--Pertaining to an alternate, one-way-at-a-time, independent transmission (sometimes referred to as "single"). (Contrast with "duplex.")
Hardware--The equipment components of a computer system, the machinery as opposed to the programs which are run on the machinery.
Heuristic--A guide to finding a solution to a problem that cannot be proved to always succeed.
Instructional programing language--A computer language or notation particularly suited to the description of instructional procedures for computer delivery. (See "programing.")
Interactive--Computer operation providing for exchange between user and program (or system), whichever may take the initiative. An interactive drill program checks the time and accuracy of answers and responds immediately to the user; an interactive problem solving system responds to solution attempts by the user and allows modification in the procedure at the moment. (For non-interactive, see "batch.")
Interface--A shared boundary, for example, the boundary between two subsystems or two devices.
Interrupt--A hardware feature which allows the computer to stop working momentarily on one task, handle the interrupting task, and return to the first without losing information or interim results of processing.
INWATS--Similar to WATS (which see), but allows inward calls on a flat monthly rate.
I/O--Input/output of information to and from computers; usually refers to devices such as an electric typewriter, card reader and punch, paper tape reader and punch, printer, etc.
IPI--Individually prescribed instruction. Originated with an instructional project at the University of Pittsburgh's Learning Research and Development center, now used widely as label for strategy of individualizing selection of exercises and rate of work for each student.
K--Thousand; e.g., 32K words of memory means 32,000 words of computer memory.
LDX--Long Distance Xerography. A name used by the Xerox Corporation to identify its high speed facsimile system. The system uses Xerox terminal equipment and a wide band data communication channel.
Latency (student response time)--The time from the display of an instructional stimulus to the start or completion of the student's response.
Light-pen--A photo-sensitive device used for communication with a computer via a cathode ray tube; an electronic pointer.
Linear programming--(a) Mathematics: techniques for optimizing a linear function of several variables subject to linear inequality constraints on some or all of the variables; (b) instruction: the simplest form of programed instruction or CAI; all students follow the same sequence.

Line switching--The switching technique of temporarily connecting two lines together so that the stations directly exchange information.

Link--See "channel."

Log--To record student-computer interactions.

Memory--The storage components of a computer's central processing unit in which bits of information are stored and from which they may later be recalled. (See also "storage.")

Microwave--All electromagnetic waves in the radio frequency spectrum above 890 megahertz per second.

Model--An idealized representation that demonstrates the relationships between relevant variables. Models are used to better understand and control a real situation.

Off-line--Processes performed outside of the operation of the central processor of a computing system.

On-line--Connected directly to the central computer, e.g., an electric typewriter in direct communication with computer processor.

Operating system--The collection of programs (software) which direct or supervise the utilization of processing components and the execution of programs.

Multiplexing--The division of a transmission facility into two or more channels.

Partition--Running the computer so that different tasks, perhaps batch-processing and time-sharing operations, are performed simultaneously. Time-share operations can be given priority.

Polling--A centrally controlled method of calling a number of points to permit them to transmit information.

Port--The physical facility for connecting a phone line from a user terminal to the computer.

Programing--(a) Instructional: the construction and arrangement of elements of a learning exercise and perhaps self-testing in a way specifically designed to promote effective and efficient learning; (b) computer: the construction and arrangement of elements of a procedure specifically designed to achieve a problem solution or demonstrate a process.

RAND Tablet--A metal writing surface developed by RAND Corporation for input of graphic information to a computer through use of a special writing stylus.

Random access--A facility whereby information can be returned from any part of a storage device rapidly at any time.

Real-time--Performance of processing during the actual time the physical process transpires, in order that results of the computation can be used to guide the physical process.

Response time--The amount of time elapsed between generation of an inquiry at a data communications terminal and receipt of a response from the computer at that same terminal.

RPQ--Request Price Quotation. Used to identify special equipment features which might be provided but are not included in price lists.

Software--(a) Computer: programs, as contrasted with computer components (see "hardware"); (b) Instructional: curriculum materials as contrasted with computer facilities or people.

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

Storage--The capacity of an information processing system to put aside or save for future use bits of information. (See "core" and "disk.")

Storage protect--A hardware feature which prohibits one user in a shared system from using or changing information stored in memory allocated to other users.

Student station--I/O equipment designed for student use in interacting with a computer.

Teaching logic--A pattern or strategy for instruction into which various topics or sets of questions and answers may be placed.

Tele-processing--A form of information handling in which a data processing system utilizes telegraphic communication facilities, e.g., using a computer remotely via telephone lines.

Teletypewriter exchange service (TWX)--An automatic teleprinter exchange switching service provided by the Bell System.

Telpak--A service offered by communications common carriers for the leasing of wide band channels between two or more points.

Terminal--A point at which information can enter or leave a communication network, or the I/O device used at that point.

Tie-line--A private line communication channel of the type provided by communications common carriers for linking two or more points together.

Time-sharing—–A method of operation in which components of a computer facility are shared by several users for different purposes at (apparently) the same time. Although each device actually services one user at a time, the high speed and multiple components of the facility give the outward appearance of handling many users simultaneously.

Translator—–A computer program which accepts statements or instructions written in one language and produces statements in another language, or perhaps direct instructions to the computer for execution. (See "compiler.")

Voice grade channel—–A channel suitable for transmission of speech, digital or analog data, or facsimile, generally with a frequency range of about 300 to 3000 cycles per second.

WATS, or wide area telephone service—–A service provided by telephone companies which permits a customer to make calls to telephones in some geographic zone on a dial basis for a flat monthly charge.

Word—–A set of bits sufficient to express one computer instruction (usually 12 to 48 bits long depending upon characteristics of the machine). Usually the equipment is wired to transfer one word of information at a time.

APPENDIX B—INDIVIDUALS RESPONSIBLE FOR TYPICAL DEVELOPMENT AND DEMONSTRATION PROJECTS

A tactful letter, stating clearly your particular interests, may result in your being sent a recent progress report or technical paper.

I. University-based Research and Development

Dr. Steven Hunka
University of Alberta
9th Floor Education Building
Edmonton, Alberta,
Canada

Dr. John G. Kemeny
Kiewit Computation Center
Dartmouth College
Hanover, New Hampshire 02339

Dr. Duncan Hansen
Center for Computer Assisted Instruction
Tully Building
Florida State University
Tallahassee, Florida 32306

Dr. Lawrence Stolurow
CAI Laboratory
Harvard University
Cambridge, Massachusetts 02138

Dr. Anthony Oettinger
Computation Center
Harvard University
Cambridge, Massachusetts 02138

Dr. Donald Bitzer
Computer-based Education Research Laboratory
University of Illinois .
Urbana, Illinois 61801

Dr. Stanford C. Ericksen
Center for Research on Learning and Teaching
University of Michigan
1315 Hill Street
Ann Arbor, Michigan 48104

Dr. Ronald Ragsdale
Ontario Institute for Studies in Education
102 Bloor Street West
Toronto 5, Ontario
Canada

Dr. Keith A. Hall
201-202 Chambers Building
Pennsylvania State University
University Park, Pennsylvania 16802

Dr. Robert Glaser
Learning Research and Development Center
University of Pittsburgh
Pittsburgh, Pennsylvania 15213

Dr. Patrick Suppes
Ventura Hall
Stanford University
Stanford, Califronia 94305

Prof. Edward D. Lambe
Director, Instructional Resources Center
State University of New York
Stony Brook, Long Island, New York 11790

Dr. C. Victor Bunderson
CAI Laboratory
Sutton Hall
University of Texas
Austin, Texas 78721

Dr. Peter G. Lykos
Director, Cooperative Venture in College Curriculum Development
Illinois Institute of Technology
Information Science Center
Chicago, Illinois 60616

Mr. W. R. Broderick, Director
Computer-Assisted Learning Project
Royal Liberty School
Hare Hall
Rumford
Essex, England

Mr. Derek H. Sleeman, Coordinator
Leeds CAI Project
Electronic Computing Laboratory
The University of Leeds
Leeds, Yorkshire, England

II. Other Research and Development

Dr. Robert J. Seidel, Director
Project IMPACT
Human Resources Research Office
300 N. Washington Street
Alexandria, Virginia 22314

Lt. Cmdr. Richard Inmann
U.S. Naval Academy
Ward Hall
Annapolis, Maryland 21402

Dr. John D. Ford, Jr.
Computer Assisted Instruction Research Department
Navy Training Research Laboratory
San Diego, California 92152

Mr. K. F. Butler
IBM Education Research
Monterey & Cottle Roads
San Jose, California 95114

Mr. Wallace Feurzeig
Bolt Beranek and Newman
50 Moulton Street
Cambridge, Massachusetts 02139

Mr. M. Globberman
RCA Instructional Systems
530 University Avenue
Palo Alto, California 94301

Mr. Robert G. Milburn, Jr.
Univac Defense Systems, Univac Park
St. Paul, Minnesota 55116

Dr. John C. Flanagan
Project PLAN
American Institutes for Research
P.O. Box 1113
Palo Alto, California 94302

Dr. Gordon Pask
System Research Ltd.
20 Hill Rise
Richmond, Surrey, England

Dr. E. N. Adams
Computer Assisted Instruction
IBM Instructional Systems Development Dept.
Watson Research Center, Box 218
Yorktown Heights, New York 10598

III. Secondary School Applications

Dr. Sheldon H. Sofer
Detroit Public School Center
Division of Government Relation and Fiscal Planning
5057 Woodward
Detroit, Michigan 48202

Dr. John Pagen
Director, INDICOM Project
Waterford Township School District
3576 Cass Elizabeth Road
Pontiac, Michigan 48054

Dr. Julian Prince
Superintendent of Schools
McComb Public Schools
McComb County, Mississippi

Dr. Shelly Umans
Board of Education
110 Livingston
Brooklyn, New York 11201

Mr. Murry Tondow, Director
Educational Data Service
Unified School District
25 Churchill Avenue
Palo Alto, California 94306

Dr. Robert N. Haven, Project Director
Laboratory Program for Computer-Assisted Learning
Westwood Public Schools
44 School Street
Westwood, Massachusetts 02090

Mr. Williams M. Richardson
Montgomery County Public Schools
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