DOCUMENT RESUME

ED 062 913 HE 003 006

TITLE Educational Technology in Higher Education: The Promises and Limitations of ITV and CAI.
INSTITUTION National Academy of Engineering, Washington, D.C. Commission on Education.
PUB DATE Sep 69
NOTE 25p.

EDRS PRICE MF-$0.65 HC-$3.29
DESCRIPTORS *Computer Assisted Instruction; Educational Finance; *Educational Technology; Federal Aid; *Higher Education; Instructional Media; *Instructional Technology; State Aid; *Televised Instruction

ABSTRACT

The present report, prepared by the Instructional Technology Committee of the National Academy of Engineering's Commission on Education, presents some accumulated data concerning computer-aided instruction and instructional television as used in institutions of higher learning. The report consists of 4 sections: (1) The Promise of Educational Technology; (2) The Problem of Higher Education, including student unrest and increasing costs; (3) Funding Prospects; and (4) The Role of the Engineering School. Appendix A gives further background for the prospect of funding by the federal government, the state government, endowments and other institutional sources, local governments, private foundations, and industry. Appendix B presents a data base for instructional television and computer-aided instruction. (HS)

EDUCATIONAL TECHNOLOGY IN HIGHER EDUCATION
The Promises and Limitations of ITV and CAI

EDUCATIONAL TECHNOLOGY IN HIGHER EDUCATION:
The Promises and Limitations of ITV and CAI.

A report of the
Instructional Technology Committee
of the
Commission on Education
of the National Academy of Engineering

Washington, D.C.
September, 1969

INSTRUCTIONAL TECHNOLOGY COMMITTEE
OF THE
COMMISSION ON EDUCATION
OF THE
NATIONAL ACADEMY OF ENGINEERING

JOHN R. WHINNERY, *CHAIRMAN*
Department of Electrical Engineering
and Computer Sciences
University of California, Berkeley

DONALD L. BITZER
Department of Electrical Engineering
University of Illinois

RICHARD H. BOLT
Bolt Beranek and Newman Inc.

DEAN BROWN
Systems Development Group
Stanford Research Institute

LAWRENCE P. GRAYSON
Bureau of Research
Office of Education
Department of Health, Education and Welfare

LESLIE P. GREENHILL
Assistant Vice President for
Resident Instruction
The Pennsylvania State University

WILLIAM T. KNOX
Vice President
McGraw-Hill, Inc.

JOHN A. STARKWEATHER
Director, Computer Center
University of California Medical Center
(San Francisco)

STAFF:

DAVID C. MILLER
Commission on Education
National Academy of Engineering

EDUCATIONAL TECHNOLOGY IN HIGHER EDUCATION:

The Promises and Limitations of ITV and CAI.

INTRODUCTION

The Instructional Technology Committee of the National Academy of Engineering's Commission on Education recently assembled a considerable amount of data on computer-aided instruction and instructional television as used in institutions of higher learning. This data was used to prepare a pilot Technology Assessment Report for the U. S. House Subcommittee on Science, Research and Development. The Commission felt that much of the accumulated factual data might be of interest to faculty members of engineering schools and requested that this report be prepared. The background information is essentially the same as that provided as appendices to the technology assessment study. Some of the basic ideas concerning the problems of higher education and the promise of educational technology are also contained in the assessment study. This document, however, does not attempt to assess these facts or concepts by any formal process.

This report is the first step in the Instructional Technology Committee's ongoing activities and has not identified specific recommendations or conclusions. Such findings will be the goal of future studies. The Committee is particularly anxious to approach the definition of the appropriate role for educational technology in institutions of higher education in a well-balanced, objective manner. It is impressed with the far-reaching potential of the technology and the many viable activities already established. It is also aware of the many problems still to be solved. The Committee has selected only one segment of the technology for its initial study but feels that this segment is an important, if not central, part of the developing educational systems.

This report consists of four sections, namely: The Promise of Educational Technology, The Problems of Higher Education, Funding Prospects, and The Role of the Engineering School. Appendices A and B provide background information for the four selected topics.

THE PROMISE OF EDUCATIONAL TECHNOLOGY

Educational technology can be defined as the body of knowledge resulting from the application of the science of teaching and learning to the real world of the classroom together with the tools and methodologies developed to assist in these applications. A goal of the practitioners of this technology is to optimize the learning experience of each student through the design of instructional strategies that are highly responsive to the needs of individual learners.

The application of technology in the industrial world has resulted, over the past one hundred years, in a major increase in productivity, a conversion from labor intensive to mechanized or automated systems, and a steady increase in worker real wages. By analogy, educational technology might be expected to perform the same mission for the educational institutions.

Education experts have pointed out what they consider to be dangerous fallacies inherent in drawing such an analogy and holding out such hopes. They stress the difficulty in specifying the end product of the educational process, the uncontrollable variation in the human raw materials, and the vast areas of ignorance in the science of teaching and learning. They strongly counsel a policy of waiting until the problem is better understood and, in the meantime, of continuing the known practices of the past.

Unfortunately, this counsel has a strong appeal to many observers of the educational scene. Many attempts at the application of technology to education have been parochial and unimaginative transfers of devices from the industrial or entertainment world to the classroom. Applications have been often carried out with little concern for the psychology of the classroom teacher, often with uncertain and sometimes clearly detrimental results. Only in recent years has the need for broad approaches been accepted, and the ideas and counsel of the instructors actively sought. One major assumption in almost all of the efforts has been that the goal of the technology would be to automate the classroom or in less ambitious schemes, to provide intensive and expensive supplementary support for the classroom teacher.

This concentration on the classroom as the learning arena may be valid for primary and secondary education, but a realistic examination of the situation in higher education would probably support the contention that only a small fraction of student learning occurs in the lecture hall. Further, many would agree that training a university student to be a competent self-learner is the most important and lasting contribution the school can make. Bruner, in his discussion of a theory of instruction, states:

> Instruction is a provisional state that has as its object to make the learner or problem-solver self-sufficient. [1]

If these two assumptions are accepted, automating the lecture hall or even trying to convert the lecturer to a master entertainer becomes a far less significant task. The endless efforts to assess whether conventional or TV teaching sessions are superior become almost moot. In this view, the goal to which the technology should be directed is to assist the student to become an efficient, independent learner.

[1] Jerome S. Bruner, "Toward a Theory of Instruction," (Cambridge, Mass., The Belknap Press of the Harvard University Press, 1967) p. 53.

The present trend toward individualized instruction is an essential step in achieving this goal. However, much more innovative thinking is required to provide the economic answers to individualized instruction. For example, the role of the lecturer must be radically altered. Routine fact recitation or simple problem solving exercises should probably be eliminated from the instructors' duties. Students should be familiar with the material before they are exposed to the precious time of the instructor so that the instructor's time can be used more advantageously: to clarify difficult concepts, to introduce interrelationships, and to encourage creative thinking on the part of the student.

If a truly effective teaching relationship can be established between students and faculty, the actual duration of the interaction for any one student can be relatively short. The feeling of depersonalization often cited by students as a concern is probably not a linear function of the total time the student and instructor interact, but is more likely dependent upon the quality of the interaction when it does occur. If the principal role of the technology at the college level is structured to develop self-learners, it is very possible that new and effective answers to the economic problems of the schools can be developed, and, at the same time, the students' concern for depersonalization and relevance can be alleviated.

In any case, a new approach to the application of technology to higher education must be found. Many of the activities that have been pursued in the name of educational technology during the past two or three decades have resulted in widespread disillusionment and, in many educational and governmental circles, in outright hostility. At the present time, a great deal of care must be taken to avoid the possibility that the increased use of technology will only worsen the problems facing educational institutions, either by increasing costs or developing further negative faculty and student reactions. On the other hand, important groundwork has been laid and important lessons learned. Skillful and imaginative technology applications undertaken within the framework of a systems approach will be a vital component in any plan for resolving the pressing educational problems now threatening the fabric of the entire system of higher education.

THE PROBLEMS OF HIGHER EDUCATION

Higher education is facing the same basic problem that is besetting individuals and institutions throughout our present social order, namely the necessity of adapting to new conditions resulting in great part from the technological revolution and, equally important, the need to evolve and adopt a dynamic mechanism of continuous institutional change.

The need and opportunity for the schools to contribute to the resolution of this vital social problem may never be greater or more immediate. Many university and college administration and faculty members are deeply concerned and actively engaged in a variety of efforts designed to meet this challenge. However, the educational institutions themselves are no exception to the general problem; their forms, procedures and traditions resist even minor changes. The need for change in educational institutions has become increasingly obvious as the result of two problems. The first of these problems is to understand and learn how to cope with campus disorders. The second problem is to eliminate the threat of reduced educational effectiveness due to rapidly increasing costs and limited financial resources.

Student Unrest

Student unrest is an extremely complex problem, greatly complicated by the basic inexperience of the students and the influence of a few radical agitators with announced goals for the disruption or even destruction of educational institutions. It may be that the university, in its role as parent surrogate, is the victim of frustrations arising from the students' exposure to the many problems of contemporary society. It cannot be denied that reforms in the colleges and universities can and, in many cases, are providing a more meaningful, more personalized educational experience. However, the evidence is that the major thrust of student demands does not concern itself with this type of reform. Furthermore, student dissension has not been eliminated in those institutions where extensive efforts have been made to incorporate such reforms.

Increasing Costs

The second major problem facing institutions of higher education is the growing financial crisis. Costs of higher education are increasing at a rate of more than one billion dollars per year. About two-thirds of this amount is due to the increasing number of students. The remaining one-third is due to the increased educational and general expenditures per student. Average costs to the college per student in 1965-66 dollars have gone from $1,495 in 1955 to $2,164 in 1965 and are projected to be $2,557 in 1975.

Growth in Enrollment

The growth of enrollments has been the result of the general increase in population, the longer time being spent in higher education, the impact of adult and continuing education programs, and the increasing fraction of the normal college age group who find it possible to enroll in a college or university.

This latter trend has particularly important implications for the future fiscal needs of the schools. Poor academic achievement in high school studies is no inflexible barrier to acceptance in the rapidly growing community college sector. The extensive student loan programs of the federal government and the modest fees of the community colleges also allow many students to embark on a college program who, in previous years, would have been financially unable to start such an undertaking. As the minority groups' needs for quality higher education are met, expanded enrollments and the need for additional remedial programs are again the natural consequence.

In the past, the growing increase in enrollments has been compensated, in part, by an intensive "screen out" policy. A large fraction of the students entering the college or the university have dropped out or been dismissed before earning a four-year degree. Most of this attrition has taken place during the freshman year. However, this "screen out" policy, leading as it often does to a traumatic experience for so many college-oriented students, is under attack. An increasing number of parents and educators are urging the development of a "screen in" policy instead. Many of the community colleges are dedicated to the goal of educating each student to make the best possible use of his innate capabilities irrespective of scholastic aptitudes. There is much to be said for the adoption of this philosophy by a large fraction of the colleges and universities, but the almost immediate consequence would be a further aggravation of the financial needs of the schools. If the colleges and universities also accept an enlarged role in the task of continuing education of adults, another task of urgency and importance, the facilities and resources of the institutions will be still further stretched.

Cost per Student

The ever increasing cost per student has been analyzed in a paper by W. G. Bowen.[2] While emphasizing the problem of the private university, the reasoning is probably also valid for public colleges and universities. Because of continuous productivity increases in the over-all economy, labor has been rewarded with wage increases. Since general wage increases apply across the entire spectrum of employees, the consequence to higher education has been rising faculty salaries. The increasing role played by government funded research in both upgrading the qualifications of faculty and in requiring universities to compete with industrial salaries has accentuated this trend. Since the instructor/pupil ratio has not changed significantly for decades and the hours of teaching load per instructor, if anything, has decreased, the productivity in terms of number of students graduated per instructor has also been fairly constant.

In other words, the productivity of the institution with respect to its primary mission, i.e., the education of students, has not changed appreciably for many years. Because of the labor intensive nature of educational institutions, higher instructional costs coupled with a fixed level of productivity can only result in continual increases in the costs of operation. For private universities, Bowen estimates this to be about 7.5 per cent increase in cost per year. For the public supported institutions, the percentage of increase is more like 5 per cent; but this is still a relatively rapid cost escalation.

To assess the true extent and potential impact of these cost increases, offsetting possibilities for increasing income must be examined. This possibility is also discussed in the Bowen report with the conclusion that these efforts will prove grossly inadequate. A similar conclusion is also reached in a study by the Association of American Universities:

> Projecting these restraints on income growth against the inevitable increases in expenditures presents a stark fiscal future for higher education. Current analyses point to the sobering existence of a growing and substantial, even staggering, gap between income and expenditures in many private institutions, and an equally serious and growing quality deficit in public institutions.
>
> In point of fact, of course, even in the face of such deficits, few institutions will do anything as dramatic as closing down. However, unless the needed resources are found, higher education, as a whole, will experience a deterioration in effectiveness. Outlays will be cut back to meet income limitations. Such retrenchment inevitably would mean fewer faculty to teach more students, reduced library acquisitions and cultural programs, curtailed opportunities for the disadvantaged, slowed movement into new fields, less competent and productive research, loss of faculty, delayed maintenance, and adherence to the status quo instead of vigorous movement into new aspects of education or public service – in short, the slow stifling of higher education as a vital, creative, productive force in American life.[3]

There is some evidence that many schools are already experiencing the consequences of the financial squeeze. For example, there is general agreement that computers must now play an essential part in the education process. The provision of adequate computer services for all students has proved to be beyond the available resources of all but a few of the wealthiest schools. Recognizing this, in 1967, the President's Science Advisory Committee Report on *Computers in Higher Education* requested substantial federal funding assistance and stated:

> The recommendations we make are expensive, but if they are not carried out there will be a different kind of cost. Today, the best and richest institutions are able to carry part of the burden of educational computing. As time goes on, these institutions will improve the service they give their undergraduates, while smaller and poorer institu-

[2] William G. Bowen, *The Economics of the Major Private Universities*, Carnegie Commission on Higher Education, 1968.

[3] *The Federal Financing of Higher Education*, The Association of American Universities, April 1968, p. 14.

tions will be trying to catch up. Many of them will be able to catch up to today's best in 10 or 15 years instead of the 5 years we recommend. If the deficit in educational computing is not made up quickly, millions of students who will have attended these institutions in the 1970's will be poorly prepared for the world of the 1980's and 1990's.[4]

These recommendations have not been implemented. While token funds have been available through NSF, the predicted impoverishment of the education of thousands of students has already occurred. There is no evidence that any substantial improvement in the situation can be expected.

Since predicted income levels are not expected to meet the rising costs of instruction, and since there is evidence of a resultant reduction in quality of education for a significant number of students, the financial base of higher education is of grave concern.

FUNDING PROSPECTS

An examination of the trends of the funding of higher education and, in particular, the funding of CAI/ITV is useful as a guide to further actions. Data upon which such an examination can be based has been accumulated in Appendix A of this report. The level of expected support from both the public and private sectors is estimated insofar as data is available.

A summary of the data in Appendix A indicates that the support funding for ITV from all sources other than state funding, which is undocumented, will probably not exceed its 1968 level of about $3 million a year for the next few years. Further, the total support for CAI from all sources will increase from about $15 million a year in 1968 to about $20 million a year in 1972. These seem to be moderate sums for supporting what are probably the most innovative efforts in educational technology when viewed in terms of the $5 billion federal subsidy provided for higher education in FY 1970.

THE ROLE OF ENGINEERING SCHOOLS

The question might well be asked, "What has all this to do with the engineering educator?" Engineering has traditionally been a problem-solving activity, a profession dedicated to bringing the ideas and resources of technology to the resolution of real world difficulties. Increasing productivity by the application of well-designed methods and systems is a common engineering skill on the industrial scene and it seems reasonable to assume that the application of these skills to the problems of educational institutions could yield important results.

[4]*Computers in Higher Education*, Report of the President's Science Advisory Committee, Government Printing Office, Washington, D.C. (1967), p. 8.

It is true that the teaching/learning environment is quite different from the industrial production line and that the educator has a tradition and language unfamiliar to many engineers. However, the engineering educator combines a background of technological competence and an understanding of the goals and frustrations of the teacher. For this reason, the engineering educator has particularly pertinent qualifications for attacking these educational problems.

Within the broad concept of improving educational productivity while maintaining or increasing the quality of instruction, many subsidiary problems can be identified. These range from specific hardware modifications to broad technical and management systems studies. To illustrate the diversity of the contributions needed and, perhaps, to trigger the process whereby the new ideas that are essential to ultimate success are generated, the following examples of specific needs and opportunities are provided.

An important contribution to the improvement of engineering education could be made if the majority of the computer programs that have been developed for engineering student use could be made available to all engineering schools. The difficulties of computer program interchange are well-known, and economic solutions are often not obvious, but the development of many of these programs at each engineering school also represents a very significant cost. The resolution of this problem will require increased efforts on the development of computer compatibility, further considerations of universal computer languages, and the finding of other ways to identify and widely use the programs already available.

Much of the deterrent to the use of educational technology is the high cost of various hardware configurations. The availability of visual images, particularly images capable of demonstrating motion, is a recognized need to supplement written or oral materials. Motion pictures and more recently video tape have provided this capability but at a relatively high cost per minute. A low-cost, compact display unit using a low-cost recording medium usable by the average, non-technical student would be an important contribution to the development of an economically feasible self-instruction system.

The provision of communications links in the time-sharing computer applications of CAI is often the major cost of the system. The greater the data handling rate desired, the more expensive the link. The development of inexpensive, wide band transmission facilities would be of great value to all computer users. For short ranges, the investigation and development of inexpensive laser links may provide a solution to this problem.

The need for a low-cost display unit for use as a computer output device is another pressing need. The plasma screen development by Dr. Bitzer at the University of Illinois shows promise of meeting this need for some applications, but additional efforts are required.

In a more general example, the familiarity of the engineer with a systems approach to a problem offers many important opportunities to contribute to the improved efficiency of the instruction process. Too often, the study of educational technology has been committed to fixed hardware configurations with little opportunity to modify the hardware to take advantage of the study findings. One of the most impressive aspects of the PLATO project in CAI at the University of Illinois has been the continued interaction of software experience on the development of new hardware configurations and components. This has been possible because of the strong technical background of the project team and the location of the project in intimate contact with the technological facilities of the university. Efforts that permit effective interaction of the hardware and software development are essential and represent a particularly fruitful activity for the engineering educator.

Appendix B to this report covers the types of pertinent activities that are being undertaken in some of the colleges and universities of the U.S. It is not intended to represent a total compilation of all efforts by any means, but to include most of the major types of activity in the computer-aided instruction and instructional television fields. It also indicates some of the more active centers where these developments are being undertaken. It is hoped that this information might encourage more engineering educators to bring their skills to bear upon the solution of some of the educational problems by the introduction and appropriate use of educational technology.

APPENDIX A

FUNDING PROSPECTS

Funding by the Federal Government

The preparation of an accurate and comprehensive summary of federal fiscal support for institutions of higher education is beyond the scope of this study. Many different agencies are providing funds for a broad spectrum of activities. However, major sources of funding can be reasonably well identified and probably can be used to give a reliable picture of level and trends. Based on Office of Education figures, about 24 per cent[1] of the expenditures of all institutions of higher education during the 1967-68 school year were derived from federal sources. This has grown from about 12 per cent in 1955 at the rate of almost 1 per cent (of total) per year. The major growth during this period has been as a result of the institution of extensive research and development (R&D) programs. Estimates for FY 1969 and FY 1970 project little further growth in R&D expenditures in the universities. However, other support programs, principally in the areas of student grants and loans are budgeted for increases so that the total support package is expected to be about $4.7 billion in 1969 and about $5.0 billion in 1970. Although this represents an important increase in total dollars, it actually represents a leveling off of the percentage of federal support to higher education at about the 24 per cent level for these two years. There are strong pressures to provide substantially greater funding in the future. A major thrust in this direction is a bill (HR 35, the National Institutional Grants Program) introduced to the 91st Congress on January 3, 1969, which provides for $400 million in fiscal year 1970 and could contribute as much as $1 billion a year or more in succeeding years to be used for direct institutional support. Although early passage of this bill seems doubtful, it does seem likely that, in spite of the leveling off of R&D support, the over-all federal support for higher education will continue to increase. On the other hand, the increase may only maintain the fraction of federal support at its present 24 per cent, even though many educators are hoping for a major increase in the fraction as an aid to their growing financial problems.

The determination of what part of these federal funds are earmarked for the support of educational technology in higher education is an even more difficult task than estimating total sums. It has not been possible to find any organization which is collecting and maintaining statistics on the totals allocated for all of educational technology let alone the fraction devoted to higher education. However, rough estimates of the educational technology costs dealing with instructional television (ITV) and computer-aided instruction (CAI) have been made, based on the best, although fragmentary, available information. Since these two activities represent an important fraction of the total costs of educational technology, such estimates may serve as indicators of over-all support level trends.

The principal federal funding support for ITV has come from cost-shared funds covered by Title VI of the Higher Education Act of 1965. Section 601(c) of that Act covering ITV, was amended in 1968 and now authorizes up to $10 million each year for FY 1970 and FY 1971. However, the same was true in fiscal year 1969 and only $1.5 million was appropriated. With budget cuts the trend, estimates range from zero to $1.5 million as the likely appropriation for FY 1970. Section 601(a) of the Act, which provides for equipment acquisition, can be used for some associated ITV needs and is authorized at $60 million for FY 1970 and FY 1971. Of the same $60 million authorization in FY 1969, only $14.5 million was released to the Executive Branch for spending. President Johnson's FY 1970 Budget Proposal has recommended zero appropriation for all Title VI funds, and the recommendation has not been changed by the Nixon Administration.[2]

Another source of some associated funding has been Title II of the same Higher Education Act of 1965 which is concerned mostly with funds for libraries. It was amended in 1968 to provide authorization for $75 million in FY 1970 and $90 million in FY 1971. Again, however, authorization for FY 1969 was $50 million and only $24.5 million was actually appropriated. It is unlikely that the experience in FY 1970 will be very different. A very small fraction of Title II funds has been actually used for audio-visual aids to supplement the ITV/CAI effort, but it does represent a potential source of funds.

Two identical bills, S. 1189 in the Senate and H.R. 8838 entitled "Educational Technology Act of 1969" were introduced into the 91st Congress on February 28 and March 12, respectively. Title II of this bill is concerned with the use of educational technology in higher education and Section 202(a) provides authorization for $100 million a year "to improve the quality of higher education through the effective utilization of educational technology." The bills have been referred to Committee but will probably not receive hearings until after the Commission on Instructional Technology has filed its report later this year (1969).[3]

Some funds for ITV are available from the NSF and several other government agencies, but the sums are modest and usually buried in broader specific project activities. Unless the report of the Commission on Instructional

[1] *Projections of Educational Statistics to 1976-77*, Government Printing Office, Washington, D.C. (1968), p. 65.

[2] Status as of time of writing (16 July 1969).

[3] Title III of the Public Broadcasting Act of 1967 authorized a broad study of Instructional Technology to be carried out by a special Commission headed by Dr. S. McMurrin. The Commission report is due to be released 30 Aug 1969.

Technology modifies the present mood of Congress and the Department of Health, Education and Welfare, funds in support of ITV from federal sources will be, at the most, of the order of $2 million a year for FY 1970 and probably the same amount for FY 1971.

Computers are a more attractive cause for funding support and will undoubtedly continue to gain increased funding in the near future. About 5 per cent of all federal funds available to institutions of higher education are used for computer activities. According to the report of the Southern Regional Education Board (SREB)[4] total federal funding support for computers will amount to about $109 million in FY 1969 of which $62 million is expected to be spent for application work; the remainder is for machine acquisition. This level of support for applications of computers is more than twice the comparable expenditures in FY 1965. The portion of the total support which is devoted to CAI is not indicated; but, since it does not appear as a separate cost category in the SREB report, it is probably at or below the $5 million per year level.

The NSF has a specific program of support for Computing Activities in Education and Research which is budgeted at a level of $22 million for FY 1970 and there seems to be a good chance that something close to this amount will be appropriated. Less than $3 million of these funds are earmarked for CAI applications; however, this represents an important portion of the total federal funds devoted to CAI programs. Another important source of federal CAI funding has been the activities in the service Academies. Some CAI activities have been possible as the peripheral result of the Advanced Research Programs Agency support of university computer activities. The Office of Education supports a number of CAI projects and in the future will increasingly represent an important source of CAI funding support for the universities. Several other federal agencies have some college level CAI activity but at a low level.

Adding up all such known CAI efforts tends to substantiate the $5 million a year previously estimated as the right order of magnitude. This amount will probably increase in FY 1970 and FY 1971 but at a moderate rate.

Therefore, the total ITV/CAI support likely to be available from federal funds during FY 1970 and FY 1971 is on the order of only $7 or $8 million per year.

Funding by the State Government

The state governments provided about 23 per cent of the funds spent by all institutions of higher education in the 1967-1968 school year. Almost all of these funds went to public institutions, although they represented only 38 per cent of the total support for these public universities and colleges. State support has increased by a factor of three in the decade from 1957 to 1967 but has dropped from 26.7 per cent of the total support in 1957 to 23 per cent in 1967. During that decade the percentage of federal funds available to the public institutions has increased at almost exactly the same rate that the percentage of state funds has decreased. This could indicate that future increases in federal support might be somewhat counterbalanced by a further decreased fraction of state support. In 1967-68, these state funds amounted to $4.2 billion and represented an important fraction of the total state tax receipts. These sums will probably be about $4.5 billion in 1968-69 and $4.8 billion in 1969-70.

In keeping with past patterns, the principal source of fiscal support for higher education ITV will be from state funds, usually as a part of the over-all backing of the state university system. No estimate of the total can be made since there are no reliable data on this point. The total will increase as additional states establish ITV networks and existing networks are extended and modernized. However, because of the growing difficulties in expanding taxation sources for the state governments and the attitude of some electorates as the result of student demonstrations, any increase of state funding for ITV during the next two years will probably be quite moderate.

The pattern for over-all computer support from state funds is a different story. Total computer expenditures in FY 1969 are estimated to be $142 million of non-federal funds. About one-third of these funds or about $47 million are supplied by the states. This represents almost three times the comparable FY 1965 funds or a 32 per cent per year increase. With the over-all higher education expenditures increasing at the rate of about 8 per cent, it is not likely that the 32 per cent per year increase in computer funding from the state resources will continue. However, the increase in funding will undoubtedly be greater than 8 per cent because of the important and broad areas of application served by the computer.

Coming to CAI activities specifically, again no accurate fiscal data are available, but a rough estimate would indicate that about 3 per cent of the total state contribution to computer expenditures will be devoted to CAI projects. This would amount to $1.3 million for FY 1969 and $1.5 and $1.7 million for FY 1970 and FY 1971, respectively.

Funding from Endowments and Other Institutional Sources

Institutional funds provide 68.5 per cent of private university funding and 38.5 per cent of public university funds. In 1968, institutional funds provided 50.8 per cent of all funds for all institutions, down from 56.6 per cent in 1957. This percentage will probably continue to decrease in future years. However, the $9.3 billion that this funding represented in 1968 is the major resource of many of the schools.

The fraction of this funding which is used for ITV/CAI is not known. The ITV support in the private schools is at a lower level than in the state-supported, public institutions.

An estimate of the level of over-all computer support available from institutional funds can be derived from the

[4] J. W. Hamblen, *Computers in Higher Education*, Southern Regional Education Board, Atlanta, Georgia, 1967.

SREB report. In FY 1969 it represented about two-thirds of the $142 million non-federal funds or about $94 million. Again, the fraction of this computer effort devoted to CAI is quite small. If we assume it is the same percentage as for the state funds, namely, 3 per cent, the CAI effort would account for only about $3 million a year.

Funding by the Local Government

It is unlikely that any appreciable amount of tax revenues will be available for the support of CAI/ITV activities in institutions of higher learning. Some local tax support will go to city colleges in large metropolitan areas and to some of the community colleges, but this source of funds will not significantly affect any totals or trends.

Funding by Private Foundations

One or more grants have been made to promote ITV programs for the pre-school child and for the disadvantaged child. Insofar as these programs are supervised by personnel from institutions of higher learning, these foundation funds will be helpful in supporting efforts in ITV at the university level. Otherwise, ITV/CAI support by foundations at the college level is at a low level.

Funding by Industry

With the future prospects for substantial increases in funding support rather poor from the sources which have customarily provided assistance, proponents of ITV have been trying to encourage industrial organizations to increase substantially their rather moderate contributions. Since industry is most enthusiastic about funding activities with well-defined returns to the sponsoring organization, progress has been slow. However, one of the most promising plans which recognized the need to provide value in return for support is the Stanford Program for continuing education at the graduate level. Similar in concept to a program (GENESYS) which has been under way in Florida for several years and one (TAGER) in the Dallas area which is also several years old, this plan provides graduate instruction in the sponsor's plant or in a nearby facility, eliminating lost time due to travel and making a broad spectrum of graduate engineering courses available to any of the participating firms. By effectively converting employee travel time costs to university income, this type of support plan can be attractive to all parties and can represent a sound basis for growth. Some variant of the plan is under consideration in at least a dozen schools and could represent the largest single increment of growth support in the next few years.

The principal industrial support for computer programs in institutions of higher education has come in the form of educational allowances, grants and gifts from the computer companies themselves. This has amounted to about $40 million per year for the past four years and there are no expectations that this will change markedly in the next few years. At best, about 10 per cent ($4 million) of these contributions may have been used to encourage efforts in CAI. Such efforts will probably continue although the nature of the particular efforts supported may change as the appropriate role of the computer in the educational process becomes better defined.

APPENDIX B

DATA BASE FOR INSTRUCTIONAL TELEVISION AND COMPUTER AIDED INSTRUCTION

INSTRUCTIONAL TELEVISION

BACKGROUND INFORMATION

Definitions

Instructional television has been identified as follows by C. R. Carpenter and L. P. Greenhill:

> Instructional television is understood to refer to educational efforts using television which have as their purposes the production, origination, and distribution of instructional content for people to learn; efforts in which television is used as the principal or as an auxiliary medium of communication. This conception includes closed-circuit television, limited range broadcasts, and even extended broadcast activities which handle information specifically organized and produced for learning . . . The scope of *instructional* television is more specific than that of *educational* television and very different from commercial television. In brief, instructional television is closely related to the work of organized formal educational institutions.[1]

Since the paper was written, moderately priced video tape recorders have become generally available, having the unique characteristic of allowing the user complete freedom in the choice of program viewing time. Inflexibility of scheduling was an important deterrent to the widespread use of extended instructional broadcast activities. The extensive use of video recorders by the TV broadcasters themselves testifies to their effectiveness in meeting a real need. These recorders have also provided the teacher with a tool which can record pupil or class activities and then permit immediate playback for observation and comment or correction. Finally, the incorporation of a television type cathode-ray tube as the major display unit in a computer classroom console to present stored video signals or video tapes, increases the number of the areas where instruction by television display can and will be used.

Historical Data

FROM 1948-1963

As is often the case, the enormous training job that the military services must effectively undertake coupled with significant amounts of available research and development funding, resulted in the military services spearheading the adaptations and uses of ITV.[2] In 1948, the Navy's Special Devices Center began its investigations and these were soon followed by Army and Air Force demonstrations and field tests.

In 1952, when the Federal Communications Commission was making its final decisions concerning the allocation of broadcast TV channels, a few strong educational proponents were able to secure a significant number of channel allocations for educational purposes. Since the allocations were made with reservations, an immediate effort was required to demonstrate that these channels would actually be used.[3] Mr. C. S. Fletcher, President of the Fund for Adult Education (FAE), after some considerable effort, obtained a grant of $5 million from the Ford Foundation to finance the initial programming assistance required to enable a small group of noncommercial stations to start operations. Later, with additional major support from the FAE this effort evolved into the National Education Television (NET), a nonprofit, program-generating organization and an associated network of about 120 noncommercial TV broadcasting stations. As the NET developed, however, the programming emphasis tended toward what has now come to be known as Public Television,[4] which, although noncommercial in support, is more closely related to and largely competitive with commercial television for its viewing audience. Therefore, a need still existed for the development of TV systems more closely related to the aims and methods of formal education.

Professor Carpenter summarizes how this need was approached:

> The Fund for the Advancement of Education launched in the mid decade of the 1950's a nationwide effort to introduce, demonstrate and field test a wide range of patterns of instructional television applied in formal education. Such efforts required evaluations and emphases established by the early work at Penn State and Miami

[1]C. R. Carpenter and L. P. Greenhill, "Facilities for Instructional Television," *Educational Television: The Next Ten Years.* (Stanford University, Palo Alto, California 1962), p. 286.

[2]C. R. Carpenter, "Research on Instructional Television," presented at Conference on The Economics of Educational Television, Brandeis University, Waltham, Mass., May, 1963. (The Pennsylvania State University, University Park, Pa.).

[3]R. A. Carlson, "Establishing ETV as a Viable Institution: The Early Leadership of C. Scott Fletcher," *Educational Broadcasting Review*, vol. II, no. 3 (June 1968), pp. 45-52.

[4]The Carnegie Commission on Educational Television, *Public Television: A Program for Action*, Introductory Note. (New York, Bantam Books, 1967).

> University, Ohio; considerable research has been done on variables and conditions affecting the results of applications of instructional television. Mainly, the areas studied were those of effectiveness, appropriateness, acceptability and feasibility. In line with the objective to introduce instructional television into American education, "models" of different kinds of operations were established and given high public and professional visibility. Examples of these "models" were those at Penn State, Hagerstown or the Washington County public school system, the Dade County school system and the Chicago Junior College. There were many other locations where instructional television projects were sponsored. Extended broadcasts were put into use for schools in North Carolina, Alabama, and Oregon. Many educational television stations cooperated like those in Philadelphia, Pittsburgh, Houston and San Francisco. Both closed-circuit systems using cables and micro-wave links as well as broadcasts were used. Recently the schools of South Carolina have been interconnected with a statewide cable system. Evaluations and assessments were made of most of the early projects as confidence was strengthened in the general soundness of the applications of instructional television in formal education. Field tests were made in many different situations and at all levels of education from the primary schools through the mid-college years. A validation criterion which was used apparently by the Fund for the Advancement of Education in judging the success of a project, whether or not it survived, was accepted and became a regular means of conducting educational and instructional programs. Clearly this was a severe and critical test. Many of the projects have survived and been expanded, some have continued on a limited scale, and others have been radically modified or even discontinued.[5]

Following events further, Carpenter continues:

> Historically the National Defense Educational Act of 1958, and particularly Title VII, Section A of that Act, was the next most important development in promoting research on the "new" media including instructional television. Grants have been made of federal funds to support many research projects on instructional television. Generally these subjects have had more emphasis on experimental designs and controls of variables and conditions which affect human learning than for projects conducted earlier. Nevertheless, two observations are in order: First, the purposes of the Act and its implementation have emphasized research for solving relatively practical problems and for improving teaching and formal learning. Second, extended and more analytical research has added to the results of former studies but it has not radically changed the results and interpretations of previous research.[6]

AFTER 1963

Since 1963, when Carpenter's paper was written, there have been several further developments.

Instructional Television Fixed Service

Demands for educational broadcast TV channel allocations exceeded the supply in the early 1960's and many potential TV users were discouraged by the high costs of professional broadcast television equipment. As an attempt to provide relief for both problem areas, in July 1963, the Federal Communications Commission opened 31 TV channels in the 2500 to 2690 megahertz frequency range for use by educational institutions and organizations. Designated the Instructional Television Fixed Service (ITFS), it uses low power (10 watt) transmitters, provides the possibility of four simultaneous broadcasts from the same transmitter and has equipment costs that are a tenth or less than the cost of a commercial UHF or VHF broadcast system. This 2500 MHz service is now coming into use in a number of local areas.

GENESYS Systems

In 1963 the Florida State Legislative Act provided for establishment of a program of graduate engineering education taught via television. The University of Florida at Gainesville was selected to implement this program and provision was made to allow government agencies and industry to set up their own receiving rooms so that students would not have to travel to the nearest center during the working day. The resulting closed-circuit TV network using leased lines is known as the Graduate ENgineering Educations SYStem (GENESYS) and is successfully operating and growing. It provides a successful attack on the continuing education problem and it establishes stronger ties with industry. An excellent description of the system and its mode of operation is contained in a paper presented at the National IEEE Meeting in March 1968.[7] This system has established a basic pattern that has been followed with variations at Southern Methodist University (TAGER) and that will be followed by systems in the final planning stages at Stanford University[8] and the

---

5Carpenter, "Research on Instructional Television."

6*Ibid.*

7M. E. Forsman, "Graduate Engineering Education Via Television," 1968 IEEE International Convention DIGEST, The Institute of Electrical and Electronics Engineers, Inc., (New York 1968), p. 19.

8*Proposal for an Instructional Television Network* (unpub.), School of Engineering, Stanford University, (Palo Alto, California, April 1968).

University of California at Irvine and at Los Angeles. Other universities are studying the system carefully and no doubt several more will establish similar systems.

Higher Education Act of 1965

The growing importance of federal funding was further emphasized when Congress passed the Higher Education Act of 1965. Title VI, in particular, has provided about $1.5 million a year of matching funds for closed-circuit ITV. Additional funds were made available under Title II for certain types of related materials and equipment. In an attempt to strengthen the theoretical base of the technology in the past three years the U.S. Office of Education has set up twenty Regional Educational Laboratories, nine Research and Development Centers and twelve Educational Research Information Center (ERIC) clearinghouses. The latter two organizations are almost all university based although their fields of interest include all levels of education.

State Programs

The state efforts to encourage the establishment and growth of ITV in local and state school systems have also continued. One of the most complete and recent investigations of ITV was undertaken by an advisory committee appointed especially for this purpose at the request of the Minnesota State Legislature. The report of this committee was issued in January, 1967.[9] In its broad array of information, it contains extensive data on past and present ITV activities in other states, pointing out for instance, that all but five states now have an educational TV authority designated by the governor or legislature of the state.[10] Some experiments were also conducted in interinstitutional use of ITV at the college and university level in a variety of configurations. Problems of communication between participants and general long term faculty apathy were experienced. These problems have also been experienced by previous interinstitutional efforts such as the Texas Educational Microwave Project (TEMP) at the University of Texas, the program of the Oregon State System for Higher Education, and the demonstration study of the Council of Higher Education Institutions (CHEI) in the New York City area.

In addition to the statewide investigations with their broad interest in all levels of education, state university systems have also continued to produce studies to bring the faculty and administration up-to-date on advances in ITV and serve as planning documents for future activities. An excellent example is the recent report prepared at the University of California.[11]

[9] *Report of the Minnesota Inter-Institutional Television Feasibility Study*, University of Minnesota, Minneapolis, Minnesota, (January 1967).

[10] *Ibid.*, p. iv-28

[11] *Television as an Aid to Instruction at the University of California Campuses*, (unpub.), Office of the Vice President, Business and Finance, Business Services Division (January, 1967).

Public Television

Two conferences, both held in the summer of 1966, will bring the story up-to-date and will probably play an important part in shaping the future of ITV.

The first of these was the high point in the work of the Carnegie Commission on Educational Television and resulted in the report entitled *Public Television: A Program for Action.* The Commission was chaired by Dr. J. R. Killian, Jr. and included many nationally known educators and proponents of the best in TV. A consequence of the report was the passage by Congress of the Public Broadcasting Act of 1967. The Report's only comment on ITV consisted of the recommendation that its future role could not be easily assessed and that it should receive further study. This study was authorized under Title III of the Public Broadcasting Act, and Dr. S. McMurrin was appointed by the Secretary of Health, Education and Welfare early in 1968 to chair a Commission on Instructional Technology which would address itself to the problem. As the title of the Commission suggests, it has a very broad scope; however, ITV will be a prominent concern.

EDUCOM

The second conference of interest was the "Summer Study of 1966," sponsored by the Task Force on Information Networks of the Interuniversity Communications Council (EDUCOM). As the use of computers and closed-circuit television systems have proliferated at the universities, the desirability of wide band communications links within a campus and between campuses has become more apparent. The EDUCOM Study,[12] headed by Professor G. W. Brown, was directed to the problems and promise of such a communications network (EDUNET). As the result of the contribution of a number of noted and imaginative participants, the study contains a wealth of data including many possible uses of such a network. In discussing applications, ITV is mentioned at some length several times.[13] Since EDUCOM is an on-going and active organization with good foundation support, implementation of many of the concepts developed at the conference may materialize and the future of ITV at the university level will be influenced accordingly.

Modes of Application

INTRA-INSTITUTIONAL USE

As pointed out by Greenhill:

> At the college level the presentation of televised instruction has been principally over closed-circuit

[12] G. W. Brown, J. G. Miller, T. A. Keenan, *EDUNET: Report of the Summer Study on Information Networks Conducted by the Interuniversity Communications Council (EDUCOM)*, Wiley Information Science Series, (New York, John Wiley & Sons, Inc., 1967).

[13] *Ibid.*, pp. 57, 89, 155, 362.

systems by means of which receivers in a number of small classrooms on a campus can be linked by coaxial cable to an originating center or centers from which the instruction is presented.[14]

It was indicated earlier that the advent of the video tape recorder has introduced a new type of system, and made possible program storage and use at any time, either at the transmitter or receiver end. The broadcast or cable link can even be eliminated, and the taped programs can be physically delivered from originator to user by mail, express or messenger. The flexibility made possible by the video tape recorder is bringing an ever increasing number of students in contact with the television screen as a learning resource.

The specific ways in which ITV is used on campus can be classified into the following five categories:

The Presentation of Regular Classroom Instruction

Probably the most extensive use of ITV is for presentations of regular classroom instruction. it provides a means for coping with mounting enrollments of students without a proportionate increase in numbers of faculty. It also allows all students to have the experience of viewing presentations by the best professors in the subject area. The TV presentation can be in a classroom or at the library or even at a student's dormitory. In addition to live broadcasts, the TV monitors can be used to present new types of tests incorporating lifelike problem situations for students to solve.

Supplementing the Teacher's Presentation

Many effective methods have been developed for using TV to improve lecture demonstrations. The student can readily see small items, magnified by a microscope if desired, and watch as these items are examined or manipulated. This also minimizes the need for duplication of demonstration equipment and set-up times. If films or video tapes are to be shown, the TV monitor can provide an instant theater and eliminate the necessity of setting up a movie projector and screen and darkening the room. In the case of laboratory demonstrations, uniform instructions can be given and duplication of expensive equipment can be avoided. A particularly effective use is the demonstration and experimentation possible with large and often inaccessible equipment. The TV camera can be used to show what the device is and does and then follow an experiment as it is carried out by an instructor and his aides, showing the student all the instrument readings necessary for the student to calculate experimental results.

Televising and Recording of Student Performance

Recording student activities and then playing them back for the student to view, can be used in a number of educational areas. It is effective for practice teachers, for speech students, for drama students and for learning any sport, gymnastic routine or dance. Comparison recordings can be used to show the performance of an expert, thereby assisting the student to evaluate his own efforts. This is a powerful use of TV, and experience with it can be directly transferable to use outside the school environment after graduation. Obviously, the inexpensive video recorder is the key element in this system and is the reason such applications are a relatively recent development.

Student Training in Television Techniques or Teaching Via Television

The need for ITV directors with formal TV training but also with a good understanding of the educator's problems and goals is pressing. A lack of people with these qualifications can limit the acceptance and growth of ITV. Training in an ITV environment is ideal for the student to gain the proper background and attitudes.

Research

Imaginative uses of TV as a research tool can provide extensive information on how people learn. By designing special programs, psychologists can learn a great deal about our visual responses and how they can be conditioned. Situation-type programs can provide the setting for studies of social awareness, attitude formation, and the development of interpersonal relationships. Furthermore, situation-type programs are an excellent medium for lifelike performance testing, and add new dimensions to the assessment of various types of learner behavior. This can be a particularly interesting and challenging use of TV.

INTERINSTITUTIONAL USE

So far, the interinstitutional use of ITV at the college level has been slight. In cases where it has been used, the users are rather closely associated with the originating school either as part of the same state system or because of close geographical ties. The establishment in 1962 of the Great Plains Instructional Library at the University of Nebraska as a distribution center for pre-recorded ITV video tapes has resulted in increased interinstitutional use of taped program material at the primary and secondary levels but both technical and psychological barriers must still be overcome before this use is widespread in the colleges and universities. However, it would seem that interinstitutional TV has considerable potential for making possible the sharing of instructional resources among colleges and universities. Probably its most immediate application will be to make such resources available to developing colleges whose resources are limited.

UNIVERSITY-INDUSTRY USE

The application of ITV to continuing education at the graduate level by efforts such as the GENESYS Program has been mentioned. It must be noted, however, that the

[14] L. P. Greenhill, "Closed Circuit Television for Teaching in Colleges and Universities," (The Pennsylvania State University, University Park, Pa. rev., January 1966).

successful programs and the new programs being planned are located in areas that contain concentrations of major defense industries employing personnel of the highest technical abilities and engaging in developments that have reached or exceeded the present state-of-the-art in their fields. Whether this environmental consideration is essential for a successful program remains to be explored. In any case, the efforts being expended to evolve an ITV system which is of interest to adjacent industrial establishments is an important step in furthering the growth of fruitful university-industry relationships.

PRESENT STATUS

Extent of Use

There are some 600 closed-circuit television systems in American educational institutions[15] and, almost without exception, such systems are devoted to some degree of instruction. Of the 136 educational TV stations now on the air, 130 are carrying programs designed for instructional use in the schools.[16]

The coaxial cable is still the predominant type of transmission used in the closed-circuit systems. However, the microwave point-to-point broadcast systems are coming into wider use, particularly as a result of the availability of the 2500 MHz Systems in the Instructional Television Fixed Service. By late 1967, 36 institutions were already using the service, and at least 15 more had documented plans for future use.

During the 1966-67 school year, there were 227 universities, 836 colleges, 42 seminaries, 49 institutes and 46 TV stations reporting 48 different ETV subject listings and enrollments of 461,431. Enrollments were 430,859 in 1965-66, and 317,951 in 1964-65.[17]

Research Results

A great number of studies have been made regarding the effectiveness, acceptability, appropriateness and feasibility of ITV at the university level. Most of the important work on ITV has been done at Pennsylvania State University, Miami University, Case-Western Reserve University, New York University, Purdue University, Rensselaer Polytechnic Institute, Chicago City Junior College, San Francisco State College and the Oregon State System of Higher Education. A consensus opinion of the most important results of these studies follows.

EFFECTIVENESS

Perhaps the most careful, comprehensive, and recent summary study on this important question was done by D. W. Stickell at The Pennsylvania State University.[18] In a review of over 250 research studies on the subject, he found that all of the studies based on well-conceived and implemented experiments, showed no significant difference in learning between the two methods. In reviewing less reliable studies, he also found strong agreement with this conclusion. There seems to be general acceptance of this conclusion at this time.

ATTITUDES

A principal problem in gaining acceptance of ITV on the campus has been faculty attitudes. Some of them are very negative; a majority do not express strong feelings one way or the other but do not use ITV; and only a small group are willing to actually use ITV. The faculty having ITV experience is more likely to favor its additional use and the trend is toward acceptance by an increasingly larger fraction. This reaction is characteristic of faculty attitudes toward the introduction of any new instructional methods. Time will be required to achieve general faculty approval.

Student acceptance has been generally more favorable, particularly when the reasons for introducing ITV were carefully explained. However, college students have a strong tendency to concentrate on what is required to achieve the desired grade in a course and, more or less independent of the method of instruction, learn the methods or facts or both that are necessary to this end. Therefore, while they may have personal preferences, as long as the grade achievement path is reasonably clear and the instructional method is of material significance to the end result, at least passive acceptance of the majority of the students can be expected. As stated by McKeachie:

> Attitudes of students toward the media are probably not a direct measure of their educational values. Studies of student attitudes toward teachers (by Elliott, 1949), toward films (Twyford, 1951), and television (Macomber and Siegel, 1957), indicate only small relationships between "liking" and learning outcomes.[19]

APPROPRIATENESS FOR VARIOUS COURSES

As might be expected, the most successful uses of TV are those which have been adapted to make best use of the strengths of the medium. As far as suitability for use with

[15] L. E. McKune (ed.), *Compendium of Televised Education,* Michigan State University, Continuing Education Service, (University of the Air, East Lansing, Michigan, September 1967), vol. 14.

[16] Richard H. Bell, "The Status of Instructional Television-1967," An Introduction to the EIB-NAEB Conference on ITV, Written After the Fact, *New* Relationships in ITV, (Educational Media Council, Inc., Washington, D. C. 1967).

[17] McKune, *Compendium of Televised Education.*

[18] D. W. Stickell, "A Critical Review of the Methodology and Results of Research Comparing Television and Face-to-Face Instruction" (Doctor of Education Thesis, The Pennsylvania State University, The Graduate School, University Park, Pennsylvania, 1963).

[19] W. J. McKeachie, "Higher Education," *The New Media and Education*, ed., Rossi and Biddle, (Aldine, 1966), *p. 282.*
D. N. Elliott, "Characteristics and Relationships of Various Criteria of Teaching." (Unpublished *Thesis*, Purdue University, 1949).
L. Twyford, "Film Profiles," Technical Report (SDC 269-7-23) Instructional Film Research Program, The Pennsylvania State University (Port Washington, L.I., N.Y., Special Devices Center, November 1951).
F. B. Macomber, and L. Siegel, *A Study of Large Group Teaching Procedures* (Educational Research, 1957), vol. 38, pp. 220-229.

various areas of subject matter, the situation is probably best summarized by Chu and Schramm in their most recent study:

> While the previous comparisons made by Schramm indicated that instructional television had, on the average, somewhat less success with humanities than, for instance, with natural science, the more recent comparisons we have made suggest just the opposite. The over-all impression one gets from the two summaries of comparisons seems to be: So far as we can tell from available research evidence, there is no general area where television cannot be used efficiently to teach the students.[20]

On the other hand, the attempt to develop a standard method of instruction for all courses is giving way to the realization that it is best to provide students a variety of learning situations during their university careers. These learning situations should include live lecturers in large groups, lecture groups in medium sized groups and televised instruction in small rooms but with large numbers of students per course. They should also include laboratory experiences, small study discussion groups using student leaders, a few small seminars with outstanding professors and, finally, independent study. Some ITV courses may use only TV presentations. In other cases, the TV presentations will be complemented with tutorial discussions or laboratory activities. Exposing students to this variety of learning situations, including ITV, gives them the best possibility of developing a variety of learning skills to transfer to the outside world where knowledge is acquired under all of the above conditions.

ECONOMIC FEASIBILITY

Unfortunately, there have been few studies in any depth on the economics of ITV at the university level. The two most often quoted date from 1958. The report of C. R. Carpenter and L. P. Greenhill is the most comprehensive and the results are generally favorable to the use of ITV. The critical determination is the number of students which must enroll in a course such that the cost-per-credit is the same for both conventional and televised instruction. The report states:

> Thus it may be concluded that unless there are qualitative gains in instruction or other advantages, the use of closed-circuit television for teaching in a context similar to that of Penn State will be found to be (economically) feasible for courses of more than 200 students.[21]

A second study by E. I. Seibert states:

> It can also be seen that instructional cost advantage might be gained through televised instruction in those courses which have large student enrollments and which could provide from 150 to 270 students or more for simultaneous instruction.[22]

The lack of recent comprehensive economic data is unfortunate at a time when closed-circuit systems of all types are proliferating, the video tape recorder is being introduced, costs of materials and labor are rising, and TV is being used in a variety of courses. This leads to skepticism with regard to the economic attractiveness of present day TV systems. However, from the data available, it seems to be evident that ITV can be economically feasible for classroom use if the size of the student group and the nature of the course content is chosen appropriately.

The use of ITV for continuing education at the graduate level as envisioned in the Stanford system and in the University of California at Los Angeles and Irvine, depends upon industrial support in the form of payment for services. It can be self-supporting if the expected level of industrial participation is realized.

SUMMARY

The use of television for instruction has been widely studied. It can be used to produce learning results comparable with conventional instruction. The cost has been a barrier but can be directly justified when the TV lecture is used with a large enough audience and indirectly justified when used as a supplementary aid by the increased quality of instruction. Properly used, it can be effective in most subject areas; the student reaction has been neutral or slightly negative but not correlated with the learning performance; faculty reaction has been generally negative because of the limitations of the earlier systems in terms of time, flexibility and local production. Faculty with ITV experience are usually more positive in attitude, and in willingness to look for applications.

COMPUTER AIDED INSTRUCTION

BACKGROUND INFORMATION

Definitions

The use of computers at universities has grown very rapidly in recent years and more growth is certain. The two major roles in which they find application are in administrative and accounting use and in the academic function. In the academic program, they can be used either as a subject or tool of research or as a subject or tool of instruction.

[20]G. C. Chu and W. Schramm, *Learning from Television: What the Research Says,* National Association of Educational Broadcasters, (Washington, D. C. 1967).

[21]C. R. Carpenter and L. P. Greenhill, "An Investigation of Closed-Circuit Television for Teaching University Courses," *Instructional Television Research, Project 2.* (The Pennsylvania State University, University Park, Pa., 1958).

[22]E. I. Seibert, "Cost Estimates and Comparisons for Televised and Conventional Instruction," TVPR Report Number 7 (Purdue University, Lafayette, Indiana 1958), p. 6.

Its role as a tool of instruction is the area of interest in this report. As stated by E. N. Adams:

> A fourth role of the computer is as an active element in the instructional process. This role we will refer to as Computer Assistance to Instruction, or CAI.[23]

The use of the computer as an active partner in the teaching-learning process is variously referred to in the literature as computer-aided instruction (CAI), computer administered instruction (CAI), and computer administered learning (CAL).

In the narrowest usage, CAI refers to a branching program developed for a specific course or segment thereof, programmed on a computer so that a student may interact with it through some type of remote console. In the broadest sense, it embraces the totality of computer use for assigned work in a classroom, including instruction in a foreign language, the processing of survey data in a sociology course or the computation associated with the solution of problems in an engineering or physics course. For the purposes of this report, a broad interpretation will be used, although some applications may not be treated in the detail they deserve because of time limitations.

Historical Data

A discussion of machine teaching usually starts with the pioneer work of S. L. Pressey in 1926.[24] B. F. Skinner's refinement of the theory of programmed learning[25] during the latter 1950's also used a simple machine as a teaching aid. These simple devices triggered a rash of "teaching machine" developments. Most were ill-conceived by noneducators and priced far above the means of any significant number of potential users. Fascination with the hardware, particularly when it involved combinations of already well-developed devices such as tape recorders and slide and movie projectors, led to a variety of incompatible devices, each of which required unique and scarce software. Furthermore, the choice of the term *teaching machine* was unfortunate since it created alarm in the ranks of the teachers by generating visions of technological unemployment. Since the teachers ultimately had to accept and use these devices, this nomenclature was undoubtedly an important deterrent to their widespread adoption.

It also became increasingly apparent to the teachers who did try to use the hardware that programmed learning, regardless of format, required carefully prepared software. In fact, well-prepared programs administered in simple booklet format provided essentially the same educational results as did many of the complicated machines. The net result was a disillusionment on the part of both educators and industry as to the need for hardware development, and while a few devices from that era have survived, most of the hardware efforts were abortive. On the other hand, the many publishers who published programmed materials in book formats of various kinds have continued to develop a growing market.

As educators became more experienced in using programmed materials, they began to find that the method had certain limitations. Linear programs, in which the sequencing of data and responses is rigidly fixed in serial order, failed to provide for the wide individual differences among students. These limitations led to the development of methods of introducing branching into programs so that a slow student could receive much more help and a good student could skip this detail. Crowder in 1958, was able to devise a "scrambled book" format that allowed the use of branching programs and still retained the book format.[26] However, the program still had to be rigidly predetermined and latitude for student interaction with the material was not very intensive. Finally, programmed instruction was a boring experience for many students and unless they were strongly motivated, they would not progress through the program at anything like the speed they were capable of achieving.

In the late 1950's and early 1960's, a rapidly growing number of digital computers on college campuses became available for applications other than research on the computers themselves. A few people with computer backgrounds as well as an awareness of the potential power of programmed instruction began to visualize the opportunities that could be realized if the computer could be used to manage the administration of highly sophisticated programmed material. One of the important early efforts in this regard is the Programmed Logic for Automatic Teaching Operations (PLATO) program at the University of Illinois.[27]

Starting in 1961 with a single terminal and the ILLIAC I computer, a terminal concept and teaching logic was developed. In 1962-63 the system was expanded to two terminals using a time sharing mode with a CDC 1604 computer. The next year it was expanded to 20 terminals. Simultaneously, a research effort in both the hardware systems and educational strategies was undertaken. An early realization of the critical role that console costs would play in future systems led to the initiation in 1963 of a development program having as its goal a revolutionary new, low cost console display unit. Hardware resulting from this program is now almost ready for commercialization.

[23] E. N. Adams, "The Computer in Physics Instruction," *Proceedings*, Conference sponsored by the Commission on College Physics, 1965.

[24] S. L. Pressey, "A Simple Device for Teaching, Testing and Research in Learning," *Sch. Soc.*, 1926, pp. 23, 373, 376.

[25] B. F. Skinner, *The Technology of Teaching*, (New York, Appleton-Century-Crofts, 1968).

[26] N. A. Crowder, "Automatic Tutoring by Means of Intrinsic Programming," *Automatic Teaching: The State of the Art*, E. H. Galanter, ed. (New York, John Wiley & Sons, Inc., 1959).

[27] D. Bitzer *et al*, "The PLATO System: Current Research and Developments," *IEEE Transactions on Human Factors in Electronics*, vol. HFE-8, no. 2, June 1967.

Availability of this display system can be a key factor in the drive to bring CAI system costs down to the range necessary for widespread adoption. The PLATO system details, its special CATO programming language, and the research results achieved with it are documented in numerous papers by Bitzer and his associates.

Commercial development activities were started by International Business Machines Corporation in about 1959. G. S. Rath and N. Anderson used the IBM 650 to experiment with the use of the computer for teaching binary arithmetic. This was followed in 1960 by the development of courses in stenotype, psychological statistics and German by a group under W. R. Uttal for the IBM 360. IBM started with the philosophy of meeting the need by adapting existing state-of-the-art hardware. Programs were written in a specially developed programming language known as COURSEWRITER I for use with their 1400 series computers and covering such course materials as statistics, German and stenotyping. When the IBM 7000 series time-sharing computers were introduced, some of the course material was converted for use on these newer computers. However, for either of these computers, the input/output device was still basically a teletypewriter. Later the development approach shifted, and a special purpose CAI system was undertaken. This system, known as the IBM 1500, became commercially available in 1966.[28] It incorporates specially designed terminals with a keyboard, cathode-ray-tube and light pen and is programmed with a more advanced COURSEWRITER II language. Using a totally dedicated 1130 or 1800 computer it has a capacity of up to 32 terminals. A special random-access film strip projector, which was also developed for the system, permits the use of up to 1,000 projected images on a special rear-view screen. The projector can be placed right next to the cathode-ray-tube display. An audio tape playback unit with adapter is also available.

About a dozen IBM 1500 systems are now in use at various universities, programmed for a variety of subjects and for learning levels from the first grade through the university. The teaching logic was designed principally for use with non-math subject matter, such as languages. Although a great deal of primary-level arithmetic has been taught with a specially modified unit by P. Suppes and his associates at Stanford, it is not generally suited for doing complex computation.

About the same time that the work was starting at IBM, experiments were also begun at the laboratories of the Systems Development Corporation (SDC). As a part of the early research effort, a random-access slide projector and viewer were developed as the console of a teaching system known as the CLASS system. In this system, a student's response resulted in a computer reply consisting of a number in a simple display and the student selected the slide having this number for his next instruction. Although no widespread use of this system resulted, it provided valuable research experience and led to continuing research and development programs in computer applications in education and training for civilian and military users. More recently, SDC engineers have devised the programming language CONVERSE as a step in developing the question-answering technology essential for the ultimate flexibility in CAI.[29] In addition, a program has been under way with UCLA since 1966 on an experimental statistics course using all forms of CAI including programmed instruction, problem-solving and some question and answer dialog.

In the early 1960's the military services also became interested in the use of CAI. Each of the three services instituted research and development programs to find applications for this new instructional tool in the task of training military personnel. The military academies have also instituted programs to use CAI in their course work. The Naval Academy, in particular, has developed over the past four years an extensive program with six courses being taught on the IBM 1500 system, and an additional four courses being taught on terminals connected with a large time-sharing computer system. Last year they also initiated a large contract effort to develop course programs and systems applications.

Another important effort has been the Army sponsored programs implemented by contracts with George Washington University at its Human Resources Research Office (HumRRO). Their most recent effort (1966) is a research program known as Project IMPACT and consists of two main efforts: a basic research group is searching for fundamental concepts and principles on which to base and develop a model or models of instruction; an applied research group has concentrated their efforts on the development of a program for teaching computer programmers the COBOL programming language. This teaching program has been developed, tested and put on an IBM 360. In the near future it will be used to teach COBOL to large numbers of Army personnel using specially designated terminals. The program has been designed in such a way that in addition to the presentation of learning material, a number of parameters of student response will be measured for each person, thereby using the program to provide extensive empirical data on the way people learn. These data will also be used to improve the effectiveness of the program as a training tool. The program is expected to continue for a number of years and allows for the incorporation of improved hardware designs as well as updated software. This combination of basic and applied research approaches to the development of a better-based learning theory with adequate funding for a long term should make an important contribution to the future of CAI.

Another pioneer in the CAI field has been The Pennsylvania State University.[30] Since April 1964, a faculty group

[28] IBM 1500 Instructional System Introduction to Computer-Assisted Instruction and System Summary (Available only from IBM 1500 sales representative).

[29] H. F. Silberman, "Applications of Computers in Education," *Yale Scientific Magazine*, (November 1967), pp. 18-22.

[30] "The Development and Presentation of Four College Courses by Computer Teleprocessing," Final Report, Computer Assisted Instruction Laboratory, (The Pennsylvania State University, University Park, Pennsylvania, June 1967).

has been working on the development of courses for use on a computer. The early work was done with an IBM 1410 and a teletypewriter and more recently, an IBM 1500 system. College level courses have been prepared in modern math, management accounting, audiology and engineering economics, using the IBM COURSEWRITER language.

Florida State University has also developed a strong program in CAI. Efforts in 1964 by the University Institute of Human Learning led to the establishment of a Computer-Assisted Instruction Center which started operations in April 1965. The Center started with an IBM 1440 system, with an IBM 1050 teletypewriter input/output terminal. In 1967, it added an IBM 1500 system and now both systems are used selectively according to the need. Some of the courses which have been developed over this four-year span include courses in introductory college physics, applied statistics, computer languages, chemistry, and social work.[31]

The activities at several University of California campuses deserve mention. The Irvine branch was set up from the time the campus opened in 1965 to use CAI as an important teaching tool.[32] The early efforts were concerned with preparing suitable course material and getting it programmed on the computer. Unfortunately, progress was slowed due to a computer changeover in 1967 and the introduction of new terminals in 1968. However, six full courses have been developed and it is estimated that during the 1967-68 school year more than half of the 2,400 students were exposed to some CAI. Future plans are ambitious and with the strong administrative support, are likely to be successful.

The principal CAI activity at the Santa Barbara branch of the University of California has been the development of the Culler-Fried system of interactive programs.[33] Developed in 1965 largely at TRW Inc., it was originally devised to solve research type problems. However, it is now in use successfully for instructional purposes at the Santa Barbara campus, the Lawrence Radiation Laboratory, and at the University of Kansas. A specially developed console, consisting of a double keyboard and a Tektronix Type 564 storage oscilloscope with two Type 2A60 plug-in amplifiers, has been designated the Teleputer and is marketed commercially by Bolt Beranek and Newman Inc. Using this terminal connected with an IBM 360/65 time-sharing computer, the student has immediate command of the computer including a number of preprogrammed subroutines, receives the results of any calculation immediately, and by simple keyboard operations, can combine basic subroutines into new ones specialized to his needs. As a tool for analysis, this system is an excellent example of the power of interactive programming and undoubtedly will be used extensively.

The CAI work at the Computer Center of the University of California Medical Center in San Francisco is also having a growing impact, both inside and outside of the University of California system. Using programming languages such as COMPUTEST and PILOT which were developed to simplify considerably the writing of CAI course material, a number of applications have been made at the Medical Center including one for a simulated psychiatric interview.[34] Work on COMPUTEST began in 1962 using the IBM 1620 computer and its console typewriter. Major emphasis was placed on the development of program mechanisms that would allow students and teachers who lack knowledge of computer operation to develop conversational teaching and testing material. PILOT is a more recent development of these concepts which has been implemented on the IBM 360 computer and the SDS 940 computer. In each case the system controls operation of remote typewriters or teletypes. Among other users, has been R. M. White of the Department of Electrical Engineering and Computer Sciences at the Berkeley campus who has prepared several programs, including one on Fourier analysis using the PILOT language. As a side comment, it should be noted that in an experimental situation students at all levels of education beginning with the first grade have used these languages for preparation of segments of course materials and the results have suggested a teaching strategy where the student programming effort is the key element in the learning process. A number of other schools are actively using CAI in a variety of subject areas: University of Texas, Michigan State University, University of Michigan, University of Minnesota, State University of New York at Stony Brook, Harvard University, U. S. Military Academy, U. S. Air Force Academy, and the New York Institute of Technology.

To round out the historical treatment of particular interest at the higher education level, the work which has been under way at Bolt Beranek and Newman Inc. for the past five years must be mentioned. Based on the Socratic dialog and problem-solving approaches and the special programming language MENTOR, a number of courses in medicine, management and military games have been developed and are widely used. In addition to their extensive work on software, Bolt Beranek and Newman have also put a number of hardware items on the market, including the Teleputer previously mentioned.

Modes of Application

Irrespective of use, a time-shared console seems to be characteristic of all recent CAI systems. These consoles vary

[31]D. N. Hansen, W. Dick and H. T. Lippert, *Semiannual Progress Report, July 1967 to December 1967,* Computer Assisted Instruction Center, Institute of Human Learning (Florida State University, Tallahassee, Florida, January 1968).

[32]R. M. Saunders, "Computer Assisted Learning – A Progress Report," paper presented at the Annual Meeting of the Commission on Engineering Education, Washington, D. C. (February 1968).

[33]Glen J. Culler, *Users' Manual for an On-Line System* (University of California, Santa Barbara, California).

[34]J. A. Starkweather, *et al., "Psychiatric Interview Simulation by Computer,"* Methods of Information in Medicine, vol. VI, no. 1 (January 1967), pp. 15-23.

widely in sophistication. Much of the early work was done with only teletypewriter terminals. These are still used in many installations and for some types of programs are quite adequate. However, the typewriter is a slow output device, so the use of cathode-ray tube displays has increased and has been supplemented by provision for slide and/or movie projection, ITV displays and even audio facilities, all controlled by the computer.

INTRA-INSTITUTIONAL USE

Most applications of the computer have been within one institution. In some cases, there is more than one system involved but more often, the efforts are closely coupled with the computer center of the university. The principal ways in which CAI is being used are the following:

Drill and Practice

Utilizing its extensive memory, its endless (but costly) patience and its ability to adapt to student performance, this mode of computer use has been very effective. Instruction can be modified to meet the needs of each student both as to level of difficulty and rate of presentation. This potential to individualize instruction is a very strong argument for developing the use of CAI. To quote from P. Suppes:

> The computer makes the individualization of instruction easier because it can be programmed to follow each student's history of learning successes and failures and to use his past performances as a basis for selecting the new problems and concepts to which he should be exposed next. With modern information storage devices it is possible to store both a large body of curriculum material and the past history of many students working in the curriculum.[35]

Concerning individualized instruction, D. Brown points out:

> Emphasis has been placed on the special advantage that machine instruction offers the individual student . . . he can proceed at his own pace, he need not be embarrassed in the presence of his peers, an impersonal machine may be less inhibiting than a teacher who is disliked or feared, the student can freely explore alternatives.[36]

Brown also points out that, properly presented, the machine can play an important part in fostering group interactions by computer simulations, games, displays, and other calculations.

[35]P. Suppes, "The Uses of Computers in Education," *Scientific American*, vol. 215, no. 3, (September 1966), pp. 207-220.

[36]D. Brown, "The Machine: Vehicle of Media," presented at the Seventh Annual California Conference on Higher Education, Santa Monica, Calif. (May 1968).

The computer can even be programmed to generate its own drill exercises so that a wide variety of combinations can be used without excessive teacher participation. Finally, the computer can be used to pace the student so as to increase his speed of response as well as his accuracy.

Tutorial Systems

A somewhat more complex application of the computer is to use it to present to a student essentially the same data as contained in a programmed textbook. The rationale for using a computer rather than a programmed textbook lies in the computer's ability to handle extensive branching loops, to pace the student responses, and to permit the student to construct an answer to a question rather than just to recognize or guess from the three or four possibilities that are presented in the usual programmed format. The degree to which the computer is programmed to recognize the widest possible variety of correct responses including the elimination of format presentation problems such as spelling and spacing of words, the more effective this mode of application can be. However, if the advantages of the computer are not used to the fullest, cost considerations reduce the attractiveness of this method of using CAI.

Dialog Systems

The advanced methods of processing and analyzing student responses go beyond just matching student responses with a list of acceptable answers in the computer memory and indicating right or wrong before advancing to the next presentation.

In the simplest dialog system, sometimes called the conversational mode, the student is still only given right or wrong responses from the computer but he is free to make a variety of responses. For instance, in a language program, the student would start writing sentences in the foreign language being studied with very few instructions. The computer would tell him what he has done correctly, giving the proper form after a number of unsuccessful tries. Thus learning in this discovery method of instruction is by the trial and error method rather than by a highly structured program.

The more complex dialog systems contain the question-answering routines within the computer program. Based on the Socratic dialog model of instruction, the ultimate goal is to allow truly interactive CAI. Language problems present a great barrier to the achievement of this goal. The student wants to put his questions to the computer in natural language but, as yet, the computer has limited capability in really understanding the meaning of a question so presented. A first step has been made by restricting the student to the use of selected words or phrases. This method shows promise in special cases, but such restrictions are unlikely to be acceptable for widespread use of the system. Much research has been directed to this problem and considerable progress has been made, Many people feel, however, that until the language problem is solved, the full potential of CAI cannot be realized.

Computational Modes

A range of sophistication is shown in the variety of CAI systems which depend upon the computational power of the computer. The simplest of these systems merely uses the computer as a calculator to do the mathematics required to solve a problem. Because of the computer's speed and ability to use subroutines, students can handle more problems or handle problems that would otherwise be too difficult or lengthy for them to do. This simple computational application is widely used in most universities and colleges having a computer.

In a more complex system, the computer not only does the computation but assists in the problem-solving process. It can guide a student through the process, evaluating each step and indicating errors as they occur. The most elegant systems of this general type require extensive student interaction. A good example is the previously mentioned Culler-Fried system at the University of California at Santa Barbara.

Computer-Aided Laboratories

The computer can be used at least three ways in the laboratory.

First, it can be used principally as a guide, to present the student with problems that he solves at the laboratory bench and then types into the terminal for verification. At this point, he is branched to one of a variety of subsequent operations depending upon the adequacy of his findings.

A second use is to interpose the computer between the student and a piece of apparatus that is particularly dangerous or too expensive to jeopardize. The student can then be given relative freedom to run the experiment and collect data, but with built-in protection for himself and the apparatus.

Third, the computer can be used for modeling or simulation. A number of desirable experiments cannot be brought into the laboratory because of size, cost, danger or uniqueness. However, often the important characteristics of the device can be simulated by a computer program and the desired experiment can be conducted by one or more students with good learning possibilities. Start-up of a nuclear reactor, performance of a large cyclotron or operation of a complex chemical processing plant can all be studied in this manner.

A closely related application uses the simulation technique in design laboratories where students can make design decisions and test their validity without the problem of physically constructing and testing the design model. This application is well developed in many areas of engineering design. Specific examples can be found in a publication of the Commission on Engineering Education[37] and of the University of Michigan.[38]

[37] *Proceedings of the Conference on the Impact of Computers on Education in Engineering Design,* Commission on Engineering Education, Washington, D. C. (1966).

[38] D. L. Katz, *et al., Computers in Engineering Design Education,* vol. 1, (University of Michigan, Ann Arbor, Michigan, 1966).

As the computer's ability to recognize the language of its users is improved a laboratory approach to the learning of interpersonal skills will become possible. An engineer for example, may obtain practice in technical consultation activity by working against a graded series of problems presented in the form of simulated clients.

Models and Games

A wide spectrum of educational uses have been made of specially programmed models and games. Economics courses taught by Professor Radov at the University of California at Irvine includes a simulation of a market. This model is used to develop the concepts of basic economic theory. Decision making skills are developed in a wide variety of courses at many schools based on models or games. Business, agriculture, management and military studies have been exposed to these courses with very good success. This use of the computer is well established and will find ever increasing application.

Testing, Recording and Processing Student Performance

As indicated previously, the potential of CAI to undertake the assessment of student performances is a key element in individualizing instruction. The computer can be of considerable assistance to the teacher in keeping accurate and comprehensive records on individual student performance, regardless of the method of instruction used. The assessment of student performance also includes testing of a formal nature as well as collecting data on daily performance. Again the computer can be used for this activity. The testing can be quite sophisticated and results made known to the student immediately. However, using a computer for testing may be difficult to justify economically except in the special case when it is part of a research program on the evaluation of educational results.

Research

Probably the most important contribution which CAI can make in the near future is in its use as a research tool. Again quoting from Suppes:

> Before the advent of computers it was extremely difficult to collect systematic data on how children succeed in the process of learning a given subject . . . A computer can provide daily information about how students are performing on each part of the curriculum as it is presented, making it possible to evaluate not only individual pages but also individual exercises.[39]

The empirical development of learning theories will be advanced by the collection of extensive data on the parameters of the learning process and processing of this data.

[39] P. Suppes, "The Uses of Computers in Education."

The previously mentioned HumRRO program is an example of this type research.

Another research application is the use of the computer to reduce the number of evaluation-revision cycles required in the development of a set of instructional materials. The methods of attacking this problem are discussed by H. F. Silberman.

> Several approaches to achieving this objective are possible. One approach uses the conventional CAI system to collect performance data from students on-line with the computer. Data analysis routines summarize the performance data, and the computer-editing capability allows quick changes to be made in the instructional sequence. When the on-line evaluation-revision cycles have reached the point of diminishing return, the instructional sequence can be published in conventional, inexpensive media — books or films — and distributed widely.[40]

INTERINSTITUTIONAL USE

As yet, there has been very little interinstitutional use of CAI. Problems of computer compatibility have been a limiting factor even in those well established activities such as engineering design models. At the University of Illinois, plans are under way to introduce CAI into a number of geographically adjacent institutions using the main frame at the University of Illinois and putting remote consoles at each institution involved. Several other programs have remote terminals in other institutions, but they also operate all terminals from the same main frame. This method of avoiding transference of programs between main frames represents one solution to the problems of language translation and machine incompatibility that exist at this stage of CAI development. This solution will also require the development of time-sharing computers capable of handling large numbers of educational terminals economically.

It should also be noted, however, that another approach to the language problem is the development of appropriate techniques of automatic translation from one CAI language to another. The development of a sufficiently flexible and inclusive language should make this possible. For example, at University of California's Medical Center, this approach is being followed in developing the interinstitutional exchange of program material. The Center has found that even though the PILOT and COMPUTEST languages are quite different in their internal operation, an automatic translator from COMPUTEST to PILOT has been successfully produced that makes the previous programs available in the more inclusive system.

UNIVERSITY-INDUSTRY USE

Again, except for a relatively few cases, the incompatibility problems have limited the development of activities similar to those discussed for university-industry ITV use. However, there is great awareness of the potential of CAI in industry, and the need for future cooperation between industry and the university is well established.

PRESENT STATUS

Extent of Use

In a field which has only been developing for the past eight years and in which much of the activity has been started within the past two or three years, a historical treatment tends to overlap a description of current activities. Only recently have organizations such as ENTELEK and Dr. Karl Zinn's project at the University of Michigan begun to accumulate, on a systematic basis, statistics on CAI programs and their location. Experimental programs are fairly widespread, not only in the universities, but also in the military services, and as has been mentioned, in a number of industrial organizations. The most recent study on all uses of computers in colleges and universities[41] has data for fiscal year 1965 and projections for fiscal year 1969 from which one can obtain a good indication of computer usage trends. For instance, in fiscal year 1965, total expenditures were $103 million and corresponding estimated fiscal year 1969 expenditures are $276 million. In January 1966 there were 900 computers in 600 universities and colleges. It was estimated that by January 1969, 1,200 computers will be in use in 900 universities and colleges. Unfortunately, since the survey was principally concerned with instruction in computer sciences, there are no specific data on what portion of this computer effort would be devoted to CAI. However, this rapid growth of computer usage in colleges and universities shows that a considerable amount of computer time could be devoted to CAI, if desired. Recent reductions in government-sponsored research efforts may encourage CAI development at this time as computer centers try to keep up their workloads.

Research Results

The following comments are related only to the modes of CAI involving drill and practice, tutorial systems and dialog systems. Modeling, simulation and computational uses are well established and widely accepted. The only comments that might apply to these latter uses are those concerning economic feasibility.

EFFECTIVENESS

In a field this new, the number of well-documented comparative data experiments is still somewhat limited. However, the studies that have been made have demonstrated either superiority or at least the equality of

---

40 Silberman, "Applications of Computers in Education," p. 18.

41 J. W. Hamblen, "Computers in Higher Education", Southern Regional Education Board (Atlanta, Georgia 1967).

computer-assisted instruction when compared to conventional methods.[42,43] The principal difficulty in effectiveness of studies is the choice of the criteria to be used. This is not a new situation but because of the computer's great promise and great cost, there is an urgency to the search for answers. As J. R. Pierce recently stated:

> Computerized instruction has raised a clear challenge in all of instruction. We cannot afford either poor teaching or expensive teaching. How good are various means of teaching and for whom? What do various options cost? For example, what are the objectives of a given textbook? Can a student with some specified preparation, intelligence or other measurable prerequisite reach the objectives by reading the textbook? Or must a teacher make up for deficiencies of the book or of its use? Such questions must be raised and answered concerning all courses and all modalities of instruction if we are to evaluate computerized instruction.[44]

APPLICABILITY

Because of the limitations imposed by the present state-of-the-art, the most successful educational programs are those with highly structured or introductory materials requiring the user to learn a great many definitions before starting serious reading and discussion. As noted by L. Grayson:

> It appears that tutorial programs will be best introduced to instruct in basic courses which have large enrollments and very stable curricula, such as freshman English, introductory language courses, and in science areas, as biology, chemistry and physics.[45]

Considerable success with review materials has been achieved and this may grow to be a major use in the future. As more universities become involved with upper-division transfers from two-year colleges, CAI may be particularly useful in filling gaps in the backgrounds of students from different schools.

[42]D. N. Hansen, "Learning Outcomes of a Computer Based Multimedia Introductory Physics Course," Semiannual Progress Report (Florida State University, Tallahassee, Florida 1967), p. 95

[43]A. E. Hickey and John M. Newton, *Computer-Assisted Instruction, A Survey of the Literature,* (Entelek, Inc., Newburyport, Mass. 1967) 2nd ed.

[44]J. R. Pierce, "What Really Works to Help Learning — The Challenge of Computers to Education" from an address to the American Educational Research Association (February 9, 1968).

[45]L. P. Grayson, "Computer-Assisted Instruction and its Implications for University Education," IBM Research Paper RC 2169 (Thomas J. Watson Research Center, Yorktown Heights, New York, August 19, 1968).

ATTITUDES

The attitudes of students toward CAI has not been widely researched but available studies report responses ranging from those enthusiasts who become intrigued with the computer association to those who feel quite negative toward it because of the alleged dehumanizing effect. As indicated in the ITV study, it is doubtful that these attitudes have any significant effect on student learning, once the mode of instruction is specified.

Again, from the available data, the attitudes of the faculty members seems to be similar to those reported in the ITV study. The majority are not highly verbal as to their attitudes but often find reasons to bar their specialty from CAI treatment. Among administrators and department heads there is often a more favorable reception as they see e long-term advantages that can accrue. However, when administrator and faculty member become aware of the extensive programming effort required to put course material into the CAI format and to get it debugged and ready for use with the computer, they often feel that even if the method is capable of satisfactory instructional results, the programming effort is so great that CAI is impractical for widespread use.

ECONOMIC FEASIBILITY

A serious obstacle to the introduction and use of CAI is the uncertainty associated with its financial implications. Few, if any, of the existing CAI systems are totally supported by the institution at which the instruction is being carried out. Therefore, it is difficult to obtain realistic cost data on any of these systems. Available information indicates that the cost of most of the systems now in use is high. In "The Computer in Physics Instruction," a report of The Commission on College Physics, E. N. Adams estimates that IBM 1500 systems cost $3 to $5 per student per hour depending upon the number of terminals in use. Other configurations are probably more expensive, although those systems using only a teletypewriter terminal on a time-sharing basis with moderate transmission costs and high usage rates may also be as low as $3 per hour. A considerable amount of cost data on various configurations of terminals and communication media is found in this report.[46]

Probably the most careful cost analysis as applied to possible CAI systems was made by F. F. Kopstein and R. J. Seidel.[47] The conclusions of this HumRRO paper are that using specified but reasonable assumptions, the costs per student hour of CAI in higher education can be about $2.60 per hour which compares favorably with conventional university-level instruction calculated to be on the

[46]E. N. Adams, "The Computer in Physics Instruction."

[47]F. F. Kopstein and R. J. Seidel, "Computer Administered Versus Traditionally Administered Instruction: Economics," HumRRO Professional Paper (The George Washington University, Washington. D. C., June 1967), pp. 31-67.

average of about $2.75 an hour. Conventional instruction at the primary level costs about 30 cents per student hour, so CAI is not ready for that market. However, D. Bitzer at the University of Illinois PLATO Project is working toward a goal of 25 to 30 cents per student hour and has hopes of achieving it in about five years.[48] At all levels of instruction, the cost factor of greatest importance for any system large enough to be economically feasible is the terminal and the communications lines. When terminals must be supplied in thousands, their cost exceeds that of both the computer and its associated memory bank, and reduced costs can and must be forthcoming. Savings must also be made in the cost of data transmission between the terminals and the central computer. If data can be sent over regular twin-pair phone lines without sacrificing speed of computer response or size of the data base, coaxial-line transmission would not be needed and costs will fall dramatically. Development of an economically feasible system requires that the greatest emphasis must be on inexpensive terminals and low transmission costs.

A very recent study of CAI[49] costs concentrates on the over-all system costs for use at the elementary and secondary levels. The report concludes that an investment of $9 billion to $24 billion a year would be required to provide every secondary and elementary student in the United States with one hour of CAI every day of the school year. The estimated 1968 enrollment of these students is 52,000,000. The number of school days used in the estimate is 150. So, total hours of CAI would be 7.8 billion hours. CAI would then range in cost from $1.15 to $3.08 per student hour. These costs are in line with the data from other sources previously noted and represent present levels of cost. It is interesting to note that the CAI would only be used 6 hours a day, 150 days a year. If use 16 hours a day, 225 days a year were contemplated, these costs would be materially reduced. It is also interesting to note that this report considers CAI cost as completely extra costs. Obviously this assumption develops a worst-case situation with regard to extra costs.

TECHNICAL FEASIBILITY

There are three technical problems concerning the feasibility of CAI use. The first is to develop a time-sharing computer with all the necessary characteristics for satisfactory CAI use with a large number of terminals. As stated by G. S. Brown and W. W. Seifert:

> There are many professionals in the computer arena who sincerely believe that the achievement of a reliable, inexpensive and sophisticated time-sharing system is at least five or more years away, and may even be beyond the capacity of human development.[50]

The second problem is to develop methods of simplifying communication between non-computer specialists and the machines. As previously noted a part of this development is the extension of the dialog capabilities of the computer to include the broad and understanding exchange of questions and answers. Although there is much effort in this area, progress is slow and the ultimate realization of a total solution is a number of years in the future.

The third problem is the difficulty imposed by the incompatibility of computers, input/output devices and programs. To justify the cost of preparing good CAI course materials, the materials should be used widely, which, in most cases, is impossible at the present time. A possible exception is the IBM 1500 system, but this system is limited in computing power and in size. The incompatibility problem is not unique to CAI, however, and there are strong pressures from many quarters aimed at improving the situation. However, again, the success on a broad scale will take a long time.

SUMMARY

Confining the discussion to the drill and practice, tutorial and dialog systems, the present status of CAI can be summarized. The use of CAI is not extensive and tends to cluster around certain research centers. In the past two or three years, the number of experimental efforts have increased and have spread to many new areas. It is widely assumed that CAI is a viable educational tool capable of teaching in a wide variety of subject areas with results that are comparable to conventional face-to-face instruction. Student reaction is mixed but not a problem as yet. Faculty and administrative reactions are cautious or negative with notable exceptions. Economic feasibility requires large systems and the broad use of programs. Technical problems raise questions as to the time scale for realization of economically feasible systems.

---

48 P. H. Abelson, "Computer-Assisted Instruction," *Science*, vol. 162, no. 3856 (November 22, 1968), Editorial.

49 *Innovation in Education: New Directions for the American School*, Committee for Economic Development, New York, New York (July 1968), p. 66.

50 G. S. Brown and W. W. Seifert, *Report of the School of Engineering, 1966-67*, Massachusetts Institute of Technology (Cambridge, Massachusetts), Foreword.