SURVEY OF THE INSTRUCTIONAL USE OF RADIO, TELEVISION, AND COMPUTERS IN THE UNITED STATES

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In this survey we provide an overview of the instructional use of radio, television, and computer-assisted instruction in the United States. We refer to a number of more extensive publications. It is to be emphasized that the literature on the subject matter of this survey is now enormous, even when the survey is restricted to the United States. A survey that covers the three media that are the concern of this survey, with particular emphasis on the evaluation of their effectiveness, is to be found in Jamison, Suppes, and Wells (1974). Other references are given in the text.

I. EDUCATIONAL RADIO

Radio broadcasting for educational purposes began in the United States in the early 1920s, and, although its visibility has decreased with the advent of television, usage has increased steadily. As of January, 1976, approximately 10 percent of the nation's 8,000 radio stations were classified as educational (“Weekly AM-FM Agenda,” 1976). Of the educational stations, 784 were FM and 25 AM. The 168 stations affiliated with the Corporation for Public Broadcasting (CPB) are on the air at least 16 hours per day, 7 days per week. Many other stations are affiliated with universities and school systems; these generally have less extensive broadcast schedules.

As these figures indicate, many hours a week are devoted to educational broadcasting. However, relatively little of this time is used for direct instruction. A recent survey of 121 stations affiliated with CPB (Corporation for Public Broadcasting, 1973) showed that during fiscal year 1972, 647,738 hours of broadcasting were allocated as follows:

- 84.3% educational, informational, and cultural programming;
- 2.7% in-school or in-service programming;
- 13.0% all other.

In-service programs are those directed to teachers. This category and programs providing instruction to children constitute together less than 3 percent of total broadcast time.

Several broadcasting networks have been formed to facilitate the distribution of program material for school broadcasting. The National Educational Radio Network selects and distributes outstanding instructional radio series produced by member stations. Seventeen states have interconnected networks in educational radio which operate on a state-wide basis to share live programming.

Among the types of programs used in schools are news reports, broadcasts of students' creative work, dramatizations of biographies and historical events, travelogues, musical programs, and talks by prominent scientists, authors, and others. Often, direct instruction is provided in specialized subjects for which schools do not have adequate resources, including foreign languages and music.

Several technological advances are likely to affect the use of radio for instruction. Multiplexing, which permits one or more additional signals to be carried on the side bands of a main channel transmission, is being developed to allow two-way communication between the program source and the
listener. Continuing-education programs for physicians make significant use of this technology.

Other technological developments that can be used in conjunction with radio are the electrowriter, slow-scan (still-picture) television, and computer-telephone systems that will allow the collection of immediate audience-response data.

Despite the widespread use of radio for instructional purposes, there has been relatively little systematic research on its effective use. In a broad survey of instructional radio, Forsythe (1970) cites 13 experimental studies, all but 3 of which were published before 1947. Although the evidence is relatively old, Forsythe concludes:

There can be no doubt that radio is an effective instructional tool. While it has never been subjected to the intense experimental scrutiny focused on television, the accumulated evidence is no less positive.

Jamison et al. (1974) cite studies of the effectiveness of instructional radio in other countries as well as the United States and reach a similar conclusion, that "instructional radio (supplemented with appropriate printed material) can be used to teach most subjects as effectively as a live classroom instructor or instructional television."

In an attempt to build a broader research basis for this conclusion, we have recently undertaken an investigation of the use of radio for classroom instruction in primary-school mathematics. In this work, the Institute for Mathematical Studies in the Social Sciences, funded by the United States Agency for International Development, is working with the Ministry of Education of Nicaragua to develop mathematics lessons that are broadcast daily to primary-school classrooms. Lessons are characterized by a high rate of student response; children work approximately 50 mathematics exercises during the course of a half-hour broadcast, answering orally and in writing (Searle, Friend, & Suppes, in press).

In a broad program of research, the Institute is studying effectiveness of instruction, developing techniques for using data on student performance to improve curriculum, and exploring new ways of exploiting radio as an instructional tool. Preliminary results support the conclusion of Jamison et al. (1974) cited above: Students learning mathematics by radio score at least as well on an achievement test as students in traditional classrooms.

Chu and Schramm (1967), comparing the use of radio and television, examined the issue of whether visual images increase learning. Most of the research that they review used film to provide visual images. In one group of experiments, student learning was greater when pictures were combined with audio; in another the addition of pictures to audio resulted in no increase in learning; and, in a third, the combination of audio and visual images resulted in decreased learning as compared with audio only. Chu and Schramm conclude from these results:

The effects of visual images upon learning do not seem to be uniformly beneficial. Whether visual images will have beneficial effects, or no effects, or even adverse effects, seems to depend on the kind of learning task involved.

They go on to speculate that whether visual images have much to contribute depends on whether the learning task is essentially visual or not. If the learning task is not visual, and if the images do not facilitate the association process...then chances are that presentation of visual images would impair learning. Visual images would by definition be irrelevant.

Chu and Schramm raise an important issue that bears directly on the relative effectiveness of radio and television for instruction. This and many other questions about how best to exploit radio for instructional purposes remain unanswered and await further research.

II. EDUCATIONAL TELEVISION

The use of television for instruction has come, in the last generation, to eclipse the use of radio for that purpose in the United States, and the greater proportion of the research literature devoted to television reflects this fact. Nevertheless, television plays a relatively small role in schools, as compared with traditional instruction. Approximately $58 billion is spent annually to support
American schools; of this amount, approximately $12 million is for school television (Breitenfeld, 1970). At the end of 1975, the United states had 702 commercial and 259 noncommercial stations. Many of the noncommercial stations are operated by public and private school systems and colleges; this is true, for example, of about half of the 13 educational TV stations in California (Television Factbook), and similar proportions obtain in other states.

Television signals may be distributed to schools in three ways: closed-circuit television, Instructional Television Fixed Service (a low-power broadcast technique), and broadcast television. Closed-circuit television usually refers to a system that contains both the source and reception points for television signals. However, the term is also used to refer to systems that use an antenna to receive a signal that is then transmitted throughout a building or campus. Such systems might more properly be called internal-distribution systems. Many universities have such systems, and they are sometimes operated on a state-wide basis. For example, Delaware has a State Center for Educational Television, and signals are distributed to all schools, which in turn have their own distribution systems.

The term "Instructional Television Fixed Service" (ITFS) is the name given by the Federal Communications Commission (FCC) to the segment of the electromagnetic spectrum between 2500 and 2690 megacycles, which the FCC has set aside for the exclusive use of educators. ITFS signals have a coverage radius of from 8 to 25 miles and can usually cover an entire school system. ITFS use, although small, is increasing; as of 1974, 184 licenses and permits had been awarded by the FCC (Television Factbook, 1975).

Most broadcast television for educational purposes is provided by noncommercial educational TV stations (sometimes called "public TV"), and this is the most familiar use of television in schools. However, this use is typically relatively inflexible and therefore incompatible with classroom instruction schedules in diversified school districts.

Television is used for instruction at all levels of the school system, and the research literature contains many studies of its effectiveness. Jamison et al. (1974) survey this literature and conclude that television "can teach all grade levels and subject matters about as effectively as traditional instruction." Table 1, taken from Chu and Schramm (1967), presents the results of 421 comparisons between instructional television and traditional instruction. In fewer than 20 percent of these studies does traditional instruction produce greater achievement than instructional television. As Chu and Schramm remark:

There is no longer any reason to raise the question whether instructional television can serve as an efficient tool of learning. This is not to say that it always does. But the evidence is overwhelming that it can, and under favorable circumstances does...The question of whether the situation calls for instructional television is one that has to be answered in terms of needs, availabilities, and alternatives. Many reports have noted that television is often used unimaginatively, in ways that do not exploit its unique capabilities. Jamison et al. (1974) suggest that, at least in some studies, this can be attributed to the requirements of experimental design. They remark that when highly stringent controls are imposed on a study, the nature of the controls tends to force the methods of presentation into such similar formats that one can only expect the "no significant differences" that are in fact found. When ITV is used in a way that takes advantage of the potential the medium offers—
as, perhaps, with Sesame Street—we would expect more cases of significant differences between the experimental group and the “alternative treatment”...group.

The Research and Development Office of the National Association for Educational Broadcasters (1970) provides an extended catalogue of applications of television to instruction that illustrates a variety of uses beyond the presentation of lectures or TV-classroom instruction. Of their 22 types of usage, we will discuss only a few.

Internal-distribution TV is capable of providing visual displays for group viewing that involve closeups or magnification. It can be used in this way with laboratory materials and experiments, graphic pieces, book pages, computer output, and so forth, giving a front-seat view to every student.

Providing specimens for behavioral analysis is a second capability of TV that could be much more thoroughly exploited. For example, in the fields of music, speech training, or practice teaching, either exemplary performances or, with videotape, the student’s own behavior can be viewed and analyzed.

Television can provide drill exercise in such areas as calisthenics and language learning where students can be expected to benefit from group responses on an appropriate iterative schedule. Such structured and systematic drill is likely to be of more benefit than similar efforts mounted by the classroom teacher.

These uses exemplify ways that television can provide an experience for the student that is beyond the capabilities of the ordinary teacher in the ordinary program and is at the same time an integral part of the total curriculum. Few of the present educational TV programs in the United States meet the stringent criterion of using the medium imaginatively in the context of an instructional program. As the NAEB report points out:

The most frequent application of television in instruction nowadays comes under [the] general rubric [of Materials for Curricular Enrichment], by which is meant the classroom showing of unitary (or series) programs structured to heighten the student’s interest in some typical compartment of the regular curriculum. Customarily programs of this kind... are regarded as supplementary and extraordinary, with their main emphasis being on special motivation and affect. The usual practice is to allow teachers to opt for the inclusion of such enrichment materials on a purely individual basis.

Although television is largely used for supplemental purposes, there are many school systems that have integrated television into the instructional program in a more fundamental way. The oldest of such programs is that in Washington County, Maryland, serving the communities surrounding Hagerstown. Transmission began in 1956 and by 1960 reached 100 percent coverage in all 12 grades in the County school system. The system remains in operation, and recent results are described in a report by the Washington County Instructional Television Evaluation Committee (1973). In 1972 the average student received 117 hours of instruction, decreased somewhat from the maximum in 1968 (Wells & Klees, 1974). Wade (1967) reports on evaluation results of the system, documenting achievement gains in many subjects at many grade levels. One striking finding is that after three years of television, achievement in rural schools (where students had originally averaged one-quarter to one-half a grade below urban students) increased to a point where achievement was comparable with that in urban schools.

Wade remarks that “this suggests that television’s ability to share the best teaching may have had an effect.”

Children’s Television Workshop (CTW) has given great impetus to the innovative use of TV for instruction in its programs Sesame Street and The Electric Company. In Sesame Street, its first effort, CTW undertook to use popular television techniques to teach preschoolers basic cognitive skills like recognition of letters and simple counting. The series was designed for casual as well as systematic viewing and did not embody a cumulative or sequential instructional program. It was
meant for either home or school viewing, and the first-year evaluation (Ball & Bogatz, 1970) showed that children viewing at home made gains as great as, and in some cases greater than, children who watched in school under the supervision of a teacher.

A central feature of CTW's methods was the close cooperation between production and research staffs. Research was, from the outset, considered an essential component of program production, and between 10 and 15 percent of the Workshop's initial two-year budget was allocated to this function (Lesser, 1974). Lesser remarks:

We eventually assigned our highest priority to observing children's responses to our televised segments as they were being developed, and modifying them according to the children's reactions. Although we knew that problems between researchers and producers might arise, we also knew that child-watching research was essential.

The model used by CTW was that advocated by Chu and Schramm (1967), who concluded that "one of the chief residues of the last ten years of activity with programmed instruction is the mountain of evidence that more effective learning experiences can be developed by testing materials on students, revising, testing again, and so on." CTW has shown that, with sufficient resources, the melding of formative evaluation and production efforts can lead to educational television programs that are both engaging and instructive.

III. COMPUTERS

Computer-assisted instruction (as it has come to be termed in the literature), that is, the use of computers for instructional purposes, is the most expensive of the three technologies surveyed in this paper and also the most highly individualized in the character of the interaction between student and curriculum. The first projects in computer-assisted instruction began in the early 1960s, mostly in university research centers. It was only since about 1970 that computers have been used extensively for instruction in school districts throughout the United States, and the percentage of students affected is still relatively small, although the total number of projects in itself is now, in absolute terms, large.

We break this survey into the three natural levels of schooling in the United States: elementary school, secondary school, and college.

Elementary School

The main use of computers at the elementary-school level has been in supplementary drill-and-practice programs aimed at the basic skills of reading, mathematics, and language. Vinsonhaler and Bass (1972) surveyed over 30 separate experiments involving more than 10,000 students comparing the effectiveness of computer-assisted-instruction drill and practice at this school level with traditional instruction. They concluded that "there appears to be rather strong evidence for the effectiveness of CAI (computer-assisted instruction) over traditional instruction where effectiveness is measured

Table 2: Average Grade-placement Scores on the Stanford Achievement Test:
Mississippi, 1967-68

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<thead>
<tr>
<th>Grade</th>
<th>Experimental Posttest</th>
<th>Control Posttest</th>
<th>Posttest-posttest</th>
<th>t</th>
<th>Degrees of freedom</th>
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<tr>
<td></td>
<td>Pretest</td>
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<tr>
<td>1</td>
<td>1.41 (52)</td>
<td>1.19 (82)</td>
<td>2.55</td>
<td>1.46</td>
<td>1.14</td>
</tr>
<tr>
<td>2</td>
<td>1.99 (25)</td>
<td>1.96 (54)</td>
<td>3.37</td>
<td>2.80</td>
<td>1.42</td>
</tr>
<tr>
<td>3</td>
<td>2.82 (22)</td>
<td>2.76 (56)</td>
<td>4.85</td>
<td>4.04</td>
<td>2.03</td>
</tr>
<tr>
<td>4</td>
<td>2.36 (55)</td>
<td>2.45 (77)</td>
<td>3.36</td>
<td>3.17</td>
<td>1.10</td>
</tr>
<tr>
<td>5</td>
<td>3.09 (83)</td>
<td>3.71 (134)</td>
<td>4.46</td>
<td>4.60</td>
<td>1.37</td>
</tr>
<tr>
<td>6</td>
<td>4.82 (275)</td>
<td>4.36 (160)</td>
<td>6.54</td>
<td>5.48</td>
<td>1.72</td>
</tr>
</tbody>
</table>

Note: From Suppes and Morningstar (1969).

* Values in parentheses are numbers of students.
* p < .01.
by standardized achievement tests." Additional extensive data on such programs are to be found in Suppes and Morningstar (1969); Beech, McClelland, Horowits, and Forlano (1970); Jamison, Fletcher, Suppes, and Atkinson (1971); Smith and Hess (1972); and Fletcher and Atkinson (1972). The last reference is especially concerned with evaluation of the use of computers for teaching initial reading.

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) 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.

An extensive area of experimentation at the elementary-school level in the Institute has been work with handicapped students, especially deaf students. 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 (in press).

A number of recent experiments on elementary-school reading and mathematics have been initiated as part of the PLATO Project at the University of Illinois, and evaluation reports will be forthcoming concerning this work.

Still another and different direction of work is exemplified by the activities of Seymour Papert and his collaborators at the Massachusetts Institute of Technology. They are especially concentrating on teaching children problem-solving skills and the beginning elements of computer programming. Their program is in contrast to those mentioned already that have concentrated on supplementary drill and practice in the basic skills. A good account of their work is to be found in Papert and Solomon (1972).

Finally, it should be mentioned that a number of operational projects not primarily concerned with research and development but with ordinary classroom practice are now to be found in the United States. Drill-and-practice programs are offered commercially by Computer Curriculum Corporation (Palo Alto, California) and are found in school districts all over the United States. As of the writing of this article, we would conservatively estimate that there are several thousand terminals dedicated to drill-and-practice programs in elementary schools around the country and somewhere between 75,000 and 100,000 students involved.

Secondary School

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.

**College**

The situation is quite different at the college level. A number of specific experiments have been conducted, and systematic evaluation has been undertaken. We mention here some typical examples.

Hansen, Dick, and Lippert (1968) of Florida State University reported results of implementing collegiate 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 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). Recently there has been an extensive effort at Stanford in the teaching of introduction to logic and axiomatic set theory by computer. This work

<table>
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<th>Table 3 University-level Computer-assisted Courses at Stanford, 1972-75</th>
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<tr>
<td><strong>Course</strong></td>
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<tr>
<td>Philosophy 57</td>
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<tr>
<td>Introduction to Logic</td>
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<tr>
<td>Philosophy 161</td>
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<tr>
<td>Set Theory</td>
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<tr>
<td>Slavic Lang. 211</td>
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<tr>
<td>Old Church Slavonic</td>
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<tr>
<td>Slavic Lang.</td>
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<tr>
<td>Bulgarian</td>
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<tr>
<td>Slavic Lang. 212</td>
</tr>
<tr>
<td>History of Russian Literary Language</td>
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<tr>
<td>BASIC Instructional Program</td>
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<tr>
<td>Computer Science 206</td>
</tr>
<tr>
<td>LISP</td>
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<tr>
<td>Music (ear training)</td>
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<tr>
<td>Music 21</td>
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<td>Music 22</td>
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<tr>
<td>Music 23</td>
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<tr>
<td>Music 103</td>
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<td>Music 27</td>
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</tbody>
</table>

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 IMSSSS 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.
is reported in Goldberg and Suppes (1974), Smith, Graves, Blaine, and Marinov (1975), and Suppes (1975). A detailed survey of the use of computers for instruction at Stanford is to be found in Suppes, Smith, and Beard (1975). We show as Table 3 the list of courses currently offered at Stanford.

Concerning college-level use of computers, the broad summary of Jamison et al. (1974) continues to be supported. 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 saving by enabling the course load of instructors in classes of no more than three or four students to be considerably increased.

IV. CONCLUDING REMARKS

The three instructional technologies we have surveyed in this article have strikingly different characteristics as instructional delivery systems. They also have strikingly different cost characteristics. Nevertheless, it would be our prediction that all three delivery systems will see increasing use in the decades ahead. Radio seems especially important for developing countries, and we would predict a much more extensive use of radio in developing countries than in the United States. The instructional use of television is continuing to increase in the United States. Because of pressures on the budgets of community colleges and other institutions of higher education, we would anticipate wider use of instructional television at the college level. It is also our belief that the same pressures that exist in the United States are present in other parts of the world and will lead to a much broader use of television for instructional purposes, especially the kind of instruction that replaces ordinary classroom instruction.

Finally, the most expensive and the most sophisticated technology, i.e., computer technology, has a solid operational base in the United States. We anticipate that this base will expand and that the use of computers at all levels of instruction will continue to expand in the United States. The number of projects in computer-assisted instruction outside of the United States known to us is still small but we would also anticipate an increase in the use of computers for instruction in other parts of the world throughout the remainder of this century.

We have not attempted to project in quantitative terms the growth rate of any of the three technologies, but a conservative 5 to 10 percent growth rate per year seems likely as a lower bound. The greatest continued reductions in cost will almost surely be in computer technology. Quite powerful and sophisticated computing systems will be available for extensive educational use at relatively low cost by the year 2000.

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