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ABSTRACT

This paper surveys approaches that are deemed practical for instructional use of radios and computers by satellite transmission. For each of the two instructional technologies a brief history is provided, a survey of the evaluation studies of effectiveness is given, and a concluding section on planning for application is provided. Because the literature on these topics is extensive, an attempt is made to select for discussion items that are deemed of special importance or of particular use to field users. The paper concluded with some general recommendations for use of either instructional radio or computer assisted instruction by means of satellite transmission. A selected bibliography is appended to the paper. (Author)

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PLANNING FOR INSTRUCTIONAL USE OF RADIO AND COMPUTERS BY SATELLITE

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This paper surveys approaches that are deemed practical for instructional use of radios and computers by satellite transmission. For each of the two instructional technologies a brief history is provided, a survey of the evaluation studies of effectiveness is given, and a concluding section on planning for applications is provided.

The literature on these topics is very large. An attempt has been made to select for discussion items that are deemed of special importance or are particularly useful for field users.

The paper concludes with some general recommendations for use of either instructional radio or computer-assisted instruction by means of satellite transmission. A fairly extensive bibliography of the matters discussed is appended to the paper.

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The intention of this paper is to survey approaches that are deemed practical for instructional use of radio and computers by satellite transmission. In the case of computers we shall restrict the survey of practical applications to computer-assisted instruction. A subsidiary objective of this survey is to provide a brief history of educational radio and of computer-assisted instruction in the United States so as to give some perspective on the use of these instructional technologies. Another subsidiary objective is to provide a survey of the evaluation of effectiveness of radio instruction and computer-assisted instruction.

Part 1 of the paper deals with these three objectives for educational radio. The three sections of Part 1 cover the three topics of history, evaluation, and planning for applications. Part 2 deals with computer-assisted instruction and contains three similar sections.

Finally, in Part 3 the recommendations for the instructional use of radio and of computers is brought into summary form. Throughout the discussion of these various topics an effort has also been made to provide references to the literature that will be useful for readers interested in pursuing these matters further. The paper ends with a fairly extensive bibliography.

1. INSTRUCTIONAL RADIO

1.1 History of Instructional Radio

Beginning in the 1920s, instructional radio was widely used in the United States, but for a variety of reasons, including especially the advent of television, its use has dwindled in recent years. Atkinson (1942a, 1942b) provides broad, nonevaluative information on a substantial number of instructional radio projects undertaken in the United States prior to 1939. Readers will find his books useful for their general account of operational problems and history of early uses. Saettler (1968), Skornia (1962), and Wrightstone (1952) describe the later history of instructional radio in the United States.

Although the use was not extensive, there are still a number of school districts that continue to provide some instruction by radio. Some recent examples are KRVM (Eugene, Oregon), WGBO (Newark, New Jersey), KSLH (St. Louis, Missouri), KANW-FM (Albuquerque, New Mexico), KBPS (Portland, Oregon), and WYNE-FM (New York, New York). There are undoubtedly other instances beyond this list.

In many respects, radio is currently being used more extensively, and more educational attention is being devoted to its use in countries outside the United States. In Great Britain, radio has been used extensively for school broadcasts for many years, and it currently provides a component of the Open University. There are now more than 60 educational radio series broadcast to schools in England. Many of these series use illustrated pupil pamphlets as supplements to the lessons. It is characteristic of the British broadcasts that they emphasize rather close collaboration between the classroom teacher and the instructional radio program. The British use of radio has concentrated to a considerable extent on supplementary teaching that would not ordinarily be available, at least at an expert level, within the population of teachers at a school. Typical special subjects would be art, music, and foreign languages.

Australia has also made extensive use of instructional broadcasting. The geographical situation in Australia has made it especially attractive for reaching the nonurban regions of the country. Although Australia is almost as large as the United States, it has a population slightly less than 12 million, and of this population about 63 percent is urbanized. This means that approximately five million people are spread over a rural area that is almost as large as the United States. This extreme dispersion of population has presented real educational problems. The experience of Australia in providing instructional facilities by radio should be of use to any radio user that is faced with a highly dispersed population. In 1960, over 90 percent of the Australian schools received some radio lessons. Curriculum enrichment broadcasts similar to those of the BBC in Great Britain are extensively used in rural schools. At the higher educational level, the Radio University of New South Wales, for example, enrolled over 6,000 students in 1965. Some references on the use of instructional radio in Australia are Bull (1960) and Kinane (1967).

A country with a quite different population density, namely Japan, also makes widespread use of instructional radio. In 1935, NHK, the Japanese Broadcasting Corporation, began a small program of radio broadcasts to the schools (Hatano, 1960; NHK, 1964). After World War II, radical changes were made in the Japanese educational system in terms both of curriculum, discipline, and teaching techniques. The use of radio played a substantial part in this modernization. A 1958 survey by the Broadcasting Culture Research Institute of NHK reported that 47 percent of the primary schools, 37 percent of the lower secondary schools, and 27 percent of the upper secondary schools regularly used radio broadcasts. NHK has an extensive correspondence school program and it is possible to receive the equivalent of a high school education, including certification, without attending any regular classrooms but by taking a program of correspondence courses, radio lessons, and final examinations. It should be noted that, in spite of the widespread use of television in Japan, the extensive use of radio for instruction continues.

Mexico is another country that has made recent extensive use of radio. Spain (1973) reports on and evaluates a project in the rural parts of the state of San Luis Potosi that was designed to provide fourth-, fifth-, and sixth-grade instruction by radio for schools that previously had only the first three years of elementary school. This use of radio is to be put in the context of the standard situation in developing countries, namely, by the upper elementary grades, the percentage of the age population still in school is small, and it is consequently expensive and difficult to provide adequate instruction. The project that Spain describes concentrated on the teaching of mathematics and the teaching of Spanish. Other Mexican projects are examined in Schmelkes de Sotelo (1972, 1973).

The Institute for Mathematical Studies in the Social Sciences at Stanford is currently funded by the United States Agency for International Development, in conjunction with the Ministry of Education of Nicaragua, to develop mathematics lessons that are broadcast daily by radio to primary school classrooms, especially in the rural areas of Nicaragua (Searle & Suppes, 1975). These lessons are characterized by a high rate of student response; children work approximately 50 mathematics exercises during the course of a half-hour broadcast. Their responses are either given orally as a group or individually in writing. Because this project has assumed responsibility for such an important segment of the elementary-school curriculum, it may be worthwhile to describe in somewhat more detail how it operates on a daily basis.

A daily lesson consists of a radio broadcast lasting for from 25 to 30 minutes, followed by approximately 20 to 30 minutes of teacher-directed activities. No textbooks are used and no printed materials are distributed to the students. In the initial year, students received a one-page worksheet each day, but as the project gained experience, it was feasible to eliminate this worksheet, and the second-grade curriculum is currently being developed without the distribution of worksheets. From the standpoint of developing countries, avoiding the cost of distribution is one of the most important and critical features of the program. In areas that are not as cost conscious in terms of workbooks, it can still be desirable because of the difficulties of distributing materials to dispersed populations. In developing the Nicaraguan project, the staff at the Institute at Stanford has found some people skeptical that mathematics can be effectively taught by means of radio. It is a primary purpose of the project to test this hypothesis. The data thus far indicate overwhelmingly that radio instruction in mathematics and, indeed, radio instruction that carries the main part of the instructional burden, is not only possible but can be a highly effective method of instruction.

1.2. Evaluation of Instructional Radio

An excellent survey of studies of the effectiveness of instructional radio is to be found in Section VI of Chu and Schramm (1967). Their book is primarily devoted to a comprehensive review of instructional television, but for comparative purposes they include detailed information about instructional radio. Their study includes a large number of conclusions, and three of these that bear on instructional radio are the following:

1. Given favorable conditions, pupils can learn from any instructional media that are now available (p. 151).

2. The use of visual images will improve learning of manual tasks as well as other learning where visual images can facilitate the association process. Otherwise, visual images may cause distraction and interfere with learning (p. 162).

3. Student response is effectively controlled by programmed methods, regardless of the instructional medium (p. 172).

Another broad survey is a paper by Forsythe (1970). In summarizing radio's effectiveness he concludes:

> Research clearly indicates that radio is effective in instruction. Experimental studies comparing radio teaching with other means or media have found radio as effective as the so-called "conventional methods." Even though radio has been criticized for being only an audio medium, studies have shown that visual elements in learning are not uniformly important. In many educational situations visuals may be more harmful than helpful. Also, the efficiency of combined audio and visual media has been challenged by studies which show that multi-channel communications may not be inherently more effective than single channel presentations.

Further information on effectiveness of instructional radio may be found in a large bibliography compiled by Madden (1968). An earlier survey - the effectiveness of radio instruction may be found in Woelfel and Tyler (1945).

We mention here two specific projects that received rather detailed evaluation. One was an early study of radio lessons in music by the Wisconsin Research Project in School Broadcasting (1942). This study reports work extending over a period of 20 years, back to the first course in music broadcast in 1922 in Wisconsin. A careful study was conducted in the 1930s of classes listening to the music broadcasts and comparable classes that did not. The instructional radio classes showed significantly better learning in maintaining correct rhythm and in their ability to recognize note values, read at sight, and recognize rhythms. In other features there were no significant differences between the classes taught by instructional radio and the classes taught by traditional instruction, but none of the other measures favored the traditional classes. These included measures of singing quality and ability to take musical dictation. The students who participated in these radio classes were in the upper elementary grades and were in both rural and urban schools.

At quite a different level, Menne, Klingensmith, and Nord (1969) compared teaching an introductory psychology course at Iowa State University by use of tape recorders or by live lectures. Lecture notes were prepared in booklet form and given to the students who elected the tape version of the lectures. For two academic quarters they compared students that took the course solely from audio tape with students who took it from a live lecturer. The live lecturer was the same person who prepared the audio tapes earlier. A total of 290 students elected to take the course by tape, and 408 chose the live lectures. Although selection was voluntary, the two groups were actually closely matched in terms of their high school rank in class and on measures of achievement and scholastic aptitude.

In terms of posttest scores and final grades, the two groups did not differ significantly. When comparisons were made in terms of the lowest quartiles of the two groups according to high school rank, there was a clear advantage to using tapes for the lowest quartile; for the other three quartiles there was no significant difference.

Perhaps at least as interesting was the dropout rate. Only 5 of the students learning by tape dropped out whereas 58 attending the lecture sessions did so.

These two specific examples, as well as the detailed discussion earlier of the Nicaragua Radio Mathematics Project, indicate the wide range of topics that apparently can be successfully taught by radio.

1.3. Planning Applications of Instructional Radio by Satellite

I summarize some of the more pertinent recommedations or conclusions.

1. There is substantial evidence that instructional radio can be used to teach an enormous range of subjects and students at almost every age level. There is no reason to think that delivery by satellite would affect in any negative way the positive conclusions from more than 50 years of research and development on extensive use of instructional radio.

2. There is evidence that instructional radio can be used for supplementary work ranging from news reports, broadcasts of students' creative work, and dramatizations of biography and historical events, to travelogues, musical programs, talks by prominent scientists and others. In addition, direct instruction can be provided in specialized subjects that are not easily available for instruction in terms of an isolated school's educational resources. The most extensive examples of such direct instruction have been in music, foreign languages, and art.

3. There is evidence that essential subjects in the curriculum can also be taught by instructional radio. These range from elementary-school mathematics to major courses at the university level. It should also be

mentioned that in developing countries there has been fairly extensive literacy training by radio.

4. The main recommendation is to use instructional radio for those areas of instruction for which there is a clear need on the one hand and for which there exist no adequate local facilities on the other. It is important to recognize in the case of isolated schools that this sense of need should extend to important and attractive supplemental topics and not be restricted to the main parts of the curriculum concerned, for example, with instruction in basic skills of reading, mathematics, and language arts.

5. In the case of instruction by radio for adults, there is evidence to indicate it is important that there be regular intermittent two-way communication, for example, by mail. If the program being developed has an adequate budget. the collection of regular exercises or other forms of homework from students would almost certainly be a desirable feature. It would of course be most desirable to have this homework collected on an immediate basis by two-way interaction, but, for purposes of economy, this would often not be possible, and therefore a schedule of regular collection is the most important feature even if there is a delay of several days in returning corrected homework to the student.

6. It should be borne in mind that group learning can be as important as individual learning. This seems especially true of younger students in the elementary school. Radio instruction to groups of students at this younger age should be considered as an important possibility. For this purpose, broadcasts should be directly into the school. For work with older students, it will in many cases be more attractive and convenient to broadcast into the homes for individual work

by the student. However, even in this case some formal structure of credit and certification is strongly recommended. Extensive surveys of home-based instruction (e.g., Macken, van den Heuvel, P. Suppes, and T. Suppes, 1976) indicate that a clear credit and certification structure is a desirable feature of all home-based instruction.

2. COMPUTER-ASSISTED INSTRUCTION

2.1. History of Computer-assisted Instruction

The use of computers for instructional purposes, that is, computer-assisted instruction, as it has come to be termed in the literature, is the newest and most expensive of current educational technologies. It is also by far the most highly individualized in the interaction it provides between student and curriculum. The first projects in computer-assisted instruction began in the early 1960s, mostly in university research centers. It is only since about 1970 that computers have been used on an operational basis for instruction in a number of American school districts. The percentage of students affected is still relatively small although the total number of projects in itself is now, in absolute terms, large.

Since the initial experiments with computer-assisted instruction in the early 1960s, three or four major aspects of this form of instruction have become salient and seem to offer great potentiality for education at all levels, but especially at the elementary level. The first and most important aspect centers on the well-known fact that there exist definite and clearly significant individual differences among students, especially in their rates of learning. Students at all levels work at varying rates and at different levels of accuracy and understanding. Moreover, perhaps at least as important is fluctuation within a given student over a period of several years. Students who are slow in the beginning grades sometimes have a period of rapid catch-up in later grades. For reasons that are not clearly understood, students who begin school with an initially high rate of learning will often slow down to something much closer to the average and occasionally to a rate below the average. To accommodate these manifest individual differences in learning is a continuing concern in much of our educational efforts. In the past, let us say any time earlier than about 1800, the solution was relatively easy because only a small part of the population was given extended education, and what were considered the most important future members of society, children of the nobility and aristocracy, were educated primarily by private tutors. Even in 1870 only two percent of the age population graduated from high school in the United States. However, since the turn of the century, particularly with the opening of John Dewey's laboratory school at the University of Chicago, the concern for adapting the curriculum to the ability or achievement level of each student has become a serious concern of our schools, whose mission is to educate future citizens of a broadly based democratic society. Today, essentially all of us accept that education is universal, and a continued increase in the number of years of education of the average citizen is anticipated throughout the remainder of this century.

Unfortunately, the economics of education are such that we cannot afford even in an affluent society to provide tutorial instruction to individual students on a broad basis. The use of computer-based instructional devices offers a method of meeting the problems of individual differences at a much deeper level and in a more scientific way than has yet been possible.

The second aspect of individualization is attention to the responses of individual students. There are many studies indicating the desirability of relatively immediate reinforcement of answers once they are given by students to exercises, especially in the lower grades. In an individualized program, it is simply not possible for a teacher to provide this immediate attention to correction of mistakes, etc.

It is useful in discussing these matters of individualization to get a sense of the kind of numbers we are talking about. To a large extent, the most widely used operational programs in computer-assisted instruction are programs providing drill and practice in basic skills at the elementary-school level. I have in mind especially programs in reading, mathematics, and language arts. Let us take the drill-and-practice program in mathematics for Grades 1-6 as an example. In a period ranging from six to ten minutes, depending on the age of the child, the student will work somewhat more than 30 exercises. If he is in this program 150 days of the school year, he will then have completed more than 4,500 exercises that were individually tailored to his level of achievement and immediately evaluated for their correctness. The content of an elementary-school textbook in mathematics is about equal to these 4,500 exercises, that is, textbooks at this level contain somewhere between 4,000 and 5,000 exercises. Consider now the situation of the teacher who has a class of, let us say, 25 students. If she were to construct these individual exercises and evaluate them for the students, this would mean more than 100,000 exercises for the school year. In addition, she would be faced with a similar task in reading and language arts, not to speak of some of the other subjects it is her responsibility to teach. It is little wonder that in the ordinary classroom situation it is a difficult matter for the teacher to provide the kind of intensive drill and practice that is a simple and natural thing within the framework of computer-assisted instruction. Even the teacher who understands well the need for individualization and has the zeal and drive to produce a great many individual exercises for students will have great difficulty providing a product comparable to that which can be provided in a relatively straightforward manner by computer-assisted instruction. This is a third aspect of computer-assisted instruction that needs considerable emphasis. It provides an opportunity to relieve the teacher of routine and burdensome tasks, so that the teacher may devote time to giving more individualized attention to students.

A fourth aspect to be mentioned is the record keeping and information flow about the performance of students that can be brought to teachers, administrators, and others is a by-product of computer-assisted instruction, that is, as a by-product of students doing their work at computer terminals.

To give a more concrete sense of the kind of courses that have been developed for computer-assisted instruction, I survey here work at the three levels of education: elementary school, secondary school, and college.

<u>Elementary school</u>. The most widely used programs in elementary schools are those developed by Computer Curriculum Corporation (Palo Alto, California), with which the author is associated. Currently, these are essentially the only programs commercially available for standard use in ordinary elementary-school settings by school districts unconnected with university research projects or other research centers. Their three most widely used curriculums are in the basic skills of reading, mathematics, and language arts

Secondary school. Some of the most imaginative work in this area has been exemplified by the activities of Seymour Papert and his collaborators at the Massachusetts Institute of Technology. They have concentrated on teaching students problem-solving skills and the beginning elements of computer programming. Their program is in contrast to those mentioned already because the emphasis is not on supplementary drill and practice in the basic skills. A good account of their work is to be found in Papert and Solomon (1972). Papert and his colleagues are working with students roughly in the age ranges 8 to 15, so some of them also fall within the elementary-school level.

The activities in computer-assisted instruction are not as vigorous at the secondary-school as at the elementary-school level, partly because there has been a history of concentrated effort in the development of drill-and-practice programs in basic skills. On the other hand, some of the basic-skill programs originally developed with elementary-school students in mind have been used with disadvantaged students needing additional work in the basic skills of mathematics, reading, and language at the secondary-school level. A variety of projects around the United States reflect this emphasis.

The more important fact about the use of computers in instruction at the secondary-school level probably centers on the use of computers for problem solving and introduction to data-processing applications. A number of high schools offer courses that provide elementary instruction in data processing. Many of them are aimed at training that will lead to direct entry into the labor market by high school graduates. A substantial portion of the high schools in the United States now have some form of data-processing instruction as part of their regular instructional program. A smaller, but still significant, number have interactive computing as part of their program, in many cases aimed at problem-solving activities in mathematics, physics, and chemistry. Most of the activities at the secondary-school level have not been built around specific research and development projects, and consequently the published literature on the activities is considerably less than the volume of activity would lead one to expect.

It is anticipated that commercially available courses for secondary-school work in computer-assisted instruction will be available in the reasonably near future.

College. The situation is quite different at the college level. There is a large number of courses in many different institutions, many of them partial courses, but the number of such is very large indeed and it will not be possible to give anything like a detailed factual survey in this report. I shall attempt rather to provide some examples. Several specific institutions and places will be mentioned only later because I will concentrate on a summary of their evaluations. It is fair to say that the main work has focused on courses that require mathematical skills or language skills. Consequently there has been a great deal of work in the teaching of elementary mathematics and elementary college-level science by means of computer-assisted instruction. A similar generalization applies to the teaching of foreign languages. To the writer's knowledge, at least the following foreign languages have been taught at least once by means of computer-assisted instruction in the United States: French, German, Spanish, Russian, Hausa, Swahili, Mandarin Chinese, Arabic, and Bulgarian.

One of the largest recent efforts at the college level has been the TICCIT project, which has been aimed at computer-assisted instruction for community colleges in basic skills of English and mathematics. This project is just reaching maturity and will be reported on in depth in the literature in the next few years.

A second large project is the development of the PLATO system at the University of Illinois. This project has been extensively supported by the National Science Foundation over the past several years, and extensive course material at the university level and the community-college level has been developed. Much of the material is supplementary to regular classroom instruction. The range of topics and the number of instructors involved have been very large. No comprehensive public report of this multifaceted activity is yet available, although there are reports on individual projects, some of which are mentioned below.

At Stanford, my own university, we have been engaged in computer-assisted instruction at the college level for a number of years. A recent detailed survey of the use of computers for instruction at Stanford is to be found in Suppes, Smith, and Beard (1975). I show in Table 1 the list of courses currently offered at Stanford.

Insert Table 1 about here

Some more detailed particular studies are mentioned in the next section on evaluation.

2.1. Evaluation of Computer-assisted Instruction

This section on evaluation is also divided into three levels of education, used to demarcate the last section.

<u>Elementary school</u>. Vinsonhaler and Bass (1972) surveyed over 30 separate experiments that involved a total of about 10,000 students and that compared traditional instruction and traditional instruction augmented by CAI drill and practice. They concluded that "there appears to be rather strong evidence for the effectiveness of CAI over traditional instruction where effectiveness is measured by standardized achievement tests." This is a good summary reference and one of the most extensive. A corresponding extensive survey of the curriculums of the drill-and-practice courses of Computer Curriculum Corporation is to be found in Macken and Suppes (1976). This covers a very large number of students and represents data reported from nine different states. Additional extensive data on drill-and-practice programs at the elementary level are to be found in Suppes and Morningstar (1969, 1972). Beech, McClelland, Horowitz, and Forlano (1970), Jamison, Fletcher, Suppes, and Atkinson (1971). Smith and Hess (1972), and Fletcher and Atkinson (1972).

Typical evaluation results obtained in such drill-and-practice programs at the elementary-school level are to be found in the achievement data shown in Table 2, which are taken from Suppes and Morningstar (1969)

Insert Table 2 about here

for an experiment in the state of Mississippi in 1967-68. The experimental group as shown in the table is the group receiving computer-assisted instruction, and the control group is the group receiving in each case only traditional instruction. The number of students involved under each experimental condition is shown in parentheses after the mean grade placement. As can be seen from Table 2, significant results were obtained at each of the six grade levels of the elementary school involved in this evaluation. I refer to these data from McComb, Mississippi, because it is one of the more extensive CAI experiments in a rural setting.

Corresponding data for the use of computer-assisted instruction with American Indian students in a rural setting is reported in Suppes, Fletcher, and Zanotti (1975).

In addition, an extensive body of evaluation on the use of computer-assisted instruction at the elementary-school level with handicapped students, especially deaf students, has been a major focus of research in the Institute at Stanford for several years. Reports on this work, especially on the evaluation of its effectiveness, are to be found in Suppes, Fletcher, Zanotti, Lorton, and Searle (1973) and Suppes, Fletcher, and Zanotti (1976).

Secondary school. There are very few published reports of evaluation of computer-assisted instruction at the secondary-school level. It may be anticipated that this situation will change in the near future.

College. There has been a fairly large number of systematic evaluations of the use of computer-assisted instruction at the college level. I mention here some typical examples.

Hansen, Dick, and Lippert (1968) of Florida State University reported results of implementing collegiate computer-assisted instruction in physics; in particular, problem-solving sessions were handled by computer. The CAI groups did as well as groups receiving traditional instruction in problem sessions and in fact slightly better, but there was no difference at a statistically significant level.

Adams (1969) and Morrison and Adams (1969) conducted experiments at the State University of New York, Stony Brook, on the teaching of German. The CAI students performed somewhat better than the control students on tests of reading and writing achievement, and not quite as well in terms of performance on listening and speaking tasks.

Extensive experience has been obtained on the PLATO system at the University of Illinois. Bitzer and Boudreaux (1969), for example, used the PLATO system for a CAI course in nursing. They report substantial savings of time over what was required in standard lecture presentation.

At the University of Texas a number of experiments and demonstration projects have been completed over the past ten years. One of the more significant ones is an effort by Castleberry and Lagowski (1970) in the teaching of elementary chemistry. At the same institution, Judd, Bunderson, and Bessent (1970) studied the effects of learner control in a computer-assisted-instruction course in precalculus mathematics.

At Stanford University, Joseph Van Campen developed a full two-year tutorial course in introductory Russian. An evaluation of the course for 1968-69 is presented in Suppes and Morningstar (1969). The results were significantly better for the CAI group than for the group receiving traditional instruction.

Concerning college-level use of computers, the broad summary of Jamison, Suppes, and Wells (1974) continues to be supported by the available data. First, no simple uniform conclusions can be drawn about the relative effectiveness of CAI in comparison with traditional instruction, when effectiveness is measured in terms of student achievement.

Second, the conservative conclusion is that CAI is at least as effective as traditional instruction, if not more so, when it is used as a replacement.

Third, there needs to be an investigation of possible cost savings by the use of computers for instructional purposes as opposed to traditional instruction. It is emphasized especially in Suppes (1975) that in intermediate-level college courses with small enrollment the extensive use of computers may lead to substantial cost savings by enabling the course load of instructors in classes of no more than three or four students to be considerably increased.

2.3. Planning Applications of Computer-assisted Instruction by Satellite

As in the case of instructional radio, I summarize here some of the more pertinent recommendations or conclusions.

1. There is considerable evidence that computer-assisted instruction can be used to teach an enormous range of subjects to students at almost every age level. There is no reason to think that delivery by satellite would affect in a negative way the positive evaluations that have been made over the past decade of uses of computer-assisted instruction.

2. The kinds of things for which computers have been used effectively in instruction complement rather than compete with the subjects in which instructional radio has been especially successful. Radio has been useful for supplementary work of an expository and discursive kind, as mentioned in Section 1.3. In contrast, by far the most extensive and effective use of computer-assisted instruction has been in the teaching of basic skills involving mathematics or language, whether at the elementary-school or the college level. The use of computers to teach subjects like history and literature has as yet been far less developed and, in the minds of many people, has still to overcome considerable technical and conceptual

difficulties to be successful in these areas. In contrast, a very large amount of work has been done in using computers in the teaching of basic skills, and there is every reason to think that this work, already successful in many areas of the curriculum, will continue to expand and develop.

3. In contrast to the main recommendation concerning the use of instructional radio for areas of instruction for which there is a clear need and no adequate local facilities, the main recommendation on computer-assisted instruction would be to aim it at the development and maintenance of basic skills, presumably in areas in which there already exists instruction. The purpose of the use of computers in these areas would be to bring these skills to a level of competence closer to acceptable norms for the given student at his age and ability level. Evidence from the use of computers in rural Mississippi for this purpose indicates that such programs can be very effective. Similar data from use in more recent years with American Indian students in a rural setting in New Mexico have been equally positive.

4. In implementing a program aimed at basic skills, whether for young students or adults, using computer-assisted instruction, there is evidence from many sources to indicate that distributed practice is desirable. This means that whenever possible the work should take place on a daily basis and not on an intermittent or irregular basis. The amount of work on a daily basis need not be large. At the elementary-school level it can, for example, be on the order of ten minutes per subject per day. In the teaching of language skills at the adult level, it can range upward to an hour a day. What is important is the organization of the effort for regular work on a daily basis.

5. A wide range of experience has indicated that it is desirable to have computer terminals clustered in a single room. This is true whether the work is being conducted at the elementary-school, secondary-school, or college level. The room in which terminals are located should be under the supervision of a proctor or teaching assistant. On the basis of a number of years of work in this area, I have concluded that the organizational problems of managing single terminals in individual classrooms are too complicated and difficult to solve, in comparison with the ease with which proctor supervision of a single room in which the terminals are clustered can be organized.

6. Because of the newness of computers in most educational settings, it is most desirable that there be held a teachers' workshop, to be attended by teachers, teachers' aides, and interested administrators, at the beginning of a program of computer-assisted instruction. This workshop should last at least a full day and should direct itself toward the practical problems that arise in operational use of CAI in a regular school setting. It has been my experience that a workshop of this kind can do a great deal to familiarize teachers with this new instructional technology and allay some of their fears about what may appear to be a new and mysterious electronic device. In fact, the programs that have been developed for computer-assisted instruction have, by and large, aimed at ease of use by students and teachers. Any new program should have similar aims for itself.

3. GENERAL CONCLUSIONS AND RECOMMENDATIONS

Particular recommendations about instructional radio have been given in Section 1.3, and particular recommendations about use of computer-assisted instruction have been given in Section 2.3. I give in this final

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part a summary of broad conclusions and recommendations about the use of educational technology in the schools and colleges.

1. There is a variety of evidence to indicate that at whatever level of education a new educational technology is introduced it is desirable that all pertinent levels of the administrative and teaching staff be aware of the introduction of the new technology, be informed as to the goals of the project, and be clear about their role in the implementation of the project. Especially in the case of computers, it is desirable that detailed information be given when asked for about the ways in which the new technology will be used and what its implications are as a method of instruction. One of the reasons for recommending a teachers' workshop in Section 2.3 is precisely to meet this need. It is also important that the teachers responsible for the individual students being provided instruction by a new medium be made aware of what exactly is expected of them. In the case, for example, of instructional radio, this may consist of doing some additional work. It also may consist of giving evaluative tests from time to time. In the case of computer-assisted instruction, it may consist of providing additional help to students who are having difficulties, and making sure that individual students are making their regular schedules at computer terminals.

2. There is a sign on the desk of an applied statistician who is a good friend of mine that says simply "see me first." The implication of this in the present context should be clear. In planning for the evaluation of the use of a new technology, it is most desirable that the evaluation plans be made in advance of the introduction of the technology. It is too often the case that plans for the evaluation of a new approach to teaching are made after the new approach has begun. It is important that,

where possible, pretest assessments be made of the students who will be a part of the project and that plans for evaluation at the end of the first year be made early.

3. The rise of satellite communications should not seriously affect the use of instructional radio or computer-assisted instruction, except for a small time delay in the two-way interaction at computer terminals, which is not long enough to disturb the students once they have had some experience.

4. Finally, in introducing a new technology, it is often most effective to begin with a pilot project and then to expand in a systematic way in each succeeding year.

Bibliography

Adams, E. Field evaluation of the German CAI Lab. In R. C. Atkinson & H. Wilson (Eds.), Computer-assisted instruction: A book of readings. New York: Academic Press, 1969.

Atkinson, C. Broadcasting to the classroom by universities and colleges. Boston: Meador, 1942. (a)

Atkinson, C. Public school broadcasting to the classroom. Boston: Meador, 1942. (b)

Beech, R. P., McClelland, S. D., Horowitz, G. R., & Forlano, G. Final report: An evaluation of the Dial-a-Drill program. New York: State Education Department, 1970.

Bitzer, M., & Boudreaux, M. Using a computer to teach nursing. Nursing Forum, 1969, 8.

Bull, C. R. Australia. In G. Bereday & J. Lauwerys (Eds.), The yearbook of education 1960—Communication media and the school. London: Evans, 1960.

Castleberry, S., & Lagowski, J. J. Individualized instruction using computer techniques. Journal of Chemical Education, 1970, 47, 91-96.

Chu, G. C., & Schramm, W. Learning from television: What the research says. Stanford, Calif.: Stanford University, Institute for Communication Research, 1967.

Fletcher, J. D., & Atkinson, R. C. An evaluation of the Stanford CAI program in initial reading (Grades K through 3). Journal of Educational Psychology, 1972, 63, 597-602.

Forsythe, R. O. Instructional radio: A position paper. Unpublished manuscript, Stanford University, 1970. (ERIC Document Reproduction Service No. ED 044 933)

Hansen, D. N., Dick, W., & Lippert, H. T. Research and implementation of collegiate instruction of physics via computer-assisted instruction, Vol. 1 (Tech. Rep. 3). Tallahassee: Florida State University, Computer-Assisted Instruction Center, 1968.

Hatano, K. Japan. In G. Bereday & J. Lauwerys (Eds.), The yearbook of education 1960—Communication media and the school. London: Evans, 1960.

Jamison, D., Fletcher, J. D., Suppes, P., & Atkinson, R. C. Cost and performance of computer-assisted instruction for compensatory education (GSB Research Rep. 20; IMSSS Tech. Rep. 175, Psych. & Educ. Ser.). Stanford, Calif.: Stanford University, Graduate School of Business and Institute for Mathematical Studies in the Social Sciences, July 1971.

Jamison, D., Suppes, P., & Wells, S. The effectiveness of alternative instructional [illegible]ia: A survey. Reviews of Educational Research, 1974, 44, 1-67.

Judd, W. A., Bunderson, C. V., & Bessent, E. W. An investigation of the effects of learner control in computer-assisted instruction prerequisite mathematics (MATHS. Tech. Rep. 5). Austin: University of Texas at Austin, Computer Assisted Instruction Laboratory, 1970.

Kinane, K. Australia's correspondence schools with support broadcast programmes and Radio University. In New educational media in action: Case studies for planners—I. Paris: UNESCO, International Institute for Educational Planning, 1967.

Macken, E., & Suppes, P. Evaluation studies of CCC elementary-school curriculum, 1971-75. CCC Evaluation Studies, 1976, 1(1).

Macken, E., van den Heuvel, R., Suppes, P., & Suppes, T. Home based education: Needs and technological opportunities. Washington, D.C.:

U.S. Department of Health, Education, and Welfare, National Institute of Education, 1976.

Madden, R. Educational radio bibliography 1954-67. Educational Broadcasting Review, 1968, 2, 66-79.

Menne, J. W., Klingensmith, J. E., & Nord, D. L. The feasibility of using taped lectures to replace class attendance. Paper presented at the meeting of the American Educational Research Association, Los Angeles, 1969. (ERIC Document Reproduction Service No. ED 027 748)

Morrison, H., & Adams, E. Pilot study of a CAI laboratory in German. In R. C. Atkinson & H. Wilson (Eds.), Computer-assisted instruction: A book of readings. New York: Academic Press, 1969.

NHK Radio-Television Cultural Research Institute. Proceedings of the second international conference of broadcasting organizations on sound and television school broadcasting. Tokyo: NHK, 1964.

Papert, S., & Solomon, C. Twenty things to do with a computer. Educational Technology, 1972, 12, 9-18.

Saettler, P. H. A history of instructional technology. New York: McGraw-Hill, 1968.

Schmelkes de Sotelo, S. Estudio de evaluacion aproximativa de las escuelas radiofonicas de la Tarahumara (Mexico). Revista del centro de estudio educativos, 1972, 2.

Schmelkes de Sotelo, S. The radio schools of the Tarahumara, Mexico: An evaluation. Stanford, Calif.: Stanford University, Institute for Communication Research, 1973.

Searle, B., & Suppes, P. The Nicaragua radio mathematics project. Educational Broadcasting International, September 1975, pp. 117-120.

Skornia, H. Educational radio: Its past and its future. In W. Schramm (Ed.), Educational television--The next ten years. Stanford, Calif.: Stanford University, Stanford Institute for Communication Research, 1962.

Smith, I. D., & Hess, R. D. The effects of computer-assisted instruction on student self-concept, locus of control, and level of aspiration (Research and Development Memorandum 89). Stanford, Calif.: Stanford University, Stanford Center for Research and Development in Teaching, 1972.

Spain, P. A report on the system of Radioprimaria in the state of San Luis Potosi, Mexico. Unpublished doctoral dissertation, Stanford University, 1973.

Suppes, P. Impact of computers on curriculum in the schools and universities. In O. Lacarme & R. Lewis (Eds.), Computers in education, IFIP (Part 1). Amsterdam: North-Holland, 1975.

Suppes, P., Fletcher, J. D., & Zanotti, M. Performance models of American Indian students on computer-assisted instruction in elementary mathematics. Instructional Science, 1975, 4, 303-313.

Suppes, P., Fletcher, J. D., & Zanotti, M. Models of individual trajectories in computer-assisted instruction for deaf students. Journal of Educational Psychology, 1976, 68, 117-127.

Suppes, P., Fletcher, J. D., Zanotti, M., Lorton, P. V., Jr., & Searle, B. W. Evaluation of computer-assisted instruction in elementary mathematics for hearing-impaired students (Tech. Rep. 200, Psych. & Educ. Ser.). Stanford, Calif.: Stanford University, Institute for Mathematical Studies in the Social Sciences, March 1973.

Suppes, P., & Morningstar, M. Computer-assisted instruction. Science, 1969, 166, 343-350.

Suppes, P., & Morningstar, M. Computer-assisted instruction at Stanford, 1966-68: Data, models, and evaluation of the arithmetic programs. New York: Academic Press, 1972.

Suppes, P., Smith, R., & Beard, M. University-level computer-assisted instruction at Stanford: 1975 (Tech. Rep. 265, Psych. & Educ. Ser.). Stanford, Calif.: Stanford University, Institute for Mathematical Studies in the Social Sciences, October 1975.

Vinsonhaler, J., & Bass, R. A summary of ten major studies of CAI drill and practice. Educational Technology, 1972, 12, 29-32.

Wisconsin Research Project in School Broadcasting. Radio in the classroom. Madison: University of Wisconsin Press, 1942.

Woelfel, N. E., & Tyler, I. K. (Eds.). Radio and the school: A guidebook for teachers and administrators. Yonkers-on-Hudson, N.Y.: World Book, 1945.

Wrightstone, J. W. Radio education. In W. S. Monroe (Ed.), Encyclopedia of educational research. New York: Macmillan, 1952.

Table 1

University-level Computer-assisted Courses at Stanford, 1972-75

Course	Number of students per academic year 1972-73	1973-74	1974-75	Avg. number of student hours at computer terminal
Philosophy 57 Introduction to Logic	56	160	209	70 for A 54 for PASS
Philosophy 161 Set Theory	-	-	12	51 for A 31 for PASS
Slavic Lang. 211 Old Church Slavonic	5	2	1	30
Slavic Lang. Bulgarian	3	0	1	35
Slavic Lang. 212 History of Russian Literary Language	4	4	4	30
BASIC Instructional Program	-	100	200	10[a]
Computer Science 206 LISP	-	-[b]	79	93[c]
Music (ear training)				
Music 21	-	42	41	d
Music 22	18	19	23	
Music 23	5	26	8	
Music 103	5	6	-	
Music 27	-	-	33	

[a]BIP students were limited to 10 hours of time for experimental reasons. During unlimited pilot runs, students have taken up to 30 hours to complete the course.

[b]During 1973-74, LISP was taught at Stanford using the IMSSS machine, but students logged in as users and there was no special CAI for LISP.

[c]LISP students spent an average of 69 hours in the LISP interpreter and 24 hours in the LISP CAI system.

[d]The students had restricted terminal time.

Table 2

Average Grade-placement Scores on the Stanford Achievement Test: Mississippi, 1967-68

Grade	Pretest[a]		Posttest		Posttest-pretest			
	Experi-mental	Con-trol	Experi-mental	Con-trol	Experi-mental	Con-trol	t	Degrees of freedom
1	1.41 (52)	1.19 (62)	2.55	1.46	1.14	0.26	3.69*	112
2	1.99 (25)	1.96 (54)	3.37	2.80	1.42	0.84	5.23*	77
3	2.82 (22)	2.76 (56)	4.85	4.04	2.03	1.26	4.64*	76
4	2.26 (58)	2.45 (77)	3.36	3.17	1.10	0.69	2.63*	131
5	3.09 (83)	3.71 (134)	4.46	4.60	1.37	0.90	3.43*	215
6	4.82 (275)	4.36 (160)	6.54	5.48	1.72	1.13	5.18*	433

Note. From Suppes and Morningstar (1969).

[a]Values in parentheses are numbers of students.

*$p < .01$.