To the Graduate Council:

I am submitting herewith a dissertation written by Inja Namkung entitled "Computer-Assisted Instruction in Higher Education." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Education with a major in Curriculum and Instruction.

John R. Ray, Major Professor

We have read this dissertation
and recommend its acceptance:

Accepted for the Council:

Vice Chancellor
Graduate Studies and Research

E

COMPUTER-ASSISTED INSTRUCTION IN HIGHER EDUCATION

A Dissertation

Presented for the

Doctor of Education

Degree

The University of Tennessee

Inja Namkung

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ABSTRACT

Computers have strongly influenced most aspects of modern society, and especially education. During the past fifteen years, extensive research has been conducted into instructional uses of computers. This has influenced development of computer systems, software, and hardware.

The purpose of this study was to describe the status of Computer-Assisted Instruction activities from 1970-1975 in those colleges and universities in the United States chiefly engaged in this new development. A representative set of seven colleges and universities was chosen for in-depth examination.

In order to examine current activities of computer-assisted instruction, this study drew from three primary sets of data:

1. The Index to Computer Based Learning,
2. The Proceedings of Conferences on Computers in the Undergraduate Curricula.
3. CAI activities of the seven selected universities and colleges: The University of Illinois (Urbana), Stanford University, Pennsylvania State University, the University of Texas (Austin), Dartmouth College, the University of California (Irvine), Coast Community College (Costa Mesa, California).

Major findings of this study included:

1. A lack of adequate documentation of CAI activities.
2. That CAI is more effective in some subject areas than in others.
3. That Mathematics, the Physical Sciences, Computer Sciences, and the health professions are outstanding in CAI.
4. That the best informed view of CAI directors is that computer cannot entirely replace effective teachers, but will continue to provide a valuable supplement to conventional teaching.
5. Though some projects-- e.g., Illinois' PLATO -- developed their own hardware system, the majority of CAI projects have used commercially available hardware and equipments.
6. That computer hardware in educational use depends on two different systems, the network system; and the stand-alone system. In the near future, microcomputer technology will probably provide a powerful stand-alone system.
7. That graphic terminal facilities--developed and made economically feasible by the PLATO project --are extremely important for CAI.
8. That COURSEWRITER, APL, BASIC, TUTOR are dominant among programming languages.

9. That the major difficulty in the development of CAI is not hardware but the development of strong programming.
10. That many small colleges have recently become very active in CAI.
11. That CAI activities in higher education fall into two major categories, the centrally controlled CAI laboratory and the individual departmental development.
12. That the high potential of future CAI programs depends upon two essentials: (a) Administrator's cooperation, (b) Willingness on the part of faculty members to consider new teaching techniques.

This research shows that in spite of numerous difficulty and some criticism directed against this technology, CAI development and implementation, as part of the educational system, has merit. Most components of the educational process are increasing in cost whereas the cost of computer-based teaching is declining. With cooperation by administrators and faculty, the computer may eventually become a major factor in the instructional program.

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CHAPTER I

INTRODUCTION

Computers have strongly impacted most aspects of our modern society. According to D. Alpert and D. L. Bitzer,[1] much research on the subject has been conducted in the past decade:

> To explore the possibility of utilizing modern computer technology for education, a widely varying array of such efforts is encompassed by the term "computer-assisted instruction" . . . The setting for these activities is an overall formal eudcational process in which the national investment is more than $50 billion annually, a commitment which is expected to increase to well over $100 billion by 1980. Yet, despite this large National commitment, it is commonly agreed that there are vast unmet needs in education, in terms both of quantity and of quality. There are growing demands for more mass education over a large fraction of the human life-span, and demands for more individualized instruction tailored to the specific preparation and motivation of a given student.

With regard to this desideratum of individualized instruction, Patrick Suppes writes[2] as follows:

> . . . the central argument for instruction by computer may be found in an examination of the deep possibilities of individualized instruction. The first and most important aspect of individualization is based on the well-known psychological

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[1]D. Alpert and D. L. Bitzer, "Advances in Computer-based Education," Science, CLXVII, (March 20, 1970), p. 1582.

[2]Patrick Suppes, "Alternatives through Computers," Alternatives in Education, General Publishing Co., Ltd., Toronto, 1971, pp. 61-62.

> generalization that there are definite and clearly significant individual differences in students. The fact is that children enter school with remarkably different abilities and retain them throughout their careers; further, they work at different rates and different levels of accuracy and understanding. But, unfortunately, for obvious economic reasons, schools and colleges are not able to offer an individual curriculum program to each student according to his needs. The computer, simultaneously handling many students, can let each progress at his own pace and at his own level of achievement.

Suppes points out, further, that the computer does not compete with the teacher. Rather its role, like that of a book, is

> To amplify the skill and time of the teacher . . . skilled teachers . . . will be able to use computers to individualize instruction . . . and to reserve their own efforts for troubleshooting and individual attention of an intensive sort.

Many educators have realized the important role of the computer in instruction but little integrated research has been done to show the range of achievement in this new field. The reason for this lack of informed understanding is that "prior to the early 1960's, projects in CAI were virtually unknown" to those not immediately engaged in them. "Until 1970 or 1971, almost all the projects were developed" separately and independently "in university research settings, especially in universities with rich computer resources."[3] For the same reason, computer-assisted instruction is still most active in large universities. Recently community colleges

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[3]D. Jamison, P. Suppes and S. Wells, "The Effectiveness of Alternative Instructional Media: A Survey," Review of Educational Research, XLIV, (1974), p. 42.

have become increasingly active. Beginning in 1970 at the University of Iowa, educators interested in computer potential began to work together. Their first conference was concerned with the role of the computer in undergraduate curricula, and the second annual conference at Dartmouth showed that their interest in CAI was increasingly active.

A. THE PROBLEM

Statement of the Problem

The purpose of this study was to describe Computer-Assisted Instruction activities from 1970-1975 in colleges and universities in the United States. A representative set of seven colleges and universities was chosen for in-depth examination.

Importance of the Study

Since the use of computers will become ever more common in coming decades, it is very important to know the general trend and the current status of CAI. It is also important to know which colleges and universities have programs for instructional use of computers, how intensively they are used, how effective they are, their cost, their future potential, what their "hardwares" and "softwares" are. The sharing of high-quality instructional programs and learning materials with other institutions reduces the cost of implementing them and can provide the most effective use of technology for instruction in higher education.

Limitations of the Study

1. The study was limited to describing the instructional use of computers as documented by available reports and/or other publications of seven colleges and universities in the field. These were the following schools:

   1. The University of Illinois (Urbana)
   2. Stanford University
   3. Pennsylvania State University
   4. The University of Texas (Austin)
   5. Dartmouth College
   6. The University of California (Irvine)
   7. Coast Community College (Costa Mesa, California)

Other limitations to the study were imposed by

2. available data
3. the willingness of CAI representatives to cooperate through responding to questions
4. the time limitation, 1970-1975.

B. DEFINITION OF TERMS

Computer-Assisted Instruction - "(CAI) is a highly flexible method of automating the teaching-learning process. Instructional content is presented by a computer that guides the learner through the content by performing a running analysis of his successes and failures."[4]

Computer-Managed Instruction - "(CMI) differs from CAI in that in CMI students and profiles are kept stored in the computer and the student enters test or examination answers or scores. The results of the tests are recorded and evaluated

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[4]"Computer-Assisted Instruction at the Florida State University," IBM Application Brief, International Business Machines Corporation, Data Processing Division, New York.

against previous data, and a prescription is printed out which directs the student to new materials such as a concept film or a lesson, or the computer may provide him with remedial work to improve a detected weakness."[5]

Hardware - "Physical equipment, such as the mechanical, magnetic, electronic, or electrical devices or components from which assemblies are made, or the assemblies themselves; for example, the assembly of material that forms a computer, as distinct from data, routines, or programs. An entire computer system is considered a hardware item."[6]

Software - "Data and information that are associated with the hardware of a machine or system; for example, a collection of computer programs, routines, compilers, assemblers, translators' manuals, circuit diagrams, and operational procedures."[7]

Operation, on line - "An operation performed on equipment or devices that are under the direct control of a central processing or control unit of a system."[8]

Operation, offline - "An operation that is performed on equipment or devices that are not under the direct control of a central processing or control unit of a system. Usually, offline operations are performed on peripheral equipment."[9]

Time-shared system - "A specific system in which available central-computer time is shared among several jobs as directed by a scheduling plan or formula."[10]

C. PROCEDURES

After a thorough study of available documents, seven

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[5]Andrew R. Molnar, "Computer Innovations in Education," 1973, p. 36.

[6]Martin H. Weik, Standard Dictionary of Computers and Information Processing: Hayden Book Company, Inc., New York, 1969, p. 152.

[7]Ibid., p. 267. [8]Ibid., p. 208.

[9]Ibid., p. 207.

[10]Charles J. Sippl and Charles P. Sippl, Computer Dictionary and Handbook: Howard W. Sams & Co., Inc., Indianapolis, Indiana, 1972, p. 458.

college and universities[11] were selected as most representative of schools active in computer-assisted instruction. Data utilized in determining the seven schools included:

1. The proceedings of conferences on computers in the undergraduate curricula held at the University of Iowa in 1970, at Dartmouth in 1971, at Georgia Institute of Technology in 1972, at Claremont College in 1973, at Washington State University in 1974, and at Texas Christian University in 1975.
2. The Index to Computer Based Learning[12] (previously entitled Index to Computer-Assisted Instruction).
3. After careful examination of all available documents--i.e., Annual reports, interviews, published articles and books, letters to and from the institutions concerned, etc., seven colleges and universities were selected because they had the most numerous, currently the most active CAI programs and/or the most definite or most promising plans for future developments.

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[11]Each of the colleges and universities here listed was asked to supply its most recent Annual Report of work in Computer-Assisted Instruction.

[12]Compiled by the Instructional Media Laboratory, University of Wisconsin, Milwaukee. The Index lists a total of 1766 programs.

4. Data studied can be categorized into three sets:

   (1) The Index to Computer Based Learning
   (2) Proceedings of Conferences on Computers in the Undergraduate Curricula
   (3) Activities of seven selected colleges and universities.

   Findings based on The Index to Computer Based Learning have been set forth in seven tables dealing respectively with (1) Quantitative Distribution of Instructional programs, by subject (2) by Disciplines (3) by Institutions (4) by major Instructional Strategy (5) by major Programming Language (6) by major Central Processor (7) by major Computers Used in CAI.

   Findings set forth under Appendices A, B, C, D, and E are drawn from Proceedings of Conferences on Computers in the Undergraduate Curricula. CAI activities at the seven selected colleges and universities are set forth on pages 49-93 of Chapter III.

D. ORGANIZATION OF THE STUDY

This dissertation consists of five chapters, as follows:

Chapter I includes an introduction, and later sections on the purpose of the study, its importance, its limitations, definitions of terms and procedures and organization of the study. Chapter II is devoted to a survey of related research and literature. Chapter III deals with data concern-

ing Index on Computer Based Learning, the proceedings of The Conferences on Computers in the Undergraduate Curricula, CAI at seven selected universities and colleges. Chapter IV discusses analyses of data in Chapter III. Chapter V presents summary of findings and conclusions.

CHAPTER II

A REVIEW OF RELATED LITERATURE

A. BACKGROUND

During the past three decades, the growth of computer activity has been phenomenal. The first operational digital computer, MARK I, went into use at Harvard University in August, 1944. In 1946, the University of Pennsylvania developed the first electronic computer, ENIAC (Electronic Numerical Integrator and Calculator). In 1950, there were approximately a dozen computers installed in the United States. By 1960, the number of installations had grown to approximately 6,000. In 1970, there were more than 80,000 general purpose computers in the United States, and this growth was expected to become even more rapid during the next 25 years. Some estimate that the number of computers will double by 1975, and double again by 1980. Even though growth has generally exceeded the most optimistic estimates, forecasters are unable to predict accurately the future of computing.[13]

The important fact, however, as Levien has noted, is that computer development has been most merely quantitative

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[13]Roger E. Levien, The Emerging Technology, McGraw-Hill, New York, 1972, p. 1.

but also significantly qualitative.

> We are now experiencing the transition from an era in which the computer . . . will be an everyday necessity . . . the next 25 years will be a universal era, in which, for an extremely broad range of applications computers will become economical and, consequently, will be widely applied to tasks that now seem infeasible. For almost everyone, the computer will be accessible, both physically, because it will be close at hand in the form of a typewriter or television-like device; and intellectually, because it will become a convenient, tireless, and reliable assistant in daily tasks . . ..[14]

Even now, the computer has become an almost common place instrument in the service of higher education.

The computer has the great advantage - lacking in earlier teaching aids - of being able to serve individual needs of learners. Historically, the face to face give and take of Socratic teaching could do this for only the very few. The needs of the many in their search for knowledge were met by the study of books - especially textbooks - and by pictures, maps, phonograph records, films and radio. But all these aids and instrumentalities provided inadequately for the differences and needs of individuals. In 1926, however, what then seemed to be a hopeful step toward achieving this objective was taken when Pressey built his first simple teaching machine. His purpose was to relieve over-burdened teachers from the drudgery of mechanical drill work, in order to free them for "inspirational and thought-stimulating activities."[15] Later Pressey developed several improved teaching

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[14] Ibid., pp. 1, 3.

[15] Sidney L. Pressey, "A Simple Apparatus Which Tests

machines, but, having as he thought, failed to win adequate professional support, he "regretfully" dropped further work on this project though he hoped that others might carry on.[16] This hope was not soon fulfilled but some twenty years later the Harvard psychologist B. F. Skinner made another constructive move.

In 1954 Skinner pointed out that his extensive studies on "the experimental analysis of behavior" effectively applicable by "appropriate instrumentation" had "direct implications for the teaching process."[17] Skinner's research, as summarized by Ohmer Milton,[18] basically emphasized: (1) "active . . . learning by doing," (2) the necessity of logical presentation in a "series of small steps," (3) adaptation to the individual student's "own pace," (4) "immediate" report of results to the student.

Later N. A. Crowder developed an alternative technique intended to avoid a possible shortcoming of Skinner's

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and Scores-and Teachers," School and Society, XXIII, No. 586. March 20, 1926.

[16]Sidney L. Pressey, "A Third and Fourth Contribution Towards the Coming 'Industrial Revolution' in Education." School and Society, XXXVI, No. 934, November 19, 1932.

[17]F. Glaser Lumsdaine, Teaching Machine and Programmed Learning, Washington, 1960, p. 95.

[18]B. F. Skinner, "The Science of Learning and the Art of Teaching," The Harvard Educational Review, XXIV, No. 2, 1954; "Computer-Assisted Instruction," Teaching-Learning Issues, The Learning Research Center, The University of Tennessee, No. 3, Winter, 1967.

method, its tendency to bore "the more intelligent students" who might find the "questions too simple." For them he provided "larger steps" or "branching" them on to more difficult material.[19]

In spite of the advantages accruing to programmed instruction (PI) from the work of Skinner and Crowder, professional opinion thus far has not found "convincing demonstration" of P.I. superiority to "human teachers."[20]

The next important forward step toward effective individualized teaching is the real potential of CAI: in spite of many misconceptions[21] still current, the "flexibility and adaptability"[22] of the computer. These resourceful characteristics of the computer have helped to achieve many effective "modes" for teaching. Among those which have thus far been authoritatively recognized are: the following as listed for example by Roger E. Levien[23] tutorial, drill and practice,

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[19]Norman A. Crowder, "Automatic Tutoring by Intrinsic Programming," Teaching Machine and Programmed Learning, A. A. Lumsdaine and Robert Glaser (ed.), Washington, 1960, pp. 286-88.

[20]Donald E. McGovern, "Computer-Assisted Instruction," unpublished Master Thesis, The University of Tennessee, Knoxville, 1970, p. 13.

[21]D. Alpert and D. L. Bitzer, "Advances in Computer-based Education," Science, CLXVII, (March 20, 1970), p. 1584.

[22]Ohmer Milton, "Computer-Assisted Instruction," Teaching-Learning Issues, The Learning Research Center, The University of Tennessee, No. 3, Winter, 1967.

[23]Roger E. Levien, The Emerging-Technology, p. 354. See also below, Chapter 3.

inquiry, socratic or dialogue, gaming, simulation, problem-solving and testing.

Within approximately a decade and a half almost all American universities and more than a third of the colleges granting only bachelor's degrees have made available to their students and staff computer services to be used both in teaching and research. By 1971 about 70% of the total number of American college students were studying at schools with some type of computer facilities which could be used to assist in instruction. There were also many institutions which belonged to computer networks or could gain access to a remote terminal located on the campus, or were serviced by commercial firms.[24]

Since the early 1960's, several studies of the computer in higher education have been completed. Under the direction of Dr. John Hamblen, the Southern Regional Education Board, in 1967 and 1969, made quantitive national surveys of computer use in higher education.[25] Of these two surveys, the later one is especially useful. The data in this survey were derived from a 79% response to questionnaire sent to 2,477 colleges and universities, i.e., "all the public and private institutions with degree programs" ranging

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[24]Andrew R. Molnar, "Higher Education and the Post-Industrial Society," 1971.

[25]John W. Hamblen, Computers in Higher Education, Southern Regional Education Board, Atlanta (conducted under a cost-sharing contract with the National Science Foundation), 1967.

from Junior college diplomas through the doctorate degree.[26]

A slightly earlier but no less important qualitative report of educational computer needs was the Rosser Report of 1966 made for the National Academy of Sciences.[27] According to Dr. Tom Kurtz, Director of Dartmouth's Computer Center Writing in CCUC/1,[28] the major short-coming of the Rosser Report was that "it dealt almost exclusively with . . . research needs for computers in the scientific discipline and ignored the needs of computing in the educational process."

A year after the Rosser Report, the President's Science Advisory Committee published the result of its analysis of educational computer needs under ten[29] recommendations, summarized as follows:

1. All colleges and universities should provide computer facilities "comparable in quality with those" available in "the more pioneering schools."
2. The government should share the cost of installing

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[26]John W. Hamblen, Inventory of Computers in U.S. Higher Education, Computer Sciences Project (conducted under a cost-sharing contract with the National Science Foundation), Southern Regional Education Board, Atlanta, 1969.

[27]Digital Computer Needs in Universities and Colleges, National Academy of Sciences, National Research Council, Washington, D.C., 1966.

[28]Tom Kurtz, "The Pierce Report Revisited," Proceedings of a Conference on Computers in the Undergraduate Curricula. The University of Iowa, Iowa City, Iowa, June, 1970.

[29]Computers in Higher Education, Report of the President's Science Advisory Committee, U.S. Government Printing Office, Washington, D.C. 1967.

and continuing educational computer service.

3. The . . . DOD-NSF agreement should "be extended to other government agencies and private supporters, and include . . . capital and operating cost grants . . .."

4. Adequate faculty computing competence must be achieved.

5. Extension of federal government support of research and education in computer science.

6. Free exercise by schools of application of supporting government funds towards cost of equipment or staff.

7. The establishment of "large central educational computing facilities capable of serving several institutions."

8. The development of "accounting procedures" for accurate measurement of "the cost and utilization of computer services."

9. Encouragement of investigation to study the use and development of computer service "in secondary schools" with the cooperation of "university centers."

10. Annual federal report and forecasts of educational computer data with special emphasis on personnel and job potential.

In 1972, Clark Kerr (the Chairman of the Carnegie Commission on Higher Education), under the direction of Roger

E. Levien and with the assistance of the RAND Corporation, produced "The Emerging Technology," one of the most comprehensive reports ever attempted on computer-assisted instruction. The three parts of this report provide respectively, (1) a general introduction by Levien on The Computer Use on Higher Education, (2) a discussion of the instructional use of the computer, and (3) discussion of future prospects.

In the early 1960's, with the active support of the National Science Foundation,[30] Amerian colleges and universities were beginning to acquire computing equipment, primarily for scientific research. This was a period of rapid growth; in 1962 about two hundred schools had computers,[31] by 1969, over 1,250 schools had computers.[32] Estimated expenditures on computers was approximately $49,000,000 in 1962-63; and $352,000,000 in 1968-69, or "more than a seven-fold increase." However, only 30% of the total amount used for the purposes of administration, research, instruction, etc., was for instructional use of the computer. Some six hundred thousand students in fifteen thousand courses were reached, but almost all this instruction was about computer use in engineering, business and "computer science;" there was

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[30]Andrew R. Molnar, "Computer Innovations in Education," (This publication was originally drafted for a UNESCO), 1973, p. 8.

[31]John W. Hamblen, Computers in Higher Education, 1967.

[32]John W. Hamblen, Inventory of Computers in U.S. Higher Education, 1969.

almost no direct instruction with computers.[33]

B. INSTRUCTIONAL USE OF COMPUTERS

In 1958, the first instructional uses of the computer began at the Thomas J. Watson Research Center at Yorktown Heights, New York which developed computer teaching of binary arithmetic. In the same year, The System Development Corporation used a computer as "a random-access projection device" for research on branching in a flexible teaching machine. Again in 1958, the firm of Bolt, Beranek and Newman developed a variety of uses, including the construction of graphs in response to requests made by students in analytic geometry.[34]

In 1960, "as a result of conversations between engineers, physicists, psychologists and educators," the PLATO[35] (Programmed Logic Automatic Teaching Operation) program began at The University of Illinois. The original PLATO system has been refined to PLATO II, III, IV. "The use of CAI as a research vehicle is still a strong component of the Illinois

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[33]Roger E. Levien, The Emerging Technology, McGraw-Hill, New York, 1972, p. 123.

[34]Karl L. Zinn, "Instructional Uses of Interactive Computer Systems," Datamation, XIV (September, 1968), p. 22.

[35]A summary analysis of this program appears in my Chapter III. See Plato Highlights, Computer-Based Education Research Laboratory, University of Illinois, May, 1974.

program."[36]

In 1963, the Institute for Mathematical Studies in the Social Sciences at Stanford University began a program of research and development in computer-assisted instruction, mainly elementary mathematics and reading. After initial development, these CAI services were extended through telephone lines to schools over 2,000 miles away in Mississippi, Kentucky, Tennessee, Ohio and Washington, D.C.[37]

In 1964, The Florida State University initiated CAI on their campus. "IBM 1050 terminal was connected by dialup long distance telephone lines to a dedicated IBM 7010 Data Processing System at the Thomas J. Watson Research Center in Yorktown Heights, N. Y. . . . As of June, 1966, this computer-assisted instruction center had more than thirty six separate courses in various stages of development."[38] But, according to information given to the writer at the Fort Worth Conference[39] in June, 1975, curtailed support and funds have substantially slowed up developments at Florida State.

In 1964, the CAI Laboratory at Pennsylvania State

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[36]The Emerging Technology, p. 347.

[37]P. Suppes, "Computer-Assisted Instruction at Stanford," Man and Computer, Bordeaux, 1970, pp. 298-330.

[38]IBM Application Brief on "Computer-Assisted Instruction" at the Florida State University.

[39]1975 Conference on Computers in the Undergraduate Curricula at Texas Christian University, Fort Worth, Texas.

University began their work "for testing the feasibility of using computers" for instruction in college level courses.[40] According to The Emerging Technology,[41] "Pennsylvania State University has been among the most prolific in the generation of programmed course material. Its CAI Laboratory sponsors work in evaluation of instructional approaches and on such problems as student attitudes."[42]

Beginning in 1965, The University of Texas CAI Laboratory became increasingly active in the "research possibilities of computer use" especially "in the design of systems" to simulate "laboratory experiments."[43] (By 1972, however, most of the personnel concerned in this work moved over to Brigham Young University which, in turn, came to emphasize mini-computer services especially for "community colleges and other small institutions.")[44]

After 1966, the numbers of centers engaged in research on CAI increased. The Computer-Assisted Instruction Laboratory at Harvard, directed by Dr. Lawrence Stolurow began a very active program, "studying the psychological and

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[40]The Pennsylvania State University Computer-Assisted Instruction Laboratory, January, 1975.

[41]The Emerging Technology, p. 348.

[42]Ibid., p. 347. [43]Ibid.

[44]Kenneth J. Stetten, "The Technology of Small, Local Facilities for Instructional Use," Computers in Instruction, October, 1970; C. Victor Bunderson, The TICCIT Project: Design Strategy for Educational Innovation, Brigham Young University, September 1973, p. 2.

emotional factors affecting instruction in CAI."[45] They also developed a number of programs especially on elementary reading and elementary and secondary mathematics.[46] But, as in the case of Florida State University, the current recession has cut short Harvard's work in this field. Dr. Stolurow has moved to the State University of New York, Stony Brook, where some of this work is being continued.

Between 1967 and 1970 the National Science Foundation supported at Brooklyn's Polytechnic Institute "exploration . . . of the uses of digital computers in high school curricula." Successful findings indicating that "simulation were potentially valuable educationally" led the National Science Foundation to fund a two year extension (1970-72 at The Polytechnic Institute) of simulation-material development for high school "biology, physics, and social studies." This grant was supplemented by another two year extension at the State University of New York.[47]

According to the authors of the Huntington Computer Project,[48] effective advertising of the computer manuals growing out of this work led to the sale in 1973-74 of 25,000

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[45]Andrew R. Molnar, "Computer Innovations in Education," p. 10.

[46]From Index to Computer Based Learning.

[47]Marian Visich, and Ludwig Braun, "The Use of Computer Simulations in High School Curricula," Huntington Computer Project, the State University of New York, Stony Brook, January, 1974, p. 1.

[48]Ibid., p. 3.

manuals concerning nine different simulation packages. Four hundred schools reaching about 100,000 students are said to have been reached.[49]

Meanwhile, between 1965 and 1970--but not more definitely dated in available sources of information--there were developments at (A) Pittsburgh and (B) Wisconsin,

> (A) Pittsburgh, Learning and Development Center emphasized research in computer technology chiefly concerned with "individualized instruction" especially at the elementary level.[50]
>
> (B) Wisconsin, Madison Campus similarly undertook "an ambitious program" of individualized computer courses "to be taken by the student at his own convenience and at his own pace." At the Milwaukee Campus, "information services" on "instructional technology and media" were provided. These later produced The Lekan Index.[51]

In 1969, Helen A. Lekan published the first comprehensive listing of instructional programs designed for use with computers. She had gathered information on the basis of questionnaires returned to her by participating institutions, with the result that the findings were necessarily incomplete. Nevertheless, the project has been useful enough to

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[49] Ibid., pp. 3-4.

[50] The Emerging Technology, pp. 347-348.

[51] Hereafter referred to as Index I.

its readers to have gone through four revised and augmented editions by 1973. In keeping with the changing attitudes and uses, its title has been changed from Index to Computer Assisted Instruction to the more comprehensive Index to Computer Based Learning.[52]

Since 1969, at the University of California, Irvine, the Physics Computer Development Project has been engaged quite actively "in development of computer-based teaching material in a wide variety of modes."[53] Under the direction of Professor Alfred Bork, the project has produced "about forty highly interactive student-computer dialogs."[54] The most recent of these "use graphic facilities," i.e., visual computer screens which are capable of drawing graphs of mathematical equations, etc. The aim of this project was to develop "compelling examples of effective use of the computer in learning situations, primarily in physics and other sciences, at the undergraduate level."[55] These materials of Irvine's project have been used also in other University of California campuses "through an intercampus telephone

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[52]Hereafter referred to as Index II.

[53]According to Alfred Bork, all the modes will be considered, including problem solving, tutorial, simulation, and dialog, Proceedings of CCUC/6, June, 1975, p. 57.

[54]"Student computer dialog" means a "conversation" between a student and a computer device, possibly a terminal or display. Ibid., p. 242.

[55]Alfred Bork, "Current Status of the Physics Computer Development Project," Ibid., p. 61.

system."[56]

In 1970, Penn State University began a fresh and significant experiment. Basically it was like the bookmobile which brought central library resources to the homes of out-of-the-way readers. The new "mobile van" computer takes the computing equipment and selected personnel to "hundreds of teachers in Appalachia who cannot easily get to a college campus." It enables them to earn graduate-level courses, and in turn, to take their findings to the handicapped children whom they teach.[57]

Since 1970, many community colleges have become very active in the use of CAI programs in their regular school curriculum. A leading community college district in the nation in use of the computer as a tool of instruction is the Coast Community College District, located in Costa Mesa, California, which includes Orange Coast College and Golden West College. Dr. Bernard J. Luskin, the administrator of this district is an expert in this field. Dr. Luskin's research on An Identification and Examination of Obstacles to the Development of Computer-Assisted Instruction[58] may be a

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[56]Alfred Bork, "Learning with Computer-Today and Tomorrow," a recent paper, Xerox copy, no date.

[57]From the brochure of "Taking a Computer to the Hills," originally from THINK, IBM's Employer Publication, 1972.

[58]Bernard J. Luskin, "An Identification and Examination of Obstacles to the Development of Computer Assisted Instruction," unpublished doctoral dissertation, University of California, Los Angeles, 1970. University Microfilms, Ann Arbor, Michigan, 1972.

useful guide to college administrators who are planning to employ CAI in their schools. According to the IBM statement concerning this community college district, "the computer has been used in the actual instructional program in many fields."[59] "In the school year 1971-72, Golden West had alone approximately 2,000 students . . . learning from over 500 instructional segments involving approximately 239 hours of instructional materials in 21 different subject areas." More than 60 teachers "incorporated CAI into their instructional system."[60]

In 1971, the University of Texas, Austin, began PROJECT C-BE (Computer based education) which ranged over many different fields. This new project absorbed and replaced all earlier University of Texas Computer Learning. Characteristically the project does not involve "significant hardware effort." Rather it applies "current technology and currently available devices in concert with sound pedagogical practice to increase the effectiveness of higher education."[61] Especially noteworthy are the activities of CAI in Freshman English and of CMI in Introductory Psychology, Statistics

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[59]IBM Computer-Assisted Instruction at the Coast Community College District.

[60]A letter with Xerox copy from Dr. Luskin, on "Computer Assisted Instruction at Golden West College, a description and Evaluation."

[61]John J. Allan, III, and J. J. Lagowski, Eighteen Months of PROJECT C-BE, The University of Texas at Austin, November, 1973, p. 2.

and Anthropology. In these last three subjects, virtually all instruction is by computer, teachers serving only for occasional advice at students' requests.[62]

Computer Assisted Instruction at Ohio State University has also advanced during recent years. By October, 1974, seventy six different programs covering eighteen different fields were available at sixty five student terminals located in various buildings of the campus.[63] CAI at Ohio State University "provides individualized instruction . . . supplemental to classroom lectures and laboratory sessions."[64] Among other CAI activities education dentistry and medicine are most heavily involved.

At the University of Minnesota and at Purdue separate departmental activities in CAI stand out. At Minnesota, the Mathematics Education Department conducted research on a Computer-Assisted Mathematics Program (CAMP) which produced student texts for grades seven through twelve with teacher commentaries for use in current secondary school mathematics. The materials include instruction on programming the computer in the BASIC language, and provide problem settings on computer use as a problem-solving aid in the curriculum. Several

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[62]Jan H. Bruell, "Completely Computer-Managed Self-paced Classes," Proceedings of CCUC/6, June, 1975, p. 249.

[63]"A list of CAI courses available on OSU system," Ohio State University, Computer Assisted Instruction, October, 1974.

[64]CAI Newsletter at Ohio State University, no date but approximately March, 1975.

experiments in this field were conducted at the University of Minnesota High School.[65]

At Purdue, the Computer Sciences Department produced a number of CAI programs in Mathematics. The majority of these - according to the detailed description in the Index II[66] - deal with Numerical Analysis. Their project is known as "Computer-Assisted Instruction in Numerical Methods Project."

Network Systems

Ascertainable facts concerning the instructional use of network system may be summaried as follows:

1. "Initial efforts in time-sharing began during the period of (1961-1965) with a successful demonstration of computer time-sharing at M.I.T. . . ."[67]

2. "In 1964 Dartmouth College established a time-shared computer center" and opened it without charge to all students and faculty.[68] For the students, familiarity with the DTSS[69] and learning the BASIC

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[65]Larry L. Hatfield and Thomas E. Kieren, "Computer-Assisted Problem Solving in School Mathematics," Journal of Research in Mathematics Education, March, 1972, pp. 99-112.

[66]Index II, pp. 406-412.

[67]Andrew R. Molnar, "Computer Innovations in Education," p. 9.

[68]Ibid., p. 9.

[69]Dartmouth Time-Sharing System.

programming language is part of the first-year curriculum.[70] The IMPRESS (Interdisciplinary Machine Processing for Research in Social Sciences) project at Dartmouth is "one of the few examples of database applications in education. . . . IMPRESS is a series of programs running on the Dartmouth time-sharing system."[71]

Another significant development of the sixties was the establishment of Regional Cooperative Computer Networks for instructional purposes.

3. The North Carolina Educational Computing Services (NCECS) is a typical example of a regional network. It services the entire state of North Carolina[72] and provides "interactive teletype computer services" to forty three North Carolina universities, colleges, and technical institutes. It also provides "technical support and curriculum development services."[73] The curriculum areas provided are biology, business, economics, chemistry, engineering, humanities,

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[70]T. C. Hsiao, (ed.) Directory of Computer Education and Research, I: Senior College, Science and Technology Press, Inc., Washington, D.C., 1973, p. 647.

[71]The Emerging Technology, pp. 377-378.

[72]Andrew R. Molnar, "Computer Innovations in Education," p. 21.

[73]Joseph R. Denk, "Curriculum Development of Computer Usage in North Carolina," Proceedings of CCUC/1, June, 1970, p. 11.9.

mathematics, physics, and statistics.[74]

4. Considerable variations in organization and services occur in other networks. For example, the University of Iowa Regional Cooperative Network is one of the few which supplies instructional services through remote-batch terminals. The following institutions participated in the University of Iowa regional computer network: Iowa Wesleyan, Kirkwood, St. Ambrose, Central, Clarke, Coe, Marycrest, Loras, Grinnel Augustana, and the University of Dubuque.[75]

5. On the other hand, the Colorado Educational Computing Network "combines an academic television network with a computer network."[76]

6. The University of California at Santa Barbara has established an On-Line Computing System for CAI in chemistry and engineering. According to its directors, this is "a unique nationwide experiment of a disciplinary network," and "an extended version of the Culler-Fried system (an on-line symbol manipulation system) . . . implemented on an IBM-360/75 computer" and employing a user station consisting of

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[74]Ibid., pp. 11.11-11.12.

[75]Gerard P. Weeg, "The Role of Regional Computer Networks," Computer in Instruction, (ed.) R. E. Levien, 1971, pp. 62-63.

[76]Andrew R. Molnar, "Computer Innovations in Education," p. 22.

a storage oscilloscope . . . for output and dual keyboard for input . . ." It has "about 50 user-stations, including a sixteen-station" at Santa Barbara and "remote stations from as far away as Oak Ridge and Princeton." The project was undertaken in order to evaluate "the effectiveness of the on-line system as a CAI tool "and to examine its impact upon the curriculum.[77] Santa Barbara chemistry department "recognized the necessity of providing students with the use of computers" enabling them "to develop solutions to problems directly from fundamental theory without . . . tedious algebriac development."[78] For example, students required to solve quantum mechanical problems "were supplied with subroutine for solving second-order differential equations."[79] The Santa Barbara on-line system is now used also by other schools "via terminal consoles and telephone-line linkage."[80] Among these others are Beloit College, the University of Pittsburgh, the University of Minnesota, Illinois Institute of Technology, Georgia

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[77]Philip Kinsey, David O. Harris and James A. Howard, "The UCSB On-Line Computing System," Proceedings of CCUC/1, pp. 9.15-9.32.

[78]Roger E. Levien, The Emerging Technology, p. 381.

[79]Ibid., p. 381.

[80]Ibid., p. 382.

Institute of Technology, Florida State University, Louisiana State University, and Washington State University.[81]

7. Another variety of network is the New England Regional Computer Network (NERComP), a non-profit organization, which conducts "a program of research leading to the improvement of interconnections between computers in higher education."[82] This network "provides access to seven regional centers:" Babson College, Bowdoin College, Brown University, Massachusetts Institute of Technology, the University of Massachusetts, Worcester Polytechnic Institute, and Dartmouth. Dartmouth in turn has augmented NERComP's offerings "with over 3,000 terminal hours per week." Recently some thirty colleges have purchased service through NERComP and this service continues to grow to meet the expanding needs.[83] Several public schools have also been involved quite actively in CAI through network systems. The first one was Philadelphia, closely followed by New York City.

8. In 1966, the Kansas City Missouri Public School District began its initial investigation on CAI. By

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[81] Ibid., p. 382.

[82] Biennial Report 1971-1973, The Kiewit Computation Center, Dartmouth College, p. 16.

[83] Ibid., p. 16.

1970, they had gained much experience: "almost 2,000 student subjects," ranging from the primary to the post-doctoral level, had "contributed about 35,000 terminal hours of on-line instruction data in CAI."[84]

9. Since 1968, The Montgomery County schools, Maryland CAI program has been in operation. By 1974-75 it became an operational part of the school system "with 91 terminals operating in 20 schools." The curriculum in use was developed by the county teaching staff, and evaluation of the results showed that this curriculum was "significantly more effective than traditional instruction."[85]

10. In 1974, The Minnesota Educational Computing Consortium (MECC) began "the statewide organization for coordinating educational computing at all levels . . . in Minnesota." According to its users, this network was "very successful" in its first year of operation and those in charge thought it would "no doubt serve as a model in many other states."[86]

The network system provides many advantages, especially to small colleges. According to an NSF statement, it

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[84]Fred O'Neal, "The Role of Public Schools in Computer-Assisted Instruction," Educational Technology, March, 1970, p.9.

[85]A personal letter from Mrs. Catherine E. Morgan, Director, CAI Program at Montgomery County Public Schools, May 14, 1975.

[86]ACM SIGCUE Bulletin, IX, No. 1, January, 1975, p. 2.

also "eliminates transfer problems associated with moving instructional programs" from one place to another, and makes possible "the centralization of and access to large data bases."[87]

Financial support and funding for the development of computer technology has come mainly from three sources: The U.S. Office of Education, The National Science Foundation and from state, local or business organizations.

Mini-Computer Developments

Beginning in 1970 the development of the mini-computer made an important impact on computer-aided education. The recent developments of Ticcit[88] (mini-computer) proved to be particularly attractive to many small colleges and secondary schools. An available mini-computer "located in the school building simultaneously serves 100 to 300 students with a new level of computer instructional service."[89] The system, moreover, not only serves students in "centrally located clusters of terminals, but can also serve students in dormitories, office, and even homes off-campus via a standard cable

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[87]Andrew R. Molnar, "Computer Innovations in Education," p. 21.

[88]Ticcit (time-shared interactive, computer-controlled information television) system, which was developed by the Mitre Cooperation in collaboration with the University of Texas and Brigham Young University.

[89]Kenneth J. Stetten, "The Technology of Small, Local Facilities for Instructional Use," p. 35.

[90]An Overview of the TICCIT Program, The Mitre Co., January, 1974, p. 7.

television system."[90] The Ticcit course materials are developed through "collaborative effort of programmers, educational psychologists and specialists in the subject of the course."[91] In August, 1970 the NSF funded an experiment which assisted ten colleges[92] in acquiring mini-computers, with coordinating supervision by the Southern Regional Education Board (SREB). The results were reported at the 1975 Conference on Computers in the Undergraduate Curricula (CCUC/6 at Fort Worth, Texas). The ten colleges varied somewhat in the objectives sought and/or attained by their mini-computers but the general finding was that the results attained were favorable.[93]

R. E. Levien has summarized as follows the major implications of mini-computer developments:

> The development of small-size, low-cost, general-purpose computers has been a consequence of the invention of integrated circuits, which made it possible to contain the circuitry of contemporary computers as little as 1 cubic foot and to produce the computers at a small price . . ..

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[91]Allen J. Hammond, "Computer-Assisted Instruction: Two Major Demonstrations," Science, CLXXVI, (June, 1972), p.1110.

[92]Benedict College, Columbia, South Carolina; Canisius College, Buffalo, New York; Delaware State College, Dover, Delaware; Erskine College, Due West, South Carolina; Hollins College, Roanoke, Virginia; Illinois Benedictine, Lisle, Illinois; MacMurray College, Jacksonville, Illinois; Maryville College, Maryville, Tennessee; Mt. Union College, Alliance, Ohio; The University of the South, Sewanee, Tennessee.

[93]Vincent H. Swoyer, and John W. Hamblen, "Use of Minicomputer Facilities for Higher Education Instruction," Proceedings of CCUC/6, pp. 279-299.

> Most mini-computers currently cost between $5,000 and $25,000 for a basic computer with 4,000 to 8,000 words of storage and a teletype terminal . . . . In many specific situations, mini-computer costs may actually be less than time-shared computer costs plus the required communications charges . . . . By the end of the 1970's or early 1980's, the price of minicomputers may drop to a level that will make them consumer items . . . . Even though large machines are likely to retain certain advantages in economy and practicality: [especially] through time-sharing of one large machine among many users. A major feature of [mini-computer] development will be the growth of application-program libraries available in cassett (or similar) form.

A review of literature in this field shows that in many cases, CAI activities have been undertaken without being adeqyatekt documented. CAI activities have applied new hardware and software without documenting their progress. They have simply kept on trying new materials or devices. A recent annual report of work in this field is available only for the University of Illinois' PLATO project. The University of Texas C-BE project's final report is now being prepared. Other universities issue publications lists. The proceedings of the Conferences on Computers in the Undergraduate Curricula present detailed reports, written and delivered by experts in charge of various CAI projects, concerning the use of computers in higher education. For this reason, the proceedings are extremely valuable. However, the vast range of subjects covered and the technical expertise needed to deal with them makes it virtually impossible to provide here an adequate summary of the contents of the proceedings.

CAI activities in higher education can be divided into

two major parts. The first one concerns the activities of the centralized CAI laboratory. The second part concerns the individual contributions of various departments of such institutions as MIT, the University of Michigan and others. Concerning computer service facilities available to colleges and universities, R. E. Levien, writing in 1970, set forth four choices:[94]

> Centralized campus facility - serving all its needs with a centrally managed computer.
>
> Decentralized campus facilities - letting each user or group of users acquire its own computer.
>
> Regional networks - sharing the use of a computer managed in conjunction with a group of other institutions.
>
> Commercial time-sharing service-sharing the use of a computer managed by a commercial computer service organization.

In this chapter the following subjects have been discussed, in the order indicated:

(1) The background and beginning of computer development.

(2) The invention and development of teaching machines and programmed instruction.

(3) A chronological account of the development of instructional use of computers.

(4) The development of computer network systems.

(5) The development of the mini-computer.

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[94]Roger E. Levien, (ed.) Computers in Instruction, 1971, pp. 165-66.

CHAPTER III

PRESENTATION OF DATA

This chapter is divided into three sections. The first section provides data concerning the Index to Computer Based Learning; the second section provides data concerning the proceedings of the Conferences on Computers in the Undergraduate Curricula; the third section examines CAI activities of seven selected universities and colleges: The University of Illinois (Urbana), Stanford University, Pennsylvania State University, the University of Texas (Austin), Dartmouth College, The University of California (Irvine), Coast Community College (Costa Mesa, California).

A. THE INDEX TO COMPUTER BASED LEARNING

The Index to Computer Based Learning is a "comprehensive reference compilation of computer programs used in education." The Instructional Media Laboratory at the University of Wisconsin, Milwaukee produced this publication "formerly called Index to Computer-Assisted Instruction through three editions." These were "the result of a continuous information exchange between hardware producers, program development agencies and institutions using computer technology." The fourth edition has the new title.

In the course of the four editions, there has been an "impressive growth" as measured by content. Computer

programs have increased from 410 to 1766; program sources have grown "from 51 to 176 agencies"; and subject areas have increased from 31 to 98. The fourth edition's 1766 program descriptions are drawn from sources in the U.S., Canada, Europe and Japan. "Elementary and secondary school systems, colleges and universities, military and government agencies," and "business and industry" are represented.

The editors of the Index II summarized its method as follows:

> The Index is cross-indexed in five ways in order to assist users in locating information: (1) subject matter, (2) central processor, (3) computer language, (4) instructional logic and (5) source. It covers the most vital aspects of each given computer based learning program, so as to provide users with quick access to whatever aspect of a subject they are interested in at a given moment."[95]

The second edition (1970) of the Index I edited by Helen A. Lekan, according to R. E. Levien's analysis in The Emerging Technology[96] lists 890 programs.[97] The writer has assembled below a series of quantitative and analytical summaries of information set forth in the 1766 programs of the most recent (1973) fourth edition of the Index II (see Tables 1 through 7).

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[95]Index to Computer Based Learning, the Instructional Media Laboratory, The University of Wisconsin, Milwaukee, 1973.

[96]Roger E. Levien, The Emerging Technology, pp. 331-334.

[97]The Index I lists a total of 910 programs. Only those developed in the United States and Canada (890 programs) were included in his analysis.

Table 1

Quantitative Distribution of Instructional Programs, By Subject According to The Index to Computer Based Learning, 1973

Subject	Total Program	Percentage
1. Mathematics	375	21.23
2. Chemistry	206	11.66
3. Health Professions	145	8.21
4. Computer operations and programming	129	7.30
5. Physics	96	5.43
6. Economics	61	3.45
7. General science	56	3.17
8. English	46	2.60
9. Electronics	39	2.20
10. Reading	39	2.20
11. Biology	37	2.09
12. Computer systems and utility program	37	2.09
13. Law enforcement	33	1.86
14. Engineering	31	1.76
15. Educational and instructional research	28	1.58
16. Statistics	26	1.47
17. Education	25	1.42
18. Demonstration and games	25	1.42
19. Political Science	24	1.35

Table 1 (continued)

	Subject	Total Programs	Percentage
20.	Aeronautics	22	1.24
21.	Management	18	1.01
22.	Guidance and counseling	18	1.01
23.	French	17	0.96
24.	Geography	17	0.96
25.	All others	(*)	(*)

*All other fields comprise less than 0.5% each.

Table 2

Quantitative Distribution of Instructional Programs by Discipline According to The Index to Computer Based Learning, 1973

Discipline	Programs	Percentage
1. Mathematics		
Mathematics	375	
Statistics	26	
TOTAL:	401	22.70
2. Physical Sciences		
Physics	96	
Chemistry	206	
Climatology	6	
Geology	3	
Biochemistry	1	
Natural Resources	1	
Astronomy	3	
General Science	56	
TOTAL:	372	21.06
3. Biological Science		
Botany	1	
Biology	37	
Genetics	11	
Physiology	2	
Zoology	1	
TOTAL:	52	2.94
4. Computer Science		
Computer Operations and programming	129	
Computer system and utility programs	37	
CAI Lab management	2	
TOTAL:	168	9.51
5. Professional Training		
Health	145	
Education	25	
Library Science	5	
Home economics	1	
Social welfare	1	
Agriculture	4	
Food Science	5	
Fishery	1	

Table 2 (continued)

Discipline	Programs	Percentage
Driver education	1	
Educational and Instructional Research	28	
Fingerspelling	1	
Law	6	
Journalism	1	
TOTAL:	224	12.68
6. Humanities		
Reading	39	
Spelling	9	
English	46	
Speech	1	
Philosophy	1	
Logic	7	
Language arts	1	
Literature	1	
General Humanities	1	
Religion	1	
TOTAL:	107	6.05
7. Foreign Languages		
French	17	
Russian	8	
Latin	12	
German	8	
Foreign language*	5	
Chinese	6	
Japanese	1	
Spanish	10	
Esperanto	1	
Dutch	1	
Italian	1	
Bulgarian	1	
Arabic	1	
Slavic	2	
TOTAL:	74	4.19
8. Business and Economics		
Economics	61	
Management	18	
Business	3	

Table 2 (continued)

Discipline	Programs	Percentage
Accounting	8	
Banking	1	
Commerce	2	
Industrial Arts	2	
Personnel	1	
TOTAL:	96	5.43
9. Demonstration and Games	25	1.41
10. Social Sciences		
History	8	
Geography	17	
Psychology	12	
Political Science	24	
Sociology	2	
Social Study	2	
Anthropology	5	
Social Sciences**	2	
Behaviorial Sciences	1	
TOTAL:	73	4.13
11. Engineering		
Engineering	31	
Electronics	39	
Electricity	3	
Mechanics	3	
TOTAL:	76	4.30
12. Student Services		
Guidance and Counseling	18	
Programmed instruction	3	
Student opinion surveying	1	
Student response analysis	2	
TOTAL:	24	1.35
13. Fine Arts		
Music	8	
Art	1	
TOTAL:	9	.50
14. Miscellaneous		
Communication	1	

Table 2 (continued)

Discipline	Programs	Percentage
Visual perception	1	
Vocational rehabilitation	1	
Airline reservations	1	
Aeronautics	22	
Intelligence Testing	1	
Military Training	2	
Weapon System acquisition process	1	
Printing	1	
Graphic arts	1	
Law enforcement	28	
Demography	2	
Information retrieval	3	
TOTAL:	65	3.68

*The Index is not clear here; perhaps it means other foreign languages.

**The Index, again, is not clear here.

Table 3

Notably Active Institutions
According to
The Index to Computer Based Learning, 1973

Institutions	Total Programs
University of Alberta	41
Beloit College	30
University of California, Irvine	24
Coast Community College	163
Computer Based Institution System (Austin, Texas)	36
Dartmouth College	27
Entelek, Inc.	33
Florida State University	68
General Electric Company	37
University of Illin(Urbana)	157
The School District of Kansas City	64
Montgomery County Public Schools (Maryland)	36
State University of New York (Stoney Brook)	41
Polytechnic Institute of Brooklyn	105
Stanford	22
University of Texas (Department of Chemistry)	54
University of Texas (Computer-Assisted Instruction)	30
Wissenschaftliches Institut (West Germany)	106

Table 4

Major Instructional Strategy
According to
The Index to Computer Based Learning, 1973

Modes	Number of Programs	Percentage
Tutorial	936	33.35
Drill-and-Practice	625	22.27
Problem Solving	316	11.26
Simulation	360	12.83
Socratic (Dialogue)	190	6.77
Inquiry	138	4.92
Gaming	63	2.24
Others	179	6.38
TOTAL	2807	100.00

Table 5

Major Programming Languages
According to
The Index to Computer Based Learning, 1973

Programming Language	Number of Programs	Percentage
APL	324	17.60
BASIC	275	14.94
COURSEWRITER I	26	1.41
COURSEWRITER II	274	14.88
COURSEWRITER III	143	7.77
COURSEWRITER III, VERSION 2	17	.92
FORTRAN	117	6.36
TUTOR	161	8.75
CLIC	54	2.93
Others	450	24.44
TOTAL	1841	100.00

Table 6

Major Central Processor
According to
The Index to Computer Based Learning, 1973

Central Processor	Number of Programs	Percentage
CDC 1604	145	6.69
CDC 6400	86	3.97
CDC 6500	30	1.39
GE MARK II	36	1.66
GE 235	41	1.89
GE 265	122	5.63
HONEYWELL G-635	33	1.52
IBM 360/40	98	4.52
IBM 360/50	220	10.16
IBM 360/65	36	1.66
IBM 360/67	79	3.65
IBM 370/155	139	6.42
IBM 1130	50	2.31
IBM 1130 (IBM 1500 Instructional System)	224	10.34
IBM 1800 (IBM 1500 Instructional System)	88	4.06
IBM 1802	30	1.39
PDP-8	170	7.85
PDP-10	79	3.65
TSS-8	107	4.94
UNIVAC 1108	30	1.39
Others	323	14.91
TOTAL	2166	100.00

Table 7

Major Computers Used in CAI
According to
The Index to Computer Based Learning, 1973

Manufacturer	Model No.
General Electric (GE)	225, 235, 265, 524, 620, 635, 645, MARK II, DATANET 30.
International Business Machines (IBM)	91, 360, 360/30, 360/40, 360/50, 360/65, 360/67, 360/75, 360/130, 360/155, 370, 370/45, 370/135, 370/155, 650, 1130, 1401, 1410, 1440, 1440/7010, 1500, 1620, 1800, 1802, 7010, 7040, 7040/7044, 9090.
Digital Equipment Corporation (DEC)	PDP-7, PDP-8, PDP-9, PDP-10, PDP-11, PDP-12.
Control Data Corporation (CDC)	1604, 1700, 3150, 3300, 3600, 6400, 6500, 6600.
Radio Corporation of America (RCA)	SPECTRA 70/35, SPECTRA 70/45, SPECTRA 70/46.

B. DATA CONCERNING CONFERENCES ON COMPUTERS IN THE UNDERGRADUATE CURRICULA

The Conferences on Computers in the Undergraduate Curricula are "the only national multidisciplinary conferences" which serve to open channels of communication between persons who have used, are using, or would like to use computers in undergraduate education."[98]

The first meeting was held at the University of Iowa in June, 1970, with 742 in attendance;[99] the second at Dartmouth College in June, 1970 with an attendance of 1032; the third at Georgia Tech in June, 1972, with an attendance of 753; the fourth at Claremont Colleges in June, 1973, with an attendance of 470; the fifth at Washington State University in June, 1974; with an attendance of 300; and the sixth was at Texas Christian University in June, 1975, with an attendance of 372. Altogether 3669 persons attended these conferences.

A study of the annual attendance lists shows these meetings represent a geographical cross-section according to size and type of institutions (private, state, etc.). Geography was an important factor in determining attendance. The Dartmouth meeting, for example, drew many participants from New England.

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[98]From the brochure of CCUC/6, Fort Worth, Texas, June, 1975.

[99]The writer has drawn the figures in the following paragraph from the computer output of attendance lists of the six sessions.

A wide range of subjects was dealt with at these six conferences. Appendix A shows the institutions which presented papers at the Computer Conferences, the number of papers presented in each year and the number of institutions involved. Appendix B shows the institutions listed according to the number of papers given. Appendix C shows the papers presented according to subjects. Appendix D shows the papers presented according to subjects year by year. Appendix E shows the papers presented according to subject percentages.

C. CAI ACTIVITIES OF THE SEVEN SELECTED UNIVERSITIES AND COLLEGES

This section examines CAI activities of the following seven selected universities and colleges: The University of Illinois (Urbana), Stanford University, Pennsylvania State University, The University of Texas (Austin), Dartmouth, The University of California (Irvine), and Coast Community College (Costa Mesa, California).

1. Computer-Based Education at the University of Illinois

The PLATO (Programmed Logic for Automatic Teaching Operation) program was started in 1960, under the direction of Dr. Donald Bitzer. The past fifteen years of PLATO development have witnessed the development of the largest

facility in the history of computer education. The PLATO system utilizes a high speed digital computer as the central control element for teaching a number of students simultaneously. By April, 1975, the PLATO network included over 100 sites. (A site exists where one or more terminals are in a physically different location from others).[100] Some sites have 60 to 80 terminals, while others have only four per classroom. The present network has 1,000 terminals attached (the largest number in use at one time is approximately 450, but this will gc up to about 600 shortly).[101] This is a large number of graphics terminals for a single central processor. Dr. Bitzer writes: "We are not happy where we are. Our eyes are set on goals for 1980-1981, setting up a million terminal networks."[102] The PLATO system is clearly comprehensive, elaborate, and the most ambitious time-sharing system ever attempted.

Briefly, the PLATO system is "a computer-based teaching system . . . for individualizing student instruction." The teacher, the computer and the student constitute "an interactive team." By its means "each student can work at his own pace" aided by "special information and help when problems

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[100]"Interview with Don Bitzer, PLATO," Sigcue Bulletin, (Association for Computing Machinery), Computer uses in education, IX, No. 2 (April, 1975), p. 2.

[101]Ibid., p. 3.

[102]Ibid., p. 3.

arise."[103] The lesson material is easy to produce and evaluate:

> PLATO instructional material is written and edited on-line from any terminal while time-sharing the system with other authors and students. The author language is simple, though flexible and powerful. It includes a variety of graphic and computational capabilities, and gives computer control of teaching style and strategy to the teacher . . . Student and lesson performance may be automatically recorded and evaluated by the computer.[104]

The PLATO system has been effectively "used in public school, community college, and university undergraduate and graduate . . . courses." Among the many subjects covered are:[105]

Astronomy	Mathematics
Biology	Medicine
Business Administration	Music
Chemistry	Nursing
Computer Science	Physics
Demography	Physiology
Economics	Political Science
Education	Psychology
Engineering*	Reading
English	Social Welfare
Foreign Languages**	Statistics
Geography	Urban Studies
Library Science	Veterinary Medicine
Linguistics	

as well as for programs for:

Computer programming	On-line physics experiments
Election statistics	Simulation studies of technological, social, and biological systems.
Game playing	
Psychological experiments	

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[103]See Plato a brochure of the Computer-based Education Research Laboratory, The University of Illinois, Urbana-Champaign (Hereafter cited as Plato).

[104]Ibid. [105]Ibid.

* Aeronautical, Civil, Electrical, Materials, Mechanical, Theoretical and Applied Mechanics

** French, German, Chinese, Italian, Japanese, Latin, Russian, Spanish, English as a Second Language, Hebrew, Esperato

By April, 1975, PLATO instructional materials were written in "150 different areas" and "6000 to 8000 hours of materials" were available.[106]

PLATO is probably the most comprehensive and the most promising of all computer education systems thus far developed. The writer quotes in Appendix F its directors' own summary of "Highlights in Plato's History." This sets forth the detailed history of the PLATO project.

During the first seven years of "PLATO's existence, the system grew from one terminal to seventy-one (twenty of which were operable simultaneously)." During this time, the system "utilized three different computers," i.e. ILLIACI, CDC 1604 CSL, CDC 1604 NCR 160 CERL. It also "employed four different languages," i.e. ILLIAC Machine Language, CDC 1604 Machine Language, Language for CATO (Compiler for Automatic Teaching Operations).[107]

> From 1967 through 1972 the use of the PLATO III system reached peak capacity, approximately sixty hours assigned to student class time per week. Within that time, research "concentrated on the educational aspects of the PLATO III teaching system, with particular emphasis on the most efficient use of PLATO III and on the development of the hardware, software and courseware (educational

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[106] "Interview with Don Bitzer, PLATO," p. 2.

[107] Plato Highlights, pp. 3-4.

materials) for an economical large-scale computer-based education system (PLATO IV).[108]

The most recent version of the PLATO teaching system is known as PLATO IV. The system includes terminal equipment (hardware) and computer programming (software). The actual testing of PLATO IV began with "the arrival of many commercially manufactured PLATO IV terminals during the summer of 1972."[109]

> A PLATO IV terminal consists of a keyset, which transmits the user's input . . . to a central computer, and a display which can simultaneously show computer-generated graphic information and computer-selected photographic color slides to the user.[110] . . . These terminals utilized plasma display panels as the visual display rather than storage cathode ray and television tube presentation.[111]
>
> The plasma panel can display graphic information permanently without auxiliary storage equipment. It is an inherently simple device, consisting of thin, flat, glass sheets in which two-fine-wire grids are embedded. A gas contained between the sheets is ionized when an initial voltage is applied to selected points of the grid, and the ionization is sustained by a weaker alternating voltage applied to the entire grid: Since graphic information can be specified point by point or line by line for the entire 512 by 512 grid, the system provides extremely sharp images and can utilize virtually any type of characters. The panel is transparent, so that color slides can be superimposed on information generated either by the computer or by the student; motion pictures can also be shown on the panel but have not normally been included in PLATO courses.[112]

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[108] Ibid., p. 3. [109] Ibid, p. 5. [110] From Plato.

[111] Plato Highlights, p. 5.

[112] Allen L. Hammond, "Computer-Assisted Instruction: Two Major Demonstrations," Science, CLXXVI, (June, 1972), p. 1111.

> These PLATO IV terminals are controlled by "a Control Data Corporation CYBER 73 computer system. A single tv channel can connect the computer to 1,000 terminals. Extended computer core storage allows rapid access to large material for use by either students or authors.[113] . . . Extended core storage was increased in February, 1974 by 500,000 words to a total of 1 million words. In December, 1974, another one million words were added.[114]

The hardware development, as well as the software for the system, has been very much improved. In the past few years, "Many of the sophisticated refinements and extensions of the TUTOR language have been a result of suggestions from the many users on the system. . . . The language is now highly flexible and offers capabilities from complex calculation for dazzling graphics to powerful judging routine."[115]

In the PLATO IV system, it is not necessary for an author to depend on a systems programmer. "Teachers and authors can begin to prepare, edit, or modify lesson materials after a few hours of familiarization with the TUTOR language."[116]

The estimated costs for a fully implemented system are between 34 and 68 cents per student per terminal hour. This estimate is "based on optimum use of the system and includes the costs of the computer communication lines,

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[113] From Plato.

[114] Plato Highlights, p. 5.

[115] Ibid., p. 7.

[116] D. Alpert and D. Bitzer, "Advances in Computer-based Education," Science CLXVII, (March 20, 1970), p. 1585.

terminal equipment, and instructional material development.[117]

An independent evaluation of computer-based education using PLATO "was begun in September, 1974, in community college courses. . . . This . . . evaluation is being carried on by the Educational Testing Service of Princeton, New Jersey, at the Chicago City College, and Parkland College in Champaign, Illinois."[118]

The PLATO project's developments are described in a number of journal articles, and particular aspects of the projects are documented in reports available from the PLATO project at the Computer-based Education Research Laboratory. PLATO Highlights, one publication available from the laboratory, gives a history of the PLATO program and an overall view of PLATO projects, along with an extensive bibliography. PLATO Curricular Materials[119] gives the information the lessons which have been developed for the system. Using Plato IV[120] explains the PLATO IV student terminal and other peripheral equipment used by the system.

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[117]Alpert and Bitzer, "Advances in Computer-based Education," p. 1589.

[118]Plato Highlights, p. 7.

[119]Elisabeth R. Lyman, PLATO Curricular Materials, Computer-based Education Research Laboratory, The University of Illinois, Urbana, Illinois, July, 1974.

[120]David V. Meller, Using PLATO IV, Computer-based Education Research Laboratory, The University of Illinois, Urbana, Illinois, December, 1974.

The University of Illinois has been developing a low-cost terminal system. The PLATO network terminals are available not only on the University of Illinois campus at Urbana-Champaign, but at other locations ranging from "San Diego, California to Boston, Massachusetts and from Orlando, Florida to Toronto, Ontario, Canada.[121] According to Dr. Bitzer, the project aims to build a world-wide network system which will have "millions of terminals."[122] At present, regular phone lines are used to communicate with overseas terminals. This works very well but is very expensive. In the future, the researchers hope to have feasible satellite communication, but at present the use of a satellite for two-way communication takes an unacceptable length of time. In the future, a satellite will probably be used "one way and land lines will be used from the terminal to the computer." This will "keep the performance level reasonable for everyone involved."[123] The PLATO system is one of the most promising projects in the field of computer-based education.

2. Computer-Assisted Instruction at Stanford

In January, 1963, the Institute for Mathematical Studies in the Social Sciences at Stanford University undertook a program of research and development, under the direction

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[121] Plato Highlights, p. 5.

[122] "Interview with Don Bitzer, PLATO," p. 13.

[123] Ibid., p. 4.

tion of Patrick Suppes and Richard C. Atkinson.[124] Their effort was directed toward "the best-known series of projects": mathematics and reading on the elementary level. "Stanford's major contribution in CAI higher education has been a two-year introductory Russian course taught exclusively by computer and language-laboratory sessions."[125] The directors of this project state that John McCarthy of Stanford's Department of Computer Science played an important part "in the design and operation of" their "computer facilities." Stanford's research on "Artificial Intelligence"[126] has greatly influenced the development of CAI. This is especially true of McCarthy's "theorem-proving program"[127] and "automatic deductive question answering,"[128] both of which use mathematical logic.

> Patrick Suppes has conducted extensive research in the psychology of arithmetic. He built several mathematical models; i.e., three performance models and one learning model.[129]

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[124]P. Suppes, "Computer-Assisted Instruction at Stanford," Plan and Computer, Bordeaux, 1970, pp. 298-330.

[125]Roger E. Levien, The Emerging Technology, p. 347.

[126]"Research scientists in Artificial Intelligence try to get machines to exhibit behavior that we call intelligent behavior" as in playing chess, answering questions, etc. "when we observe it in human beings." James R. Slagle, Artificial Intelligence, McGraw-Hill Co. 1971, p. 1.

[127]Ibid., pp. 59-60.

[128]Ibid., pp. 137-138.

[129]Patrick Suppes, "Facts and Fantasies of Education," Changing Education, Prentice-Hall 1973, pp. 29-43.

> Suppes' other noticeable research was a study of "cognition in handicapped children," (Mentally retarded, blind, and deaf) their "problems of language and language development, concept formation and abstraction, and elementary mathematical skills."[130]

Suppes and Atkinson have summarized their CAI hardware system configuration as follows:

> The initial instructional system in the Institute consisted of a medium-sized computer (a PDP-1) and six student stations placed within 100 feet of the computer. Each student booth contained two visual display devices. The first was a random-access optical-display device . . . that presented microfilmed source material on a 10-inch by 13-inch ground-glass screen. It was possible to encode the equivalent of a 512-page book (8½-inch by 11-inch standard page) on microfilm, and any page, or one-eighth of a page, could be displayed randomly within 1 second. The student responded to the display by using a light pen on the face of the screen itself. . . . The second display device . . . is a cathode-ray tube. . . . Until June, 1968, the central computer was a PDP-1. . . . It has a 32,000-word core and a 4,000-word core, which can be interchanged within the 32 bands of a magnetic drum on files stored on two IBM-1301 disks. The two IBM-1301 disks were replaced by two IBM-2314 disks in the fall of 1968, and a PDP-10 became the main computer, although the PDP-1 is still in operation.[131]

Mathematics. On December 12, 1963, the first operational instructional program in elementary mathematical logic was demonstrated at Stanford. After the first demonstration, a series of elementary mathematics and mathematical logic was developed. In 1964, "some 20 lessons giving a fairly detailed introduction to sentential logic were written and programmed. . . ." During the 1964-65 academic

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[130]Patrick Suppes, A Survey of Cognition in Handicapped Children, The Stanford University, December, 1972.

[131]P. Suppes, "Computer-Assisted Instruction at Stanford," pp. 298-99.

year, "two groups of first-grade children were given arithmetic programs during the regular year." The most noticeable feature of these logic programs was "that the computer program accepts any logically valid response of the student." During the 1965-66 academic year, "drill-and-practice teletype programs were conducted in three schools." In 1966, they proceeded to "investigate the feasibility of teaching mathematics and reading as an integral part of an elementary school program by using individualized tutorial CAI over an extended period of time." The site chosen was in California.[132]

> A hundred small children entering the first grade in Brentwood School in East Palo Alto, California, found themselves confronted with computer terminals with screens and light pens. The machines were used to assist in teaching reading and arithmetic. Brentwood was an interesting choice of schools because it is a slum area, had an 80 percent Negro enrollment and the average IQ of the children participating in the reading experiment was 89. The technique was very effective. The children loved playing with terminals.[133]

During the 1966-67 academic year, the reading and arithmetic drill-and-practice procedure was expanded. Summary statistics are given in Appendix G. In March, 1967, "two teletypes" were installed at the "Morehead State University Laboratory School in Morehead, Kentucky, more than 2,000 miles from Stanford." Later, the number of teletypes

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[132] Ibid., pp. 229-305.

[133] James Martin and Adrian R. D. Norman, The Computerized Society, Prentice-Hall, Inc., 1970, p. 123.

and of student users was increased. In May, 1968, the "enrollment jumped from 2,387 to 4,353 for 30 schools in California, Iowa, Kentucky and Mississippi." During the 1968-69 academic year, "the total number of elementary arithmetic students grew to over 6,000. . . . Those who had begun computer "work in logic and algebra . . . in 1966-67 continued through 1969. By June in 1969, "then about 'twelve years' old "they had proved most of the standard elementary theorems that hold for ordered fields." Stanford also prepared a remedial mathematics course for college students at Tennessee State University. This "drill-and-practice program emphasized computational skills in arithmetic and elementary algebra." This program is still operative.[134]

Computer-based elementary Russian. Professor Joseph Van Campen of the Department of Slavic Languages at Stanford has developed an elementary Russian course.[135] This is "one of very few university-level credit courses being taught entirely by computer."[136] The Emerging Technology has summarized as follows, the evaluation of this course by Suppes and Morningstar:

> Of the 30 students originally enrolled in the computer based program, 22 (73 percent) finished

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[134]P. Suppes, "Computer-Assisted Instruction at Stanford," pp. 305-318.

[135]P. Suppes, "Computer-Assisted Instruction at Stanford," p. 312.

[136]Roger E. Levien, The Emerging Technology, p. 386.

> all three quarters, whereas, of the 38 students in the regular classes, only 12 (32 percent) finished the year's curriculum. This finding suggests that the computer-based course held the interest of the students much better than the regular course did. . . . Approximately 66 percent of the content of the final examinations for the autumn and winter quarters was identical for the computer-based and the regular Russian sections; the complete final examination for the spring quarter was identical for the two groups. Although the average number of errors was lower for the computer-based students in all three quarters . . . the difference was statistically significant for the fall quarter . . . and the selection process resulting from the poorer students' leaving the regular course biases the results on the examination against the computer-based group, the superiority of the computer-based group on the spring examination is more impressive than the difference indicated by the average number of errors.[137]

The Stanford Russian course shows a "high potential for computer use . . . but the impediments are also considerable. High cost relative to the traditional lecture method is perhaps the greatest impediment."[138]

> The Russian program was funded by USOE for three years at a rate of approximately $100,000 per year; this does not include some of the programming that was initially done for and is maintained by Stanford's elementary reading and arithmetic projects. Initial programming costs were estimated at $30,000 to $40,000.[139]

Reading. On the subject of Stanford's computerized reading program, Dr. Suppes reported that

> Under the direction of Professor Atkinson, an initial reading program was designed and prepared that would complement any classroom reading series

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[137] Ibid., p. 458.

[138] Ibid., p. 386.

[139] Ibid., p. 357.

> by providing drill and practice in the basic sub-skills for the complex task of learning to read. This program, pioneering the use of digitized audio, was made available to 442 first, second and third grade students.[140]

According to Fletcher and Atkinson, "The curriculum was conceived as supplementary drill-and-practice rather than tutorial. . . . The results are significant in favor of the CAI groups."[141] They also pointed out that the "great amount of material that can be covered using short daily sessions of CAI is to be emphasized."

A notable product of Stanford's research on the teaching of handicapped children was the development of a network system for deaf children: This system was adapted by the Kendall School for the Deaf in Washington, D.C., the School for the Deaf at Berkeley, California, the Day School for the Deaf in San Jose, California, the Texas School for the Deaf in Austin, Texas, and by the Special Education unit of the University of Washington in Seattle. The courses offered in the network were:[142]

> Arithmetic Drill-and-Practice Program; Language Arts; Basic English; Mathematical logic and Algebra; Tutorial Computer Programming Courses; BASIC and AID and Experimental courses in Transformational Grammars.

Suppes has stated that the "possibilities of

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[140]P. Suppes, "Computer-Assisted Instruction at Stanford," p. 316.

[141]Patrick Suppes, "Computer-Assisted Instruction for Deaf Students," American Annuals of the Deaf, CXVI, 1971, p. 501.

[142]Ibid., p. 508.

developing methods for a rich dialogue between student and computer program seem especially important for the education of deaf students."[143]

Professor Suppes further observed that the research on "dialogue" and "building on adequate psychological model of the student" are very important for the development of CAI in the coming decade.

> The central difficulty in the area of interaction between student and program is not the clumsiness or limitations of the computer, but our ignorance in understanding in any explicit way the character of a successful dialogue. Many topics being studied . . . either as a part of computer-assisted instruction or as part of artificial intelligence should contribute to a deeper understanding of the nature of dialogue.[144]

Suppes continued as regards the problem of building an adequate psychological model of the student,

> Our objective is to build a large probabilistic automaton model for the individual student, with individual parameters reflecting his state of learning and performance, and then to present instruction differentially and contingently so as to change the values of critical parameters in the model of the individual student in a manner that can be characterized is one specific sense as optimal. . . . The direction in which we must move must try to provide instruction that is properly tailored to the individual student.[145]

3. Computer-Assisted Instruction at Pennsylvania State University

In the spring of 1964, the Computer-Assisted Instruction Laboratory at Penn State was established as a research

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[143] Ibid., p. 508.

[144] P. Suppes, "Computer-Assisted Instruction at Stanford," p. 323.

[145] Ibid., p. 327.

and development laboratory "for testing the feasibility of using computers for instruction." Since that time, their effort "has expanded into full implementation of college level courses via CAI."[146]

In January, 1975, Dr. Keith A. Hall, the Director of CAI Laboratory, summarized the main aspects of their work as follows:

> Curriculum development efforts have focused on tutorial, self-contained, college-level courses primarily in the area of teacher education although materials have been developed in music for fourth grade children, literacy development skills for disadvantaged youth and adults, and general mathematics and algebra for ninth grade students. The emphasis in teacher education has produced the series of courses referred to as CARE: Computer Assisted Renewal Education.[147]

Between 1964 and 1975, the following developments occurred; the Penn State's early efforts on CAI emphasized the following subjects: Modern Mathematics, Cost Accounting, Engineering Economics,[148] Audiology,[149] at the college level;

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[146]Keith A. Hall, "The Pennsylvania State University Computer-Assisted Instruction Laboratory," The Pennsylvania State University, January 1975.

[147]Ibid.

[148]Kenneth H. Wodtke, Harold E. Mitzel and Bobby R. Brown, "Some Preliminary Results on the Reactions of Students to Computer-Assisted Instruction," Pennsylvania State University, 1965.

[149]David P. Yens, The Development and Evaluation of a Computer-Based Audiometer Trainer, Pennsylvania State University, September, 1969.

Engineering Science, Technical Mathematics, Communication skills[150] at post-high school vocational training level, and Instrumental music (especially clarinet)[151] at seventh through tenth grade level. Each of the above subjects was evaluated on its instructional materials as well as student attitudes in CAI.[152] In recent years, Pennsylvania State's efforts focused on teacher education.

The computer hardware system in the CAI Laboratory at Penn State began with "IBM 1410 computer, as a central processor. . . . And student stations consisting of eight IBM 1050 typewriters, each augmented by a random access tape recorder and random access slide projector." At first they utilized Coursewriter language I; later they switched to Coursewriter II.[153] "Systems development and modification were implemented to improve the speed and storage capacity of the system to meet the growing demands of students and authors."[154]

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[150]Harold E. Mitzel and George L. Brandon, Experimentation with Computer-Assisted Instruction in Technical Education, Pennsylvania State University, December, 1965.

[151]Ned C. Deihl, Development and Evaluation of Computer-Assisted Instruction in Instrumental Music, Pennsylvania State University, September, 1969.

[152]See above p. 18, n. 42.

[153]Harold E. Mitzel and George L. Brandon, Experimentation with Computer-Assisted Instruction in Technical Education, Pennsylvania State University, December, 1967.

[154]Keith A. Hall, "The Pennsylvania State University Computer-Assisted Instruction Laboratory," January, 1975.

The motivation in the development of the CARE programs was "a nationwide thrust to put mildly handicapped children in regular classrooms throughout the United States." Penn State's director of CARE detailed the several objectives of their project under six categories:[155]

> CARE 1 teaches regular classroom teachers to systematically observe behaviors of young children and to identify behaviors which may indicate an existing handicapping condition.
>
> CARE 2 helps the regular classroom teacher modify her instructional program through prescriptive and diagnostic teaching procedures for children at the pre-school level.
>
> CARE 3 provides the same kind of instruction for teachers of children at the primary grade level.
>
> CARE 4 assists the regular classroom teachers in adopting their instructional program to the children in their classes who are visually impaired.
>
> CARE 5 and 6, which have been proposed but not developed yet, will enable regular classroom teachers to adapt their instructional procedures for dealing with severely mentally retarded children.
>
> Each course is self-contained and utilizes the full capabilities of the student stations which consist of cathode ray tube and programmable graphics, random access image projector, and random access audio play/record device. The average course completion times are as follows: CARE 1, 30 hours; CARE 2, 40 hours; CARE 3, 40 hours; and CARE 4, 10 hours.[156]

Penn State developed "three modes of instructional delivery: . . .

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[155] Ibid.

[156] Ibid.

1) inservice education by means of three Penn State mobile CAI laboratory,

2) resident instruction at Penn State and

3) instruction at other CAI sites with compatible equipment.

These three modes of delivery . . . produced in excess of 300,000 hours of tutorial instruction to 7,539 preservice and inservice teachers.[157]

As previously detailed above p. 22. Penn State also pioneered significantly by introducing the use of a mobile computer to serve the needs of unit pupils and teachers not otherwise within reach of CAI.

Two mobile units make CARE available to inservice teachers in selected communities across the entire nation. Each van is a custom-built, transportable, mobile CAI laboratory housing IBM 1500 CAI system and 16 student stations. In the closed condition, the 40-foot van is only eight feet wide and meets the highway specifications for every state. At its destination the van is expanded to provide a comfortable air-conditioned learning environment more than 17 feet wide. On a pre-arranged schedule, the mobile CAI laboratory is moved to a teaching site (college, community school, etc.) and connected to electric and telephone services. Over the 8 weeks--during the day, late afternoon, and evenings--learners schedule themselves for one-to-three-hour sessions at the computer terminals on an individualized basis to fit the demands of their personal and professional lives. Each student station in the mobile vans has the same capabilities as the resident instruction laboratory on the Penn State campus. Learners receive grades and graduate-level, college credit (either from PSU or from a participating local college or university). Van I has been operating since October, 1970 and Van II since July 1, 1973. During that time 3,557 students have completed one or more of the courses producing 10,395 student credit hours and requiring 82,874 student station hours. With improved operating efficiency and additional curriculum materials, we

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[157] Ibid.

> expect to expand the capacity of each mobile van from 1,000 students and 3,000 student credit hours per within 3 year time period.[158]
>
> A third mobile system is being built to enroll diploma school RN's in the extended degree program in nursing. The mobile system will provide CMI and CAI learning experiences for student--CMI for material already learned in the diploma school program and CAI for course material which is not part of the diploma school program.[159]

For students in Penn State's immediate vicinity, resident instruction has been provided since the fall of 1972. Since then,

> Over 3,900 students have completed one or more of the courses producing 10,305 student credit hours. We expect that the system can provide 6,400 credits to 2,600 students annually.[160]
>
> To date the three systems with a combined total of 64 students stations have provided 216,000 student station hours for 8,419 students yielding 22,619 student credit hours.[161]
>
> Besides "the facilities available on the Penn State campus, courses developed there are available at several other stationary sites: State University of New York (Stony Brook), University of Alberta (Edmonton), and National Technical Institute for the Deaf (Rochester, N.Y.). These sites offer one or more of the CARE courses on a continuing basis with curriculum support and updating provided by Penn State.[162]
>
> During the winter term, 1971, all students who were enrolled in CARE-1 were randomly assigned to either computer-assisted instruction or conventional instruction (CI) sections. The CAI group (N=27) received all instruction by means of the computer system and did not attend classes with the CI group. The CI group (N=87) received the conventional lecture-discussion method of instruction and met three days per week in 75-minute sessions for 10

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[158] Ibid. [159] Ibid. [160] Ibid.

[161] Ibid. [162] Ibid.

> weeks. . . . The dependent variable were time and final examination scores based on 75 items. Results are shown in Table 1. . . . Table 2 summarizes data from 12 institutes which met on the campus of Pennsylvania State University during the FY 1967 through 1972, and two mobile CAI projects during parts of FY 1969, 1971, and 1972.[163]

Tables 8[164] and 9[165] show the effectiveness of CAI at Pennsylvania State University.

Table 8

Comparison of Final Examination Scores and Instructional Time for CAI and CI Students

Instructional Mode	Final Examination House			Time in Hours*
	Mean	S.D.	t	
Computer-assisted instruction	65.69	4.68		25.21
Conventional instruction	52.78	5.89	11.65**	37.50

* CAI time is mean time per student and the time for conventional instruction is the total hours scheduled in lecture session for all students.

**This difference is statistically significant with p .001.

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[163]Keith A. Hall, G. Phillip Cartwright, and Harold E. Mitzell, "A Triumph for CAI," Phi Delta Kappan, September, 1974, pp. 71-72.

[164]Ibid., p. 72.

[165]Ibid.

Table 9

Comparison of Costs, Number of Students, Student Credit Hours Produced, Average Cost Per Student Credit Hour for Traditional Institutes and Mobile CAI

	Traditional Institutes	Mobile CAI	Total
Total costs	$534,310	$577,444	$1,111,754
Total numbers of students	416	1,869	2,285
Total student credit hours produced	2,706	5,220	7,926
Total average cost per student	1,284	$ 309	$ 796
Total average cost per student credit hour	197	$ 111	$ 154

4. The PROJECT C-BE at the University of Texas at Austin

PROJECT C-BE (computer based education), a four-year project began in September, 1971, supported by 1.6 million dollars in grants received from the National Science Foundation, and sizable contributions from the University of Texas at Austin. Codirected by Dr. John J. Allan III and Dr. J. J. Lagowski, the Project was "the first coordinated, massive assault employing computer-based education ever attempted at one university." Its objective was "to study the effects of computer-based instruction at a typical large university.[166]

The project had four goals as its "primary objectives:

> Viz., (1) the evaluation of computer-based successful transfer of such techniques, (3) a description of concepts which are common across disciplines, and (4) the development of a model for implementing successful computer-based methods into another educational environment.

Its directors noted that though it was "not a curriculum development project," they were "obliged to engage in curriculum development" in order to formulate their "answers to the question pointed by the four goals.[167]

PROJECT C-BE developed the model "implementing computer-based education techniques as shown in flow chart form in Fig. 1." (p. 73). This model "can be applied at the

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[166]See PROJECT C-BE, the brochure of the Computer-based Science & Engineering Education, The University of Texas, Austin (Hereafter cited as PROJECT C-BE).

[167]J. J. Allan and J. J. Lagowski, "PROJECT C-BE: AN OVERVIEW," Proceedings of CCUC/6, Texas Christian University, Fort Worth, Texas, June, 1975, p. 303.

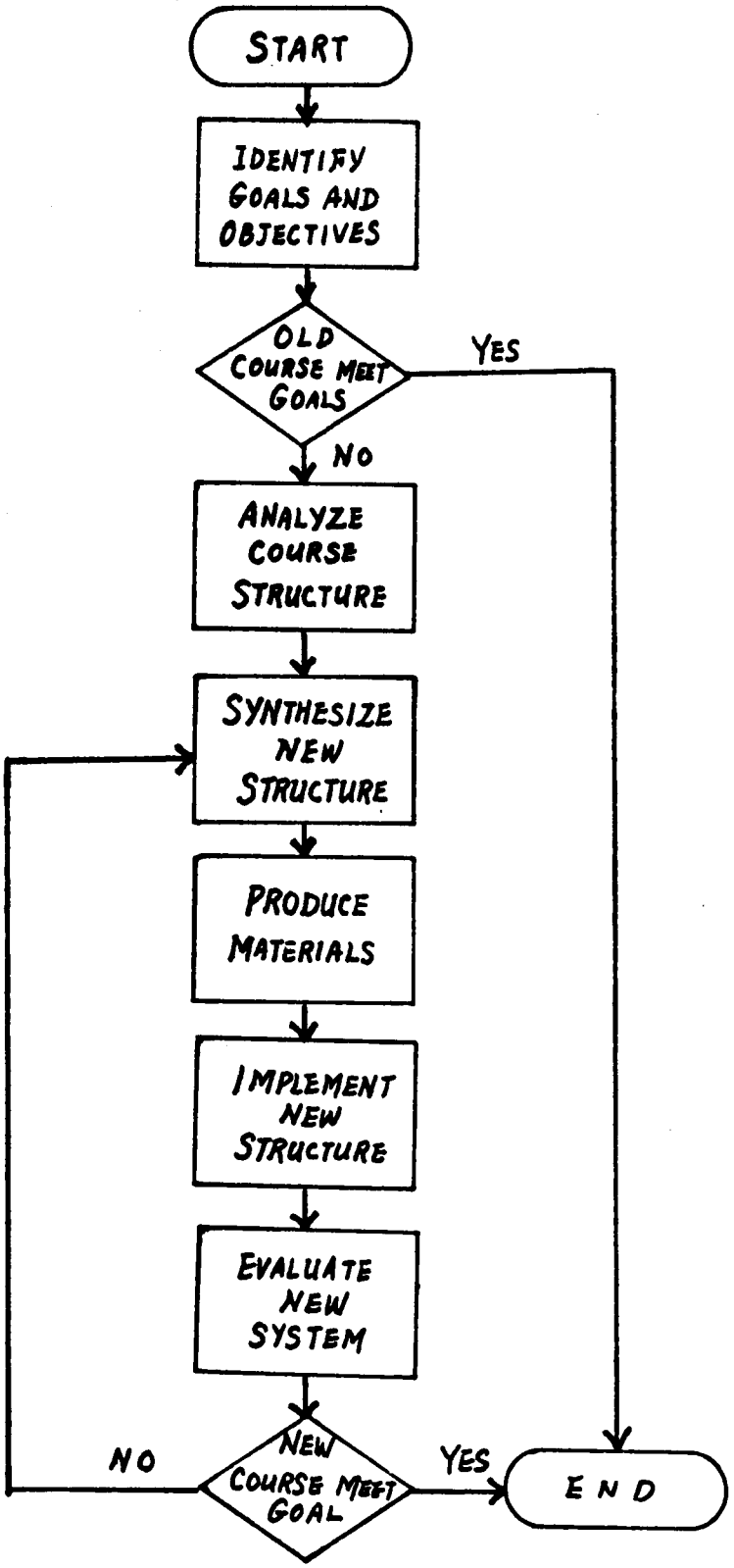


Figure 1. Flow chart of the model which PROJECT C-BE developed for implementing computer-based educational techniques.

the University level as well as for a single lesson in a given course." It "suggests that educational change is a circular process of continuous evaluation and revision." Its directors have found it "efficient and useful" in producing a "wide variety of courses using a spectrum of computer applications."

The PROJECT also provided instructors with assistance in "(a) formulating objectives" for their courses (b) "synthesizing course design," (c) producing programs effectively written or debugged, (d) providing handbooks to accompany their programs, (e) evaluating "the effectiveness of the programs and the course."[168]

PROJECT C-BE involves 5 colleges (Engineering, Natural Science, Humanities, Architecture, Social and Behavioral Sciences), including 14 departments of the University using 29 courses. The 29 courses are listed below under capitalized headings indicating their departments.

COMPUTER-BASED EDUCATION COURSES:[169]

AEROSPACE ENGINEERING
Aircraft Design: Structural Analysis

ARCHITECTURE
Survey of Environmental Control Systems

CHEMICAL ENGINEERING
Process Analysis and Simulation; Optimal Control

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[168] Ibid., p. 303.

[169] A Brief Workbook on Computer Material Design, Computer-Based Science & Engineering Education, The University of Texas, Austin, June 11, 1975.

CHEMISTRY
Vector Space Theory of Matter; Physical Chemistry Laboratory; Organic Chemistry; Introductory Chemistry; Principles of Chemistry; Introduction to Chemical Practice

CIVIL ENGINEERING
Computer Methods for Civil Engineering Laboratory

ECONOMICS
Theory of Income and Employment

ENGLISH
English Composition

HOME ECONOMICS
Child Development

LINGUISTICS
Language and Society

MATHEMATICS
Calculus I, II

MECHANICAL ENGINEERING
Dynamic Systems-Synthesis; Probability and Statistics for Engineers; Energy Systems Laboratory; Element Design; Nuclear Reactor Engineering; Kinematics and Dynamic Mechanical Systems

PSYCHOLOGY
Introduction to Psychology; Statistical Methods in Psychology

PHYSICS
Computer Introduction to Physics

ZOOLOGY
Genetics; Experimental Genetics; Biophysical Analysis.

As noted above p. 23 this Project involves no "significant hardware development." It merely applies "current technology and . . . available devices." It features utilization of readily available computer facilities described as follows by the Project directors:

> Large-scale scientific computation is provided by the CDC-6400/6600 TAURUS System dedicated to

> time-sharing operating under a communication processor called the SATURN Communication System. Local computation is afforded through a NOVA 840 Real-Time Computer System (48k with Dual Disks) and two NOVA 820 Computer-based Data Acquisition Systems (8k). Excellent facilities are also available for interactive graphics. Currently, there are five 8k IMLAC's, eight DATAPOINT 3300's, and two Beehive CRT Terminals, Model 1 and Model V. Other equipment which is being used . . . includes Decision Model 650 Optical Scanner, Model TSP-212 Analog X-4 Plotter, five Analog/Hybrid terminals, one TI Model 725 teleprinter, numerous KSR-33, KSR-35, ASR-35 Teletypewriters, and other computer auxiliary terminal equipment.[170]

The PROJECT employed four different languages (FORTRAN, CLIC, BASIC, and MACHINE LANGUAGES), BASIC is very heavily used in interactive systems. The PROJECT uses the following program modes: Tutorial (I),* Drill and practice (I), Examination (I, B),** Simulation (I, B), On line data acquisition and analysis (I).

The Freshman English course at the University of Texas employed CAI tutorial programs to supplement non-computer instruction in the basic composition skills. The course served "approximately 5000 students with a wide diversity of ability, preparation, and motivation." The programs were designed to teach "the sentence-writing and sentence-editing skills that are rarely taught+ in the classroom."[171]

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* B = Interactive ** B = Batch

\+ This assertion is seriously questioned by teachers of English not using CAI.

[170]From PROJECT C-BE.

[171]Susan W. Whittig and Marilyn Bracewell, "Evaluating Computer-Assisted Instruction in English," Proceedings of CCUC/6, Fort Worth, Texas, June 1975, p. 3.

The authors of the Texas CAI Freshman English course state further that

> One of the major objectives of the use of computer modules in composition courses is to provide systematic, personalized instruction and practice . . . to the achievement of greater proficiency in writing, instruction and practice based on diagnostic pre-tests and tailored to individual requirements. Remedial lessons can be inserted in any program for students who fail to master the regular materials; more advanced lessons can be designed to challenge the advanced students.[172]

Evaluation of the effectiveness of CAI in the Texas Freshman English course is inconclusive that is so, as the authors of the course state, because the CAI "modules . . . were used as a supplement to the conventional workbook exercises, textbook instruction and conference teaching." Consequently computer "post test scores . . . would not fairly represent instructional gains and losses." Student comments, however, were reported as being "highly enthusiastic about computer learning," and students winning high final course grades scores similarly high grades in the computer scores.[173]

During the past several years, large selfpaced classes of Introductory Psychology, Statistics, and Anthropology, "some enrolling more than 600 students each semester," were managed "entirely by computer." It is reported that students,

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[172]General Information on PROJECT C-BE, The University of Texas, Austin, October, 1972.

[173]"Evaluating Computer-Assisted Instruction in English," pp. 4-11.

> do not attend lectures, and they see their instructor . . . only if they so desire. . . . The material to be learned is subdivided into small units, and tests for every study unit are available in multiple versions. . . . Each version consists of a random sample of questions drawn from a pool of questions. . . . Tests are given in a central testing facility, a classroom kept open for selfpaced testing at various hours. . . . After a test the score and the code numbers of questions the student missed are displayed to the student on a CRI (cathode ray tube) and tests are repeatable. A student not satisfied with a test score can take the test over as often as he wishes. . . . The student is given another version of the test, and his new score replaces the old. . . . Test scoring and record keeping for all classes using the central testing facility is completely computerized.[174]

According to J. H. Bruell, the Texas psychologist in charge of this project, this "selfpaced instruction" redefines the role of the teacher. "Lecturing is eliminated, . . . record keeping and grading "are computerized, and the teacher's role is "that of selector, adapter and writer o teaching and testing material." Bruell grants that this method "cannot take over all of teaching," that "in wide areas of the humanities . . . face to face exchange" between teacher and pupil is essential. But he concludes that computerized teaching does not "dehumanize" instruction, may "make it more humane by giving the learner more . . . independence and . . . autonomy."[175]

Although the final report on PROJECT C-BE is not

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[174]Jan H. Bruell, "Completely Computer-Managed Selfpaced Classes," Proceedings of CCUC/6, Fort Worth, Texas, June 1975. pp. 249-250.

[175]Ibid., pp. 252-253.

yet available, according to a preliminary report entitled Eighteen Months of PROJECT C-BE this project "has had some initial successes in meeting each of its four goals."[176]

5. The Dartmouth Time-Sharing System

On the first of May, 1964, the Dartmouth Time-Sharing System (DISS) began operation. This successful demonstration was "perhaps the most significant event" in the history of Dartmouth's contributions to computer services.[177] For during the past decade, Dartmouth became the "recognized leader in offering computer services for educational purposes through the popular and widely-used conversational computer language BASIC and the versatile Dartmouth Time Sharing System." Both were developed by Dartmouth's President John G. Kemeny and Mathematics Professor Thomas E. Kurtz, Director of Kiewit Computation Center.[178] According to Arthur W. Luehrmann, Dartmouth's Assistant Director for Educational Application, the goal of its computer enterprises is "to teach students all that is necessary for them to make good use of computing in connection with their courses in sociology or physics or music or business."[179]

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[176]John J. Allan III and J. J. Lagowski, Eighteen Months of PROJECT C-BE, Computer-Based Science and Engineering Education, The University of Texas, Austin, July, 1973, p.6.

[177]John G. Kemeny and Thomas E. Kurtz, "Dartmouth Time Sharing," Science, CLXII, October 11, 1968, p. 226.

[178]Directory of Computer Education and Research, 1973, p. 646.

[179]A letter from Dr. Arthur W. Luehrmann, May 21, 1975.

A combined summary of computer hardware configurations at Dartmouth follows:

> The Kiewit Computation Center houses the Honeywell-635 computer which is capable of being used simultaneously, through the Dartmouth Time Sharing System. . . . . The DTSS resides in two 635 central processors[180] and Honeywell 716's[181] telecommunication computers with associated peripheral equipment which includes core storage units with a capacity of 192,000[182] 36-bit words, a 786,432-words magnetic drum, two IBM 2314 magnetic disk storage units with a total capacity of 73,000,000 words, six magnetic tape drives. . . . The computer is connected via telephone lines to more than 400[183] teletype terminals, of which up to 170 can be operated simultaneously. The computation needs of more than 100 courses are served by 300 on-campus terminals located in almost every major college administrative and academic building.

Though Dartmouth contributions to educational computer use have been of first importance, its leaders have strongly emphasized that the computer is not "going to replace the live teacher . . . the computer could supplement the teacher extremely well in certain . . . areas; for example, in drill programs to relieve the teacher of boring exercises but, President Kemeny adds that he has not seen a really convincing demonstration that a computer

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[180] Directory of Computer Education and Research, 1973, p. 646.

[181] A letter from Mr. A. Kent Morton, Secretary-Treasurer, ACM SIGCUE, Kiewit Computation Center, Dartmouth College, June 19, 1975.

[182] Ibid.

[183] This and the following totals come from "Computer Use under a Free-Access Policy," A. Luehrmann and J. Nevison, Science, May 31, 1974.

can replace a good classroom teacher."[184] His colleague, Authur Leuhrmann, agrees entirely.[185]

Dartmouth encourages computer use by both faculty and students, charging machine time costs as an operating expense to the college, rather than billing each user, "Thus the computer, like the library, is a 'free' commodity available to the entire academic community."[186]

Dr. Luehrmann has provided a detailed account of "Computer Use under a Free-Access Policy":

> Free access means that any individual sitting at a terminal may dial the computer and log in without seeking either funds or permission. It does not mean that he may execute programs that consume arbitrary amounts of computer time or storage file. . . . As a matter of policy we do not allow any users, with or without grant funds, to buy their way to a higher priority of service, since that would degrade normal service.[187]

Dartmouth's authorities summarize as follows their computer "Library Programs":

> Since its inception in 1964, DTSS has based its growth on a 'free access' policy. At Dartmouth the computer is considered a powerful educational resource, and this dynamic tool is available to all members of the college community, as well as to its on-line. . . . residents of the local community are encouraged to use its facilities . One of these available to all users in the on-line DTSS

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[184]John G. Kemeny, "Computers at Colleges," Dartmouth College, A recent paper, no date.

[185]A letter from Dr. Arthur W. Luehrmann, May 21, 1975.

[186]Roger E. Levien, The Emerging Technology, p. 369.

[187]Arthur W. Luehrmann and John M. Nevison, "Computer Use under a Free-Access Policy," Science, CLXXXIV, May 31, 1974, pp. 957-958.

> public library . . . a collection of over 900 program, subprograms, and data files.[188]

Another important part of Dartmouth's computer enterprise is its "large data-based inquiry system." This has been described summary as follows:

> Project IMPRESS (Interdisciplinary Machine Processing for Research and Education in the Social Sciences) provides quantitative data from Classic Social Sciences basic data sets to students and faculty through the Dartmouth Time-Sharing Computer System. Under development since 1968 this system now provides data on Presidential elections in the 60's, Congressional voting records, and census returns. Users are only provided with relevant data upon request, but can manipulate and analyze the data through a series of information retrieval and analysis programs developed in Project IMPRESS. This brings to the social science student a laboratory resource more typically found in the physical and biological sciences. . . ."[189] The important point in that the system is designed to be inviting: there are no cards to punch, no problem of turnaround time, no programming skills required, as it is a library (canned) program and the entire process is conducted in reasonably straight forward English questions and answers.[190]

According to Edmund D. Meyers who designed this project, "IMPRESS will totally revolutionize undergraduate education in the social sciences."[191]

COEXIST Project. Dartmouth interdepartmental work

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[188]Josie K. Claiborne, DTSS Library Programs, Dartmouth College, November 1974.

[189]Directory of Computer Education and Research, 1973, p. 647.

[190]James A. Davis, "Using the IMPRESS System to teach Sociology," Proceedings of CCUC/2, Dartmouth College, 1971, p. 382.

[191]Edmund D. Meyers, "IMPRESS and Undergraduate Education in the Social Sciences," Proceedings of CCUC/1, The University of Iowa, 1970, p. 8-26.

is also noteworthy. In the spring of 1969 several members of the Mathematics, Physics and Engineering departments combined forces to examine the effect of computer service on science curriculas. As a result, they undertook COEXIST Project based on the following principles:

(a) write core text materials for algorithmically oriented calculus and elementary physics courses.

(b) develop complete sets of computer-based exercises, for these and more advanced courses . . . provide realistic and concrete reinforcement of theoretical ideas. . . .

(c) provide classroom demonstrations involving the computer . . . motivating key ideas in calculus and physics courses. . . .

(d) carry out an accurate cost-accounting for educational use of computing facilities.[192]

This cooperative effort was fruitful but. . . . The utilization of Project IMPRESS and the use of COEXIST materials. . . . placed an ever increasing burden on the system."[193]

Another noticeable Dartmouth Computer activity was its Secondary school computer project, described as follows by its directors:

> Soon after the first DTSS began operation in May of 1964, the local high school installed a teletype. . . . Within two and one-half years, eight high schools had tied into the Dartmouth

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[192]Donald Kreider and Robert A. Norman, "Dartmouth Project COEXIST," Proceedings of CCUC/1, The University of Iowa, 1970, p. 9.1.

[193]BIENNIAL REPORT 1971-1973, The Kiewit Computation Center, Dartmouth College, June 1973, p. 5.

> System. . . . Hundreds of students were taught the BASIC language. Some of them produced highly sophisticated programs. Teachers were using computer applications in Mathematics and science courses.[194]

In June 1967, Dartmouth College, with support by the NSF began a three year project "exploring the use of computing in secondary schools." Eighteen secondary schools were in the New England area were involved in this project.[195] Its "main purpose . . . was to demonstrate" that the computer can make "a significant contribution to secondary education within the existing curriculum and without extensive teacher retraining."[196] According to Thomas E. Kurtz, this project was "successful."[197] During the year 1971-1972, many high school students left DTSS to use their own "in house time-sharing system."[198]

"The widespread use of the computer in many courses at Dartmouth provides implicit verification of its value as perceived by faculty there."[199] Over 100 courses use the

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[194]Jean H. Danver and John M. Nevison, "Secondary School Use of the Time-shared Computer at Dartmouth College," AFIPS-Conference Proceedings, XXXIV, 1969, p. 681.

[195]John M. Nevison, The Computer as Pupil: The Dartmouth Secondary School Project, Dartmouth College, October 1970, p. 5.

[196]"Secondary School Use of the Time-shared Computer at Dartmouth College," p. 687.

[197]The Computer as Pupil: The Dartmouth Secondary School Project, p. 2.

[198]BIENNIAL REPORT 1971-1973, p. 5.

[199]Roger E. Levien, The Emerging Technology, p. 458.

computer and 40 academic departments are involved in it. Over 900 programs are available to students in the Dartmouth program library, and more than 80 percent of Dartmouth's students are able to program with BASIC. Subject areas actively using the computer are: Business, Medical, Engineering, Astronomy, Biology, Chemistry, Earth Science, Mathematics, Physics, Economics, Geography, Psychology, Sociology, Classics, Modern Foreign Languages, and Literature.[200]

Although the computer generally supplements, rather than replaces, conventional instruction at Dartmouth, the College also has a few programs in the CAI category. The Emerging Technology summarizes these as follows:

> A climatology program . . . a typical tutorial program. . . . The professor in charge of an undergraduate geography course observed consistently low interest and achievement in the unit on climatology. Finding also that unit was difficult to present adequately in a lecture format, he prepared a program for the computer system located on campus. The resulting unit provided tutorial instruction in greater depth than . . . in the lecture format. Evaluations of student response to the program revealed improved interest and greater achievement than were recorded with the traditional lecture method.[201]

The Department of Romance Languages developed CARLOS (Computer-Assisted Review Lessons on Syntax) to provide review and drill in Spanish grammar.

> CARLOS comprises 15 lessons, each approximately 30 minutes in length. . . . The CARLOS program

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[200]John G. Kemeny and Thomas E. Kurtz, "Dartmouth Time-Sharing," p. 227.

[201]Roger E. Levien, The Emerging Technology, p. 356.

> demonstrates many of the advantages of computer-assisted drill for the teaching process. Its author noted that the computer drill was a significant time-saving device. Once the program was prepared, it was available for repeated use during the semester, by future classes, and by students in related courses. . . . This, in turn, allowed the instructor to prepare more innovative assignments and to give more individual attention to evaluating student work.[202]

Music. Dartmouth College has had "a decade of activity in the composition and performance of electronic music,"[203] and in the Summer of 1972 Dartmouth and the University of New Hampshire with funds from the National Endowment for the Humanities sponsored an "Institute in electronic music . . . intended for . . . college music teachers who will shortly teach electronic music. . . ."[204] A detailed technical report on the subject of electronic music is given in the paper presented at the Conference at Fort Worth, Texas. Its authors believe that "this system represents a step forward in making digital synthesis available to composers and further extends its use "to CAI in music "at low cost."[205]

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[202] Ibid., pp. 359-360.

[203] Sidney Alonso, Jon H. Appleton, and Cameron Jones, "A Special Purpose digital system for the Instruction Composition and Performance of Music," The Proceedings of CCUC/6, 1975, pp. 17-21.

[204] Directory of Computer Education and Research, p.647.

[205] "A Special Purpose digital system for the Instruction Composition and Performance of Music," p. 21.

6. The Physics Computer Development Project at The University of California, Irvine

According to Professor Alfred Bork, director of the University of California's (Irvine Campus) Physics Computer Development, Irvine, one of the University of California's three

> new campuses, runs three competing computers--a Xerox Sigma 7, a DEC PDP-10, and PDP-11/45; all offer timesharing. . . . Unlike most University computer centers, educational use dominates over research and administration, accounting for well over half the total use; computer science and physical science are the heaviest users.[206]

For the past six years this project has been supported by the National Science Foundation. As noted above (p. 21) the Project has been engaged "in development of computer-based teaching material in a wide variety of modes."[207]

Bork has set forth "five major objectives" of his Project.[208]

1. Primarily, "the Project aims to produce compelling examples of effective use of the computer in learning situations . . . in physics and the other sciences, at the undergraduate level. . . . We have never intended to teach entire courses by means of computer, but to choose those uses most effective for the learning situations and the student. . . . the dialogs should be highly responsive to student needs and inputs.

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[206]"Learning with Computer - Today and Tomorrow," The University of California, Irvine.

[207]"Current Status of the Physics Computer Development Project," p. 61.

[208]Ibid., pp. 61-62.

2. A second major objective is to explore the use of graphics in computer-based teaching material. . . . Discovery and development of effective visual dialogs was and is a major goal of this project.

3. The third major objective of the Project is to explore authoring modes. . . . Many . . . excellent teachers can see the learning potentials of the computer, but few are interested in taking the time to learn computer language, techniques, and operating systems. Hence the Project raises 'three questions: 1 How persuade . . . good teachers to develop computer-based material?' 2 How provide them with helpful 'resources, facilities and assistance?' 3 'What institutional structures will encourage' effective dialogue preparation?

4. The fourth objective is to introduce dialogs and other computer approaches into standard undergraduate environments. We wanted to work with large classes" and to counteract the "powerful conservative force inhibiting computer use "exerted by 'standard texts' which 'do not acknowledge the existence of computers.'

5. The software approach needs to be highly flexible so that it can grow because of the pedagogical demands of good teachers serving as authors. It should allow full graphic capability.

As regards "results" of the research at Irvine, the three "principal products of the Physics Computer Development Project are the dialogs, the graphic additions to APL, the underlying software, and the authoring system."[209]

1. Producing science teaching dialogs is the Project's major activity. . . . Early dialogs employ no visuals . . . but recent dialogs use graphics extensively. Many of the dialogs fit a few distinctive pedagogical classes, areas where we believe the computer to be particularly effective. . . . One major learning problem is developing problem-solving abilities. Conventional

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[209] Ibid., p. 62.

> teaching often is not effective in developing this skill, important in all areas of science. . . . A second major objective in learning . . . is developing insight; in physics we are more successful in teaching techniques than in developing intuition about the behavior of the physical world. Experience is essential in developing insight and intuition. A dialog such as MOTION creates an interactive world for students: they can move about freely, exploring the effects of the law of mechanics in a variety of abstract spaces. We can give students a range of experiences unobtainable in everyday life or in the laboratory, and so aid in developing insight. Graphics, pictorial information, is vitally important in this process.[210]

2. After a review of languages, we decided that APL was a superior problem-solving language for undergraduates in science and engineering. So we added graphic capability to APL, . . . This facility is now in widespread use not only at Irvine, but in many other locations.[211]

3. The software goals have been outlined. We chose to base development on assembly macros, writing new macros in response to pedagogical needs. . . . Programs also contain FORTRAN segments where needed, particularly for calculational purpose. . . . They "also make heavy use of the overlay facilities of the loader, as many of the dialogs are much too large to fit into the core available to a time-sharing user."[212]

   In addition to the useful dialogs that our Project has produced--teaching materials that we believe are as effective as any in wide student use developed anywhere in the world--we have made important innovations in the process of preparing such material[213]

Finally, the director of this Project emphasized that the key person in the preparation of learning sequences is the competent teacher with experience and insight into the learning process. . . . Competent teachers may have little direct interest in the computer. They can be highly interested in the

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[210] Ibid., p. 62. [211] Ibid., p. 63.

[212] Ibid., p. 62. [213] Ibid., p. 62.

> possibilities if they see a device which can assist learning, however. We must convince such a person that the computer has unique teaching capabilities and then provide a mechanism whereby teachers can generate dialogs without becoming computer experts. . . . To stimulate interest in the computer as a learning medium, demonstration is very effective. . . . We are also very interested in the process of transferring our materials to other campuses. The problems are great; they include not only the classical difficulties of transporting software, but the issues always involved in educational innovation. . . . Some use of our dialogs is currently taking place, on a limited basis from many schools in our area. . . . We are working with this idea in several interdisciplinary areas, combining physics with math, chemistry and fine arts. . . .[214]
>
> In addition to the problems of software development, two challenging obstacles must be overcome before such a system is practical; the pedagogical problems of keeping students active in a relatively free environment, and the problem of convincing faculty that the resultant course is a desirable alternative to conventional courses.[215]

7. Computer-Assisted Instruction at the Coast Community College District in Costa Mesa, California

The Coast Community College District, consisting of Orange Coast and Golden West College, "probably has had as much experience in using computers as a subject of, and an aid to instruction as any other two-year college district in the nation.[216]

The "rather dramatic" growth of Computer-Assisted Instruction at the Coast Community College District was the result of many factors:

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[214]Ibid., pp. 64-65. [215]Ibid., p. 65.

[216]Computer-Assisted Instruction at the Coast Community College District, IBM Corporation, White Plains, New York, June, 1973, p. 2.

> Wide utilization was encouraged by faculty incentives. Freedom to utilize the system by interested faculty was established by making the system available for long hours and by providing terminals which could be used at the college, in the instructor's office, or at home. New participation was encouraged by in-service training. District-sponsored faculty fellowships, which provided funds, assistance, and release time for development of materials, were supported by an enthusiastic Board of Trustees. At present, more than 80 faculty members are developing extensive media--oriented materials under the Faculty Fellowship Program. . . . Fellowship holders were given paraprofessional and laboratory assistance. As a result, computer-assisted instruction at Orange Coast and Golden West Colleges has become an integral part of the total instructional program.[217]

Computer-Assisted Instruction at Orange Coast College During the past decade, this college has gained much experience using computers in the "vocational data processing." In the fall of 1969, the introduction of the district's Faculty Fellowship Program, helped greatly toward the creation of the interactive computer-assisted instruction programs. During 1970, "instructional segments were completed in the areas of accounting, algebra, biology, chemistry, calculus, and physics."[218]

Computer hardware configurations were set forth as follows:

> Educational programs at Orange Coast College are supported by an IBM System/360 Model 50 containing 384k bytes of internal core storage supported by an IBM 2314 Disk Cluster providing online storage capacity of 387 million bytes. Input and output device consists of an IBM 2501 Reader, 2540 Reader-punch, two 1403 Printers, 2515 Tape

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[217] Ibid., p. 3. [218] Ibid., pp. 7-9.

> unit and one hundred 2741 Teleprocessing typewriter terminals, two teletype and five Data Point 3360 CRT's.[219]

Computer-Assisted Instruction at Golden West College

> In October 1968, Golden West College received its first three IBM 2741 Communication Terminals, which were driven by the computer system located at the University of California at Irvine, via telephone lines. The language in use was called Course Author Language (CAL). In January 1969, Golden West College installed six additional terminals and began using the district's IBM System/360 Model 40 computer. By March 1969, the APL computer language became available, and Golden West College used both APL and CAL. During the 1969 SAL (Systems Approach to Learning), project, . . . Fifteen English lessons were developed. . . . In the fall of 1969, English classes began to use the English lessons. . . . During the rest of 1969-70 school year, several new English lessons written in CAL/APL were improved and rewritten in APL.[220]

Later this year, Political Science I, II, Spanish lessons, and a series of ecology simulation programs employed computer aid. In 1970-71, Golden West College had "more than 80 lessons . . . used by approximately 1500 students per semester." Their development in CAI were at "an exponential rate."[221] The 1971-72 school year's detailed description has been previously set forth on p. 23.

> The evaluation of Computer-Assisted Instruction at Golden West College falls into three categories: instructional effectiveness, student usage and reactions, and programming efficiency.

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[219]T. C. Hsiao, (ed.), Directory of Computer Education and Research, Volume II: Junior College, Science and Technology Press, Inc. 1973, p. 44.

[220]Computer-Assisted Instruction at the Coast Community College District, June, 1973. p. 5.

[221]Ibid., pp. 5-6.

> During the first year, the emphasis was on the evaluation of student interaction with CAI programs. . . . Evaluation during the academic year 1971-72 has primarily been a focus on programming efficiency and search for guidelines to future evaluation.[222]

Concerning the future of CAI activities at the Coast Community College district its authorities write as follows: "The next few years promise some very dramatic changes in Computer Assisted Instruction." Their plan for the development of true Computer-Managed Instruction (CMI) will change the instructor's role. He "may become more of a counsellor and a guide." In addition to providing the potential for CMI, they are planning to develop "a true dialogue capability in CAI." The primary aim of their research is to help students to "progress at their own rates through courses managed by the computer in activities that help them overcome their learning problems."[223]

In summary, as the Coast Community College writers put it, their work on CAI "has become . . . the model to other schools . . . distant future."[224]

Describing Computer-Assisted Instruction at seven selected universities and colleges, the writer has tried to show the main characteristics of their activities. This work is the result of an in-depth study of available litera-

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[222]"Computer-Assisted Instruction at Golden West College," the Coast Community College District.

[223]Ibid.

[224]Ibid.

ture on CAI in these seven selected universities and colleges. Many of the source materials were obtained directly from the directors of these universities and colleges. In many cases, the writer has quated verbatim the information already summarized concisely in informational brochures describing their major activities.

CHAPTER IV

ANALYSES OF DATA

This chapter deals with analyses of data presented in Chapter III. The first part of these analyses concerns the Index to Computer Based Learning; the second series of analyses deals with the Conferences on Computers in the Undergraduate Curricula; the third set concerns CAI activities of the seven selected universities and colleges. The final part is a summary.

1. The Index to Computer Based Learning

Index II lists a total of 1766 programs.[225]

> Information pertaining to each of the programs and projects described in this Index II was requested by sending Program Questionnaires to organizations where programs were developed. . . . This questionnaire, developed at the Instructional Media Laboratory, was designed to include those areas considered most pertinent in the description of a Computer Based Learning program. Descriptions of the program are arranged in the Index II in the following order:
>
> Subject field; Program Name; Author; Source; Description; Prerequisites; Level of Instruction; Type of Student; Total Hours of Available Material; Average Student Completion time; Instructional Strategy; Instructional Logic; Use of Program; Supplementary Equipment/Materials; Status of Program; Availability of Program; Funding/Sponsoring

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[225]The Index to Computer Based Learning, The University of Wisconsin, Milwaukee, 1973.

Agency; Descriptive Literature; Language Programmed In; Central Processor; Terminal Description; Applications.[226]

Index II provides a good overall view of CAI activities to the reader. Further, each program contains pertinent information which may be very helpful to persons who want to develop such a program.

Index II contains 98 different subject fields. Table 1 (page 38) shows 24 different subject fields, each of which has more than 0.5% of the total number of programs. Table 1 clearly shows that mathematics is the predominant subject in CAI activities.

Table 2 (page 40) shows the quantitative distribution of instructional programs by discipline. Index II is divided into 14 different categories. Table 2 also reveals the vast range of CAI activities from mathematics to the fine arts. Mathematics has 401 programs, 22.7%; the Physical Sciences have 372 programs, 21.06%; the Biological Sciences have 52 programs, 2.94%; Computer Science has 168 programs, 9.51%; Professional Training has 224 programs, 12.68% . . . and so on. Mathematics Physical Sciences, Computer Science, Professional Training are dominant areas in CAI activities.

According to Index II, 176 agencies were engaged in developing CAI programs. Eighteen of the most important of these agencies were selected and listed in Table 3 (page 44).

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[226] Ibid., pp. ix-x.

Table 4 shows the modes of major instructional strategy. Among these the tutorial mode has 936 programs, 33.35%. Drill-and-Practice has 625 programs, 22.27%. Simulation has 360 programs, 12.83%, and Problem Solving has 316 programs, 11.26%. Tutorial, Drill-and-Practice, Simulation, and Problem Solving are dominant modes in CAI. Some programs fall into more than one category.

Table 5 shows the major programming languages APL, BASIC, COURSEWRITER, FORTRAN, and TUTOR are dominant languages in computer based learning. Table 6 shows the number of major Central Processors being used in computer-based learning. Tables 4 (page 45), 5 (page 46), and 6 (page 47) show that there is some overlapping. Table 7 shows the major computers used in computer-based learning.

2. The Conferences on Computers in the Undergraduate Curricula

The cost of these Conferences during the six years to date was supported by the National Science Foundation. The first meeting had 742 in attendance, the second had 1032, and following years had 753, 470, 300, 372, respectively. The attendance increased considerably at the second meeting, then decreased in the next three years and slightly increased again at the 1975 meeting. The current recession may be the principal cause of decreasing attendance. The other factor may be that people come to attend these meetings in order to find immediate answers for instructional uses of computers;

but upon finding little that is really helpful, they stopped attending these conferences. For example, at the 1975 Fort Worth Conference, there was a group discussion led by Dr. Arthur Luehrmann and Mr. Kent Morton. They were trying to discover obstacles to the effective use of CAI. Towards the end of this discussion, a person from a small college in California stood up and said very impatiently, "I need an answer; I need your help, not a long, tedious discussion." The writer felt that this might have been the feeling of many others present.

Proceedings of these Conferences during the past six years (Chapter II, p. 34) are a useful source of documents on Computers in Education.

Appendix A shows the institutions which presented papers at the conferences, the number of papers presented in each year and the number of institutions involved in these presentations. In 1970 the total number of papers presented was 88; the following years numbered 93, 87, 73, 54, 38, respectively. The total number of papers presented at the six conferences was 433.

Only in the cases of Dartmouth College (which presented eight papers in 1970 and seven in 1971), the University of Texas at Austin (six in 1975), and the University of Minnesota (five in 1971) have individual institutions given several papers in a year. Thus, the conferences seem to have functioned well as open forums.

Nevertheless, it must be noted that at the sixth

conference there was a sharp decrease in the number of institutions represented, with papers from Texas representing more than a third (13 of 37) of the papers offered. The leaders in the number of contributions are almost all very large state universities with enrollments of 20,000 or more. Many of the universities and colleges presenting papers at the conferences are graduate degree granting institutions, although there is a representation from four-year colleges. There are also quite a few predominantly black colleges on the attendance lists. The underrepresented group is the two-year colleges.

Appendix B shows the institutions listed in order of the number of papers offered. The top seven of these institutions are: Dartmouth College; the University of Illinois, Urbana; The University of Michigan, Ann Arbor; The University of Texas, Austin; the University of California, Irvine; the University of Minnesota, and Pennsylvania State University. During the past six conferences, 214 institutions presented at least one paper.

Appendix C shows the papers presented according to subjects. With the exception of the 1972 Conference, the number of papers presented has decreased with each succeeding year. At the last conference there were fewer than half the number offered at the first conference. Appendix C also shows that the following subjects are dominant areas using computers: Mathematics, Physics, Chemistry, Engineering, Business and Accounting, Statistics and Economics.

At the six conferences, a large range of subjects were represented. The more empirical disciplines clearly received the most attention, as a glance at the percentage of overall contributions will reveal. Most of the subjects listed received attention at four or more conferences but the following were dealt with at only one or two: education, geography, religious studies, and history. Far behind come the humanities and the fine arts.

Appendix D shows the papers presented according to subjects, by year. Appendix E shows the percentages of papers presented according to subject areas. Again, Appendices C and E show that Mathematics is the predominant subject using computers in teaching.

Examination of CAI activities of the seven selected universities and colleges indicates that computer-assisted instruction, computer-based education, computer-aided instruction and computer-based teaching are all synonymous terms. Each project differs from the others, but they do have one common goal--to search out the true possibilities of individualized instruction. These institutions do not intend to substitute the computer for the teacher . . . "as an instructor presenting the material, asking questions to check comprehension or presenting more material and testing"[227] but rather as a supplement to conventional teaching.

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[227]Computer Assisted Instruction: A General Discussion and Case Study, U.S. Civil Service Commission Bureau of Training, August 1971, p. 1.

Brief reexamination of the main characteristics of CAI activities at the seven selected universities and colleges may be helpful toward providing an overall view of CAI activities at the present time and for the future.

The University of Illinois' PLATO system is certainly the most comprehensive, elaborate and ambitious time-sharing system. Its multi-millions of terminal networks plan will surely influence future education. Its outstanding hardware development is the plasma display panel.

> The PLATO IV System is designed to economically service at least 4,000 student terminals simultaneously. One major cost in assembling such a large CAI system is the cost of terminals. To overcome this hurdle the PLATO design team developed a terminal which incorporates the plasma display panel. Basically, the plasma panel consists of two thin panels separated by about 250,000 tiny gas cells. Any of the cells can be turned on (ignited) or turned off under program control without affecting adjacent cells. This means that the plasma panel does not need refreshing as is common with CRT displays.[228]

> As regards software: Plato's "TUTOR Language is very flexible and capable for complex calculation. . . . Teachers and authors can begin to prepare, edit, or modify lesson materials after a few hours of familiarization with the Tutor language.[229]

> Suppes and Atkinson of Stanford University have developed two approaches to CAI lesson module design--the Block Design and the Strand Design. The Stanford elementary school mathematics program is based upon 24 concept blocks or units for each grade level. A block is comprised of lessons for seven days work, arranged sequentially.

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[228]S. Hunka and E. W. Romaniuk, "State of the Art: Computer-Assisted Instruction," The University of Alberta, June 1974.

[229]Plato Highlights, p. 7.

> The current reading curriculum program uses a strand design approach. The program is divided into six strands of basic component skills of initial reading: 1) letter identification, 2) sight-word vocabulary, 3) phonics, 4) spelling patterns, 5) comprehension and 6) language arts. A strand is defined as a series of problems of the same operational type arranged sequentially in classes according to their relative difficulty.[230]

Besides their series in elementary mathematics and reading, Stanford's directors are emphasizing the importance of "artifical intelligence" approach in the development of CAI. Suppes, in his paper on "Computer-Assisted Instruction at Stanford" has written that the

> question-answering system is the whole domain of developing genuine voice-to-voice interaction between student and program. We are beginning to have an understanding of natural language grammar and semantics for fragments of natural languages, adequate to produce a reasonable line of talk on the part of the computer. By making the grammar and semantics probabilistic, we can also avoid the stereotyping that otherwise would be a disturbing character of the computer talk.[231]

At Pennsylvania State's "Computer-Assisted Instruction" two things are noteworthy: The first one is their effort in evaluation of instructional approaches and on such problems as student attitudes. The second is the service of mobile CAI units which help teachers in rural community areas. The past five years of results show that these services are very effective. This mobile van service should be

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[230]Andrew R. Molnar, "Computer Innovation in Education," 1973, pp. 59-60.

[231]P. Suppes, "Computer-Assisted Instruction at Stanford," p. 325.

a useful model for the future CAI service in other ares.

As noted on p. 72, the PROJECT C-BE at the University of Texas, had four goals:[232]

1. To develop evaluation scheme
2. To develop transferability criteria
3. To develop an implementation model
4. To identify the common concepts among disciplines.

This project has had some initial success in each of its four goals. PROJECT C-BE involves no hardware development. They use commercially available computer facilities and have experimented with large self-paced classes.

Dartmouth College is an example of an institution with high computer use for instructional purposes. DTSS's public library has over 900 programs. The computer is used for administrative as well as instructional purposes. Both the students and the faculty have free access to the computer, and casual use as well as instructional use is encouraged on a basis comparable to the use of the library. Over 85% of the student body use the computer at one time or another. The Dartmouth College Regional Consortium services other colleges and universities. The Dartmouth IMPRESS system is an interactive package for social science instruction and research. It provides an undergraduate or beginner with a high probability of obtaining meaningful data the first time

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[232]John J. Allan III and J. J. Lagowski, Eighteen Months of PROJECT C-BE, p. 3.

he tries. It also provides most standard statistical routines for analysis. IMPRESS serves as an example of a data-base system for facilitating research.

The University of California, Irvine, produced highly interactive student-computer dialogs. One of them, "MOTION" is an elaborate instructional program:

> Motion was written to aid students and instructors at all levels in a study of equations of motion. The program offers each user a large repertoire of motions. Choices range from simple harmonic, central force, and constant acceleration to the very uncommon motions associated with two force centers or a multiple field--One can view the effects of anharmonicity . . ..

At the Fort Worth Computer Conference, Professor Alfred Adler of the University of Michigan told the writer that MOTION is the product of "eight years of refined work." Many physicists, he added, make large use of computer facilities in their own research: Many are not much involved in writing CAI programs, even though they foresee the usefulness of such work.

As Bork said, "the key person in the preparation of learning sequences is the competent teacher with experience and insight into the learning process." Bork further stressed that "We must convince such a person that the computer has unique teaching capabilities, and then provide a mechanism whereby teachers can generate dialogs without becoming computer experts.[233]

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[233]Alfred Bork, "Current Status of the Physics Computer Development Project," Proceedings of CCUC/6, 1975, p. 63.

The most noticeable aspect of CAI activities at the Coast Community College is the cooperation of administrators and faculty in the development of CAI programs. Towards this end they have provided effective incentives such as a faculty fellowship program which may prove to be a good model for other schools.

Summary

During the past decade and a half, much research has been conducted into instructional uses of computers. This has led to the development of computer hardwares and softwares. The initial enthusiasts thought the computer could quickly revolutionize education, usually by entirely replacing the teacher with computer-assisted programmed instruction. But most of the research which has been reviewed by the writer shows application of the computers' potential mainly to the educational needs of certain special areas and subjects. The tional needs of certain special areas and subjects. The computer may turn out to be of little value as a teaching tool in certain fields and of great value in others. For example, according to Bork, computer simulation programs are very useful in teaching. Important educational aspects of the computer appear in

> the powerful idea of simulation. Because the computer can simulate real or imaginary worlds, given its calculational capabilities, it can create unique new experiences for the student. Experience is a critical component of learning. But direct experience is often limited, and even in the laboratory, difficult to control. A computer simulation with a good student interface can in a short time

> greatly increase the experience available to students and these experiences can be unique to each student.[234]

The writer's research has shown that the computer hardware in educational uses depends on two different systems. One is the network system; the other is the stand-alone system. The network system is hooked up to a large computer, like the PLATO network system. At present, many small colleges use the minicomputer as a stand-alone system. Its utilization is expected to increase. Also, the development of the even smaller microcomputer will constitute a very powerful stand-alone system of the near future.

In using terminal facilities, graphic facilities are extremely important in educational use. The development of plasma display panels in the PLATO project made graphic facilities economically feasible.

COURSEWRITER, APL, BASIC, TUTOR, FORTRAN are dominant programming languages. Among them COURSEWRITER is the best known language but it does not allow computation. According to Bork, APL is a "superior problem-solving language in science and engineering." As noted on p. 55, TUTOR is also very flexible and powerful in calculation.

It seems that the real difficulty in the development of CAI is not the computer hardware problem. As Professor Suppes has pointed out:

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[234]Alfred Bork, "Learning with Computers," The University of California, Irvine.

> The central difficulty in the area of interaction between student and program is not the clumsiness or limitations of the computer, but our ignorance in understanding in any explicit way the character of a successful dialogue: He further indicates that "artificial intelligence should contribute to a deeper understanding of the nature of dialogue."[235]

It has been found that CAI has numerous advantages and disadvantages: "The major disadvantages of CAI include the large amount of time required for course development, personnel required for course development, personnel required, initial outlay of funds and the total costs."[236]

The major advantages of CAI include the true individualization of instruction; by means of CAI it is possible to "free professors from the need to make routine and repetitious presentations and to give them more time for enriching their teaching with up-to-date observations. It can give students more independence and more flexibility in their daily schedules."[237]

This research shows that in spite of numerous difficulties and of severe criticism directed against this new technology, CAI should be developed and implemented as part of the educational system. Most components of the educational process are increasing in cost where the cost of

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[235]P. Suppes, "Computer-Assisted Instruction at Stanford," p. 323.

[236]Computer Assisted Instruction: A General Discussion and Case Study, p. 3.

[237]The Emerging Technology, publisher's statement.

computer-based teaching is declining. With reasonable cooperation by administrators and faculty the computer, therefore, may eventually become a dominant mode for learning.

CHAPTER V

SUMMARY OF FINDINGS AND CONCLUSIONS

During the past fifteen years, the computer has been inducing many educators "to explore the possibility of utilizing modern computer technology for more 'individualized' education,"[238]

> There are growing demands for more mass education over a large fraction of the human life-span and demands for more individualized instruction tailored to the specific preparation and motivation of a given student.[239]

A. SUMMARY

The purpose of this investigation was to examine computer-assisted instruction in higher education in the United States from 1970-1975, using seven representative colleges and universities especially concerned in this new educational development. Since the use of computers will become ever more common in the coming decades, it is important to know the general trend and the current status of CAI, and which colleges and universities have programs for instructional use of computers, how intensively they are used, how effective they are, their hardware and software equipment and their future potential. In order to examine these problems, this study has drawn upon three different

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[238]See above p. 1. [239]Ibid.

sets of data:

1. The Index to Computer Based Learning.
2. The Proceedings of the Conferences on Computers in the Undergraduate Curricula.
3. CAI activities of seven selected universities and colleges:

   The University of Illinois (Urbana)
   Stanford University
   Pennsylvania State University
   The University of Texas (Austin)
   Dartmouth College
   The University of California (Irvine)
   Coast Community College (Costa Mesa, California)

The Index to Computer Based Learning is the most comprehensive reference compilation of computer programs used in education. And the Conferences on Computers in the Undergraduate Curricula represent the only national multi-disciplinary conference serving to open channels of communication between persons who have used, are using, or would like to use computers in undergraduate education.

Moreover, the documentation of the Proceedings of the Conferences on Computers in the Undergraduate Curricula was extremely valuable for the study of computer aid in higher education. The seven universities and colleges studied were representative of a cross-section of the country--by location, by size, and by type (private, state) -- and of the characteristics of their CAI projects.

Thus they furnish a representative, up-to-date and overall view of CAI activities in higher education in the United States.

When the writer began this research, the great difficulty was the lack of available documentations and the fact that some available documentation did not take account of recent CAI activities. A review of literature in this field shows that in many cases CAI activities have been undertaken without being adequately documented. Some CAI activities have applied new hardware and software without documenting their progress. Project personnel simply kept on trying new materials or devices. For many other projects, for example at Florida State and Harvard, the current recession has substantially slowed up developments because of curtailed support and funds.

In order to provide an accurate view of CAI projects the writer began by requesting written information from the directors of CAI projects at more than twenty colleges and universities. After studying the returns from these inquiries, the writer attended the 1975 Conference on Computers in the Undergraduate Curricula at Fort Worth, Texas where she was able to meet--and discuss current computer problems--with many of the directors and other persons active in CAI activities.

B. THE FINDINGS

Through an in-depth review of the literature and the activities in Computer-Assisted Instruction, the following conclusions were reached:

1. Adequate documentation of CAI activities is generally not available.

2. The use of computers in teaching has been proven more effective in some subject areas than in others.
3. Mathematics, the Physical Sciences, Computer Science, and the health professions are dominant areas using computers for instructional activities.
4. In general, the best informed view of CAI directors is that computers cannot entirely replace effective teachers but that computers will continue to serve as a valuable supplement to conventional teaching.
5. Some projects, such as Illinois' PLATO, developed, at great effort their own hardware systems. However, the majority of CAI projects have used commercially available hardware systems and equipments.
6. Computer hardware in educational use depends on two different systems. One is the network system; the other is the stand-alone system. In the near future, microcomputer technology will probably provide a very powerful stand-alone system.
7. Graphic terminal facilities are extremely important in educational use. The development of plasma display panels in the PLATO project made graphic facilities economically feasible.

8. Among programming languages, COURSEWRITER, APL, BASIC, TUTOR are dominant.
9. The major difficulty in the development of CAI is not the computer hardware problem but rather the development of a good quality of computer programs.
10. In recent years years, many small colleges have become very active in computer-aided instruction work.
11. CAI activities in higher education fall into two major categories. The first is the centrally controlled CAI laboratories. The second is the individual contributions of various departments, projects, professors, etc.
12. In order to achieve the high potential of future CAI programs, two essentials are required:
    a. Administrators' cooperation
    b. Willingness on the part of faculty members to consider new teaching techniques.

C. CONCLUSION

In recent times knowledge and technology have moved forward with such great speed as to compel constant change in educational methods and procedures. Students have difficulty absorbing the mass of new knowledge, even in summary, without assistance. To this end, especially for in-

dividualized education, Computer-Assisted instruction has come to be increasingly important.

Though this research has shown that the computer is having a noticeable impact on some courses, the best authorities are still seeking improved means to exploit computer-assisted instruction's full potential in the development of effective individualized education.

These results of this study indicate that:

1. CAI development will continue at colleges and universities across the nation, as represented by the results from the schools sampled.
2. CAI activities can be implemented in the majority of the instructional areas in higher education.
3. CAI software development will increase in quantity and quality.
4. CAI hardware development and refinement will continue.

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APPENDIXES

APPENDIX A

Table 10

Institutions Involved in Presentations

Computer Conferences on the Undergraduate Curricula

Institution	Papers Presented						
	1970	1971	1972	1973	1974	1975	TOTAL
Alabama, University of	2	1					3
Amherst College			1				1
Appalachian State University					1		1
Arkansas, University of						1	1
Austin College						1	1
Bae County College			1				1
Baldwin-Wallace College					1		1
Baltimore, Community College of				1			1
Belmont-Abbey College			1				1
Beloit College	1				2		3
Bowdoin College	1						1
Brigham Young University			1				1
Brown University	1						1
Bryn Mawr College					1		1
Bucknell University		1					1
California State College (Bakersfield)			1				1
California State Polytechnical University			1	1			2

Table 10 (continued)

Institution	Papers Presented						
	1970	1971	1972	1973	1974	1975	TOTAL
California State University, (Chico)			1		1	1	3
California State University, (Haywood)				1			1
California, University of (Berkeley)	2		1				3
California, University of (Davis)			1				1
California, University of (Irvine)		3	1	1	1	3	9
California, University of (Riverside)		1					1
California, University of (San Diego)		1					1
California, University of (Santa Barbara)		2					2
Carleton College	1	1	1				3
Carnegie-Mellon University				1			1
Centenary College	1						1
Ceritas College					1		1
Cheyney State College					1		1
Chicago, City Colleges of					1	1	2
Claremont University Center	1						1
Clarke College	1						1
Clarkson School of Technology		1					1
Clemson University			1				1
Coe College		1					1

Table 10 (continued)

Institution	Papers Presented 1970	1971	1972	1973	1974	1975	TOTAL
Colgate University	1				1		2
Colorado State University	1				1		2
CONDUIT Central				1			1
Connecticut, University of					1		1
Cornell, University of	1		1				2
Catter Junior College for Women			1				1
Dartmouth College	8	7	1	3	1	1	21
Dayton, University of			1				1
Delaware, University of				1			1
Digital Equipment Company					1		1
Drew University	1		1				2
Drexel University	1				1		2
Duke University		1		1		1	3
Earlham College		1					1
East Carolina University	1						1
Eastern Michigan University		1	1	2	1		5
Engineering Instructional Services					1		1
Fairmont State College	1						1

Table 10 (continued)

Institutions	Papers Presented						
	1970	1971	1972	1973	1974	1975	TOTAL
Florida Atlantic University	1			1			2
Florida State University				1			1
Furman University			1				1
Ganilan College		1	1				2
Gannon College				1			1
Georgia State University			1			1	2
Georgia Tech			1		1		2
Georgia, University of	1						1
Gettsyburg College		1					1
Golden West College			1				1
Gouzaga University	1						1
Grinnel College	1						1
Hampshire College			1	1			2
Harvey Mudd College	1	1				1	3
Holy Names College				1			1
Hope College			2	1			3
Houston, University of						1	1
Human Resources Research Organization				1			1
Idaho, University of					1	1	2
Illinois Institute of Technology			2		1		3

Table 10 (continued)

Institution	Papers Presented						
	1970	1971	1972	1973	1974	1975	TOTAL
Illinois State University				1			1
Illinois, University of	2	3	2	3	2	1	13
Illinois Wesleyon College	1						1
Indiana, University of (Bloomington)			2				2
Indiana, University of (Fort Wayne)			1				1
IBM Corporation						1	1
Iowa State University		1	1				2
Iowa, University of	1		1	1	1	2	6
Iowa Wesleyon College	1						1
Jersey State College	1						1
Joliet Junior College			1				1
Kansas, University of		2	3	1		1	7
Kentucky, University of				1			1
Knox College		1					1
Lawrence University		2		2	1		5
Lenoir Rhyne College		1					1
Lindenwood Colleges			2				2
Lock Haven State College				1			1
Louisiana State University		1					1

Table 10 (continued)

Institution	Papers Presented						
	1970	1971	1972	1973	1974	1975	TOTAL
Louisville, University of			2		1		3
Loyola University (Illinois)		1			1		2
Loyola University 1 (Louisiana)			1				1
Luther College	1						1
Macon Junior College			1				1
Manitoba, University of		1					1
Maryland, University of		2	1				3
Maryville College	1						1
Massachusetts Institute of Technology		1					1
Miami University (Ohio)			1		1		2
Michigan State University					1		1
Michigan Technological University	1	1		2			4
Michigan, University of (Ann Arbor)	4	2	1	1	1	1	10
Michigan, University of (Flint)			1				1
Middlebury College			1	1			2
Mills College				1			1
Minnesota, University of	1	5		2	1		9

Table 10 (continued)

Institution	Papers Presented 1970	1971	1972	1973	1974	1975	TOTAL
Minot State College						1	1
Mississippi State University				1			1
Missouri Southern State College			1				1
Missouri, University of (Rolla)						2	2
Montana, University of		2					2
Morovian College			1				1
Mount Holyoke College	1						1
National Science Foundation		2		1			3
Naval Academy, U.S.	1	2		1			4
Nebraska, University of	2	1			1		4
Nevada, University of	1				1		2
New Mexico, University of			1				1
New York City Community College			1				1
New York, State University of (Binghamton)	1	1	1	2			5
New York, State University of (Brockport)			1	1			2
New York, State University of (Buffalo)		1	1				2

Table 10 (continued)

Institution	Papers Presented 1970	1971	1972	1973	1974	1975	TOTAL
New York, State University of (Stony Brook)				1	1		2
North Carolina Educ. Comp. Service	3	1	2	1			7
North Carolina State University	1	1					2
North Carolina, University of	1	1	1			1	4
North Dakota, University of		1					1
North Texas State University	1						1
Northern Illinois University	1						1
Northwestern University					1		1
Notre Dame, College of				1			1
Notre Dame, University of			1	1	1		3
Oakland University		1			4		5
Oberlin College	1	1		1			3
Ohio State University	1	1	1				3
Ohio University	1		1				2
Oklahoma State University	1		1		1		3
Orange County Community College		1					1

Table 10 (continued)

Institution	Papers Presented 1970	1971	1972	1973	1974	1975	TOTAL
Oregon State University		1	1				2
Oregon, University of	1	2		1			4
Pacific Lutheran University					1		1
Pacific Union College	1						1
Park College	1						1
Pennsylvania State University	3	1	1	3		1	9
Pennsylvania, University of	1						1
Pepperdine University		1					1
Pittsburgh, University of	1	2	1	1			5
Pitzer College		1					1
Polytechnical Institute of New York					1		1
Prarie State College	1						1
Purdue University		1					1
Rensselaer Polytechnical University	1			1			2
Rochester University						1	1
Russell Sage Foundation		1					1
Saint Andrews Presbyterian College			1	1			2

Table 10 (continued)

Institution	Papers Presented 1970	1971	1972	1973	1974	1975	TOTAL
Saint Elizabeth, College of	1						1
Saint John's University (Minn.)		1					1
Saint John's University (N.Y.)			1	3			4
Saint Olaf's College			1				1
Saint Philips College					1		1
San Francisco, University of					1		1
San Jose College	1						1
Scripps College		1					1
Seattle Pacific College				1			1
Simon Fraser College				1			1
Slippery Rock State College					1		1
Smith College	1						1
South, University of		1					1
South Carolina, University of			1	1			2
South Florida, University of			1				1
Southern California, University of				1	2		3
Southern Methodist University						1	1

Table 10 (continued)

Institution	Papers Presented 1970	1971	1972	1973	1974	1975	TOTAL
Southern Missionary College	1						1
Southern Oregon College			1	1			2
Southern Reg. Ed. Board	2	1					3
Southwestern Louisiana, U. of			1				1
Stanford University	1		1		2		4
State University College, (New Paltz, New York)		1					1
State University College, (Oneonta, New York)				1	1		2
State University College, (Potsdam, New York)				1			1
Syracuse University	1		1	1			3
Systems Development Corporation	1						1
Tarleton State College		1					1
Temple University		1	1				2
Texas A & M University			1			1	2
Texas Christian University						2	2
Texas Tech University						1	1
Texas, University of (Arlington)			1	1			2
Texas, University of (Austin)		1	1	2		6	10

Table 10 (continued)

Institution	Papers Presented						
	1970	1971	1972	1973	1974	1975	TOTAL
Tougaloo College	1						1
Union College (New York)			1	1			2
Upsala College		1					1
Valparaiso University		2					2
Vassar College						1	1
Virginia Polytechnical Institute			1				1
Virginia, University of	1	2					3
Washington State University	2		2		1		5
Washington Technical Institute						1	1
Washington University (Mo.)		1		1			2
Washington, University of	1						1
Western College for Women	1						1
Western Michigan University			2				2
Western New Mexico University					1		1
Western Washington State College			1				1
Westmont College				1			1
Wisconsin State University		1					1

Table 10 (continued)

Institution	Papers Presented 1970	1971	1972	1973	1974	1975	TOTAL
Wisconsin, University of						1	1
Wofford College				1			1
Wooster, College of		1					1
Worcester Polytechnic Institute	1	1					2
TOTAL PRESENTATIONS:	88	93	87	73	54	38	433
Total Institutions Represented:	72	65	66	60	52	28	

APPENDIX B

Table 11

Institutions Listed in Order of

Number of Presentations

Number of Presentations	Institution	1973 Enrollment of Institution
21	Dartmouth College	3,823
13	Illinois, University of	32,393
10	Michigan, University of, Ann Arbor	41,178
10	Texas, University of, Austin	68,534
9	California, University of, Irvine	5,845
9	Minnesota, University of	44,756
9	Pennsylvania State University	52,360
7	Kansas, University of	19,026
7	North Carolina Ed. Comp. Service	
6	Iowa, University of	19,055
5	Eastern Michigan University	17,690
5	Lawrence University	1,275
5	New York, State University of (Binghamton)	7,930
5	Oakland University	8,365
5	Pittsburgh, University of	25,562
5	Washington State University	13,770

Table 11 (continued)

Number of Presentations	Institution	1973 Enrollment of Institution
4	Michigan Tech. University	4,417
4	Naval Academy, U.S.	4,004
4	Nebraska, University of	21,581
4	North Carolina, University of	19,500
4	Oregon, University of	14,418
4	Saint John's University (NY)	13,113
4	Stanford University	11,197
3	Twenty Institutions	
2	Forty-three Institutions	
1	One Hundred Twenty-eight Institutions	
TOTAL:	214 Institutions	

APPENDIX C

Table 12

Presentations According to Subject

Subject	1970		1971		1972		1973		1974		1975		TOTAL	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Art	1	1.12	4		1	1.19					1	2.78	3	.75
Biology	5	5.62	4	5.48	5	5.95	4	5.97					18	4.51
Business & Accounting	2	2.24	7	9.46	4	4.76	4	5.97	5	10.42	6	16.22	28	7.02
Chemistry	9	10.11	9	12.16	6	7.19	6	8.96	3	6.25	4	10.81	37	9.27
Economics	7	7.87	3	4.05	6	7.14	3	4.47	2	4.17			21	5.26
Education			3	4.05	10	11.90							13	3.26
Engineering	11	12.36	3	4.05	7	8.33	4	5.97	4	8.33			29	7.27
Gaming & Simulation									4	8.33			4	1.00
Geography					4	4.76	3	4.47					7	1.75
History					2	2.38	1	1.49					3	.75
Humanities: General			2	2.70			2	2.99	1	2.08			5	1.25
Language-Literature	3	3.37			2	2.38	3	4.47	2	4.17	4	10.81	14	3.51
Mathematics	7	7.87	8	10.81	7	8.33	9	13.43	6	12.50	4	10.81	41	10.28
Music	1	1.12	1	1.35			1	1.49	2	4.17	1	2.70	6	1.50
Physical Sciences; Gen.	1	1.12	1	1.35			1	1.49					3	.75
Physics	9	10.11	10	13.51	8	9.52	5	7.46	3	6.12	3	8.11	38	9.52

Table 12 (continued)

Subject	1970		1971		1972		1973		1974		1975		TOTAL	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Political Science	1	1.12	4	5.40			4	5.97	3	6.25			12	3.02
Religious Studies							1	1.49					1	.25
Science	2	2.24											2	.50
Social Sc.; Gen.	5	5.62	6	8.11	5	5.95	1	1.49	2	4.17			19	4.76
Sociology	2	2.24	2	2.70	1	1.19	3	4.47	1	2.08			9	2.26
Statistics	6	6.74	3	4.05	6	7.14	4	5.97	4	8.33			23	5.76
Panels, Workshops, Etc.	1	1.12					2	2.99			3	8.11	6	1.50
General and other	15	16.85	8	10.81	7	8.33	6	8.96	6	12.50	11	29.73	53	13.28
TOTALS:	89		74		84		67		48		37		399	

APPENDIX D

Table 13

Presentations According to Subjects*

By Year

1970			1971		
Subject	Number	Percent	Subject	Number	Percent
Engineering	11	12.36	Physics	10	13.51
Chemistry	9	10.11	Chemistry	9	12.16
Physics	9	10.11	Math	8	10.81
Economics	7	7.87	Business-Accounting	7	9.46
Mathematics	7	7.87	Social Sciences (General)	6	8.11
Statistics	6	6.74	Biology	4	5.40
Biology	5	5.62	Psychology	4	5.40
Social Sciences (General)	5	5.62			

1972			1973		
Subject	Number	Percent	Subject	Number	Percent
Education	10	11.90	Mathematics	9	13.45
Physics	8	9.52	Chemistry	6	8.96
Engineering	7	8.33	Physics	5	7.46
Mathematics	7	8.33	Biology	4	5.97
Economics	6	7.14	Business-Accounting	4	5.97
Chemistry	6	7.14	Engineering	4	5.97
Statistics	6	7.14	Psychology	4	5.97
Biology	5	5.95	Statistics	4	5.97
Social Sciences (General)	5	5.95			

Table 13 (continued)

1974			1975		
Subject	Number	Percent	Subject	Number	Percent
Mathematics	6	12.50	Business-Acct.	6	16.22
Business-Acct.	5	10.42	Language-Liter.	4	10.81
Engineering	4	8.33	Mathematics	4	10.81
Gaming & Stimulation	4	8.33	Chemistry	4	10.81
Statistics	4	8.33	Physics	3	8.11
Chemistry	3	6.25			
Physics	3	6.25			
Psychology	3	6.25			

*Subjects over 5%, ranked.

APPENDIX E

Table 14

Presentations According to Subject

Percentages of Total

Subject	Number	Percent
Mathematics	41	10.28
Physics	38	9.52
Chemistry	37	9.27
Engineering	29	7.27
Business & Accounting	28	7.02
Statistics	23	5.76
Economics	21	5.26
Social Sciences: General	19	4.76
Biology	18	4.51
Language - Literature	14	3.51
Education	13	3.26
Psychology	12	3.01
Sociology	9	2.26
Geography	7	1.75
Music	6	1.50
Humanities: General	5	1.25
Gaming & Simulation	4	1.00
Political Science	4	1.00
Art	3	.75
History	3	.75

Table 14 (continued)

Subject	Number	Percent
Physical Science: General	3	.75
Science: General	2	.50
Religious Studies	1	.25

APPENDIX F

Highlights in Plato's History*

June 1960	First design for PLATO complete (single station consisting of keyset and CRT with provision for simultaneous display of computer-generated characters and photographic slide).
Fall 1960	PLATO goes into regular research operation (2 hours per day using ILLIAC I computer) as project of Coordinated Science Laboratory.
November 1960	First formal demonstration of PLATO in operation.
January 1961	PLATO II goes into operation (two stations operating simultaneously).
March 1961	First use of remote terminal with PLATO (30 miles from computer).
Spring 1961	PLATO first used with instructional material (high school math and French grammer).
Fall 1961	College level material first used on PLATO (Network Synthesis lessons).
Spring 1962	PLATO first used to provide part of accredited college course (Math 195, University of Illinois).
Summer 1962	Inquiry type logic developed for PLATO.
November 1962	PLATO first used to collect and process physiological information (heart rate) as part of student response data.
January 1963	PLATO shifts from ILLIAC I to CDC 1604 computer.
Spring 1963	PLATO first used to provide part of accredited professional course (Nursing).
Fall 1963	PLATO III first used (capability for expansion to 32 stations).
June 1964	Two different lessons simultaneously available to class using PLATO.

October 1964	Provision for inter-terminal communication between PLATO terminals completed.
Fall 1964	PLATO used for control of real experiments in physical sciences (all stations able to observe outcome and perform analysis of results).
December 1964	On-line editing of PLATO lesson possible while students use lesson.
January 1965	CATO (Compiler for Automatic Teaching Operations) completed.
Spring 1965	PLATO first used for extensive portion of accredited college course (EE322).
Fall 1965	First College course (Library Science 195) given completely by PLATO.
March 1966	Expansion of PLATO III to 20 terminals completed.
May 1966	PLATO operating on own CDC 1604 computer.
Summer 1966	Multiple on-line author editing program first used (MONSTER tape editor).
January 1967	Computer-based Education Research (CERL) formed for continued operation of and research on PLATO.
Summer 1967	TUTOR author language first used on PLATO (specifically designed for authors with no background in computer use).
March 1968	NSF grant awarded for first steps of development of PLATO IV (ultimately to consist of more than 1000 student terminals requiring only telephone line communication with a large central computer). Terminals use the plasma display panel developed at the University of Illinois instead of the more costly CRT presentation.
June 1968	Disk storage added giving on-line editing capability to authors while students are operating (any combination of up to 20 authors or students simultaneously operating).

June 1968	Delivery of first commercially produced 4" plasma panel (Owens-Illinois).
December 1968	14 station remote PLATO demonstration center in operation at Mercy Hospital (3 other centers operation by February, 1969).
June 1969	Multiple disk storage in operation. Up to 150 lessons available to students (for use) or authors (for editing) during a class session.
November 1969	1 remote station operating at Springfield High School, Springfield, Illinois, ninety miles from Urbana.
Summer 1970	720 hours of instructional material developed; 100,000 student contact hours of use by this date.
January 1971	On-line remote demonstration for NSF in Washington, D.C.
May 1971	Delivery of first 512 X512 Digivue display memory device from Owens-Illinois.
June 1971	Delivery of first PLATO IV terminal from Magnovox Company.
Summer 1971	1100 hours of instructional material developed; 130,000 student contact hours of use by this date.
January 1972	Four PLATO IV terminals in operation.
June 1972	20 PLATO IV terminals in operation. On-line PLATO IV demonstrations between January 1972 and June 1972 in many locations from California to Massachusetts, Canada to Texas.
Summer 1972	On-line PLATO IV demonstrations in Italy, Germany, and Switzerland.
August 1972	1600 hours of PLATO III instructional material developed, 154,000 student contact hours of use of the PLATO system to date. Instructional sequences available in about 70 courses.
August 1972	40 PLATO IV terminals in operation.

Fall 1972	Intensive PLATO IV lesson development.
Winter 1972	250 PLATO IV terminals in operation in approximately 40 locations (15 on the University of Illinois campus and about 25 off campus).
February 1973	CDC CYBER 73 Computer installed.
June 1973	Phasing out of the use of the PLATO III system for teaching.
June 1973	PLATO on-line demonstration in Mexico.
September 1973	PLATO on-line demonstration in Sweden.
Fall 1973	300 PLATO IV terminals in operation in 50 sites.
November 1973	PLATO on-line demonstration in the Soviet Union - 5 terminals, Russian keysets.
Winter 1973-74	Second PLATO system started by Control Data Corporation in Minnesota.
January 1974	500,000 words of extended core storage (ECS) added.
February 1974	1500 hours of available PLATO IV instructional material. 1500 hours of instructional material in preparation. Over 90 college courses using PLATO.
March 1974	450 terminals operable. New disk system operational (CDC 844).
July 1974	700 terminals operable. 2500 hours available curricular materials.
Summer 1974	PLATO on-line demonstration in Budapest, Hungary.
September 1974	Formal external PLATO evaluation started by Educational Testing Service.
Fall 1974	PLATO terminals located at approximately 100 sites; 23 sites on the campus at the University of Illinois, 8 in elementary schools, 1 in a high school, as well as terminals in about 40 colleges and

universities, 17 government projects and 12 miscellaneous sites.

December 1974 Addition of 1 million words of extended core storage.

*"Highlights in PLATO's History" is copied from PLATO Highlights, pp. 13-16.

APPENDIX G

Table 15

Stanford Programs in
Computer-Assisted Instruction*

Program	66-67	67-68	68-69	69-70
Drill-and-practice mathematics, grades 1-8 (block structure)				
California	1,500	1,441	2,475	122
Iowa	-	640	-	-
Kentucky	-	1,632	1,060	-
Mississippi	-	640	2,113	-
Ohio	-	-	101	-
Washington	-	-	92	139
college level				
Tennessee (algebra)	-	-	206	183
Tutorial primary-grade mathematics	53	73	-	-
Tutorial reading, grade 1	50	88	-	-
Drill-and-practice in initial reading grades 1-3, remedial 4-6				
California	-	-	442	642
Language arts	-	-	-	30
Drill-and-practice mathematics, grades 1-6 (strands structure)				
California	-	-	-	1,713
Ohio	-	-	-	165
Washington, D.C.	-	-	-	39
Tutorial computer programming	-	-	115	177
Tutorial logic and algebra, grades 4-8	76	195	49	459
Tutorial problem-solving, grades 5, 6	-	27	20	18
First-and-second-year Russian	10	30	52	77

*P. Suppes, "Computer-Assisted Instruction at Stanford," p. 305.

VITA

Inja Namkung was born in Mokpo, Korea, attended schools in Korea, and graduated from Mokpo Girls' High School. She received a Bachelor of Science Degree in Mathematics from the University of Korea in March, 1960, the degree of Master of Education in Mathematics from Yonsei University in Seoul, Korea in February, 1970; and the Master of Science degree in Computer Science from The University of Tennessee in August 1973. From 1960-1970 she was a full-time teacher at Sacred Heart Girls' High School, at the International School of the Sacred Heart, St. Mary's High School and a full-time Instructor in mathematics at Sacred Heart College in Korea. She was a Graduate Assistant at The University of Tennessee from 1970 to 1974 and a computer program consultant in the Department of Computer Science in 1974-75. She graduated at The University of Tennessee with a Doctor of Education degree in December, 1975 majoring in Curriculum and Instruction with collateral areas in Computer Science and Mathematics Education.