Instructional usage of microcomputers in elementary mathematics curriculum

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Instructional usage of microcomputers in elementary mathematics curriculum

Abstract
It has been observed, by the researcher, that during the last five years schools have increasingly used microcomputers in their elementary curricula. In a recent study, Chambers and Bork (1980) selected a sample of 974 school districts, which closely approximated the total U. S. public schools, and conducted a survey in order to assess the current and projected use of the computer in the U. S. public secondary and elementary schools. It was found that nearly 90% of the responding school districts were using the computer in support of the instructional process; this is a dramatic change from the past. Starting with an estimated 13% in 1970, instructional computer usage had increased to 74% in 1980, with an anticipated 87% usage in 1985. The study projected that computer assisted learning will be used by more school districts than any other type of computer application. Usage was anticipated to increase from 54% in 1980 to 74% in 1985.
INSTRUCTIONAL USAGE OF MICROCOMPUTERS IN ELEMENTARY MATHEMATICS CURRICULUM

A Research Paper
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Stephen J. Bloom
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Date Approved

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Date Approved

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Instructional Usage Of Microcomputers In Elementary Mathematics Curriculum

The Problem

Introduction

It has been observed, by the researcher, that during the last five years schools have increasingly used microcomputers in their elementary curricula. In a recent study, Chambers and Bork (1980) selected a sample of 974 school districts, which closely approximated the total U. S. public schools, and conducted a survey in order to assess the current and projected use of the computer in the U. S. public secondary and elementary schools. It was found that nearly 90% of the responding school districts were using the computer in support of the instructional process; this is a dramatic change from the past. Starting with an estimated 13% in 1970, instructional computer usage had increased to 74% in 1980, with an anticipated 87% usage in 1985. The study projected that computer assisted learning will be used by more school districts than any other type of computer application. Usage was anticipated to increase from 54% in 1980 to 74% in 1985.

The National Council of Teachers of Mathematics stated in An Agenda for Action: Recommendations for
School Mathematics of the 1980's (NCTM, 1980) that "...computers should be integrated into the core mathematics curriculum", that they "...should be used in imaginative ways for exploring, discovering, and developing mathematical concepts", and that the computer activities should "...fit the goals and objectives of the program" (p. 9).

Statement of the Problem

Microcomputers are in widespread use in the elementary school. In the future, most people agree that this technology will be used in a variety of professions. There is concern that the value of this technology, as a teaching aid, may not be as permanent. Rather than embracing the microcomputer as an instructional aid, uncritically, teachers may reasonably ask, "How effectively are microcomputers presently being used in the elementary mathematics curriculum?"; "Can the technology provide instructional experiences beyond the teachers' current capabilities?"; "How might the technology alter the teacher's role?"; "How has and how will the inclusion of microcomputers change the curriculum?"; and "How might microcomputers be best utilized in the elementary mathematics curriculum?".

The problem, addressed by this investigation, was
to determine how microcomputers could best be incorporated into the mathematics curriculum of the elementary school.

Through a review of the related literature and current research, this investigation developed a set of guidelines concerning the instructional utilization of microcomputers in the elementary mathematics curriculum.

**Procedures in Obtaining Research Literature**

In order to obtain the necessary related literature, the researcher made extensive use of both the Educational Resources Information Center (ERIC) and the Microcomputer Information Services databases. This entailed use of the Iowa Network for Obtaining Resource Materials for Schools (INFORMS), undertaken through the facilities of Area Education Agency-Seven, and an ERIC computer search, undertaken through the facilities of the University of Northern Iowa Library. The sources listed were referenced in either Resources in Education (RIE) or the Current Index to Journals in Education (CIJE). The materials were obtained at the Drake University Library, the University of Northern Iowa Library, or the Area Education Agency-Seven Media Center.

Research studies reviewed by various authors
provided references to original sources which the researcher then obtained. Information gathered from these sources was organized and investigated for the following major areas related to the problem: the present usage of microcomputers in the elementary curriculum and the effectiveness of computer based instruction in elementary school mathematics.

Review of the Literature

Literature Regarding Instructional Computer Usage

Mathematics educators have shown an increased interest in the utilization of computer technology in the past ten years. With the invention of the microcomputer in the 1970’s, the actual and anticipated utilization has grown (see Table 1). Other factors encouraging computer utilization have been the recognition of the need for better means of individualizing instruction and an appreciation of the many ways the technology can improve the instructional management responsibilities which are required within the total instructional system.

Instructional usage of microcomputers represented the largest percentages of both the current utilization and the anticipated utilization of computer technology in education (see Table 1).
### Table 1

<table>
<thead>
<tr>
<th></th>
<th>Actual</th>
<th>Anticipated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Year % of school districts sampled</td>
<td>Year % of school districts sampled</td>
</tr>
<tr>
<td>Districts using computers</td>
<td>1980 90%</td>
<td>1985 94%</td>
</tr>
<tr>
<td>Instructional usage</td>
<td>1970 13%</td>
<td>1985 87%</td>
</tr>
<tr>
<td></td>
<td>1980 74%</td>
<td></td>
</tr>
</tbody>
</table>


Instructional usage of microcomputers was, for purposes of this review, divided into two broad categories, computer assisted instruction and computer managed instruction.

Computer assisted instruction, CAI, was defined as a teaching process directly involving the computer in the presentation of instructional materials in an interactive mode to provide and control the individualized learning environment for each individualized student. These interactive modes
are usually subdivided into drill-and-practice, tutorial, simulation and gaming, and problem-solving. (Splittgerber, 1979, p. 20)

Computer managed instruction, CMI, was defined as an instructional management system utilizing the computer to direct the entire instructional process, including perhaps CAI as well as traditional forms of instruction which do not require the computer such as lectures and group activities. CMI has some or all of the following characteristics: organizing curricula and student data, monitoring student progress, diagnosing and prescribing, evaluating learning outcomes, and providing planning information for teachers. (Splittgerber, 1979, p. 20)

The operation of CMI programs began in 1968. During the 1970's much activity in the development of these programs occurred. All the early CMI programs were based in large time-sharing computer systems and were developed at the Systems Development Corporation for the Southwest Regional Educational Laboratory at Los Angeles, the Pittsburg Learning Research and Development Center, the American Institute for Research or the Individualized Mathematics Curriculum Project at the
University of Wisconsin. Little research came from the development of these programs. In a review of these systems, Baker (1978) traced their development and reported their status. The author reported that the lack of research devoted to these CMI systems could be traced to an emphasis on "...getting something to work" (p. 63). In speculating on the future of CMI the author stated the following: "The success of future CBIM systems depends on a definition of individualization, on improved curriculum, on better diagnostic and prescriptive techniques, and on an adequate conceptualization of the teacher as the manager of an educational enterprise" (p. 68).

This researcher found it interesting that these same factors exist today along with newer concerns related to the new microcomputer technology, such as hardware limitations (memory capacity), computer independence (one machine not being dependent or connected to some larger computer system), and teacher training (learning to implement CMI systems oriented to a machine that can be utilized by almost any teacher).

Little research regarding the usage and/or the effectiveness of CMI in the elementary mathematics curriculum has been done. Dissertation studies have
compared the achievement and/or attitudes of students who experienced CMI with students in traditional classrooms. Six studies reported positive results that favor CMI students over non-CMI students, although these differences are seldom significant (see Table 2).
Table 2

Dissertation Studies Comparing Achievement and/or Attitude of CMI Students with Non-CMI Students

<table>
<thead>
<tr>
<th>Name of researcher</th>
<th>Year of study</th>
<th>Grade level</th>
<th>Achievement</th>
<th>Attitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miller, Daniel</td>
<td>1970</td>
<td>6</td>
<td>s</td>
<td></td>
</tr>
<tr>
<td>Miller, Donald</td>
<td>1970</td>
<td>6</td>
<td>s</td>
<td></td>
</tr>
<tr>
<td>Lee</td>
<td>1972</td>
<td>5</td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>Akkerhuis</td>
<td>1974</td>
<td>6</td>
<td>s</td>
<td>ns</td>
</tr>
<tr>
<td>Wilkins</td>
<td>1975</td>
<td>8</td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>Chanoine</td>
<td>1977</td>
<td>4-6</td>
<td></td>
<td>+</td>
</tr>
</tbody>
</table>

Note. + = differences in favor of computer students
s = differences significantly in favor of computer students
ns = differences not significant

From "Computers" by M. Vere DeVault in Mathematics Education Research: Implications for the 80's (Ed.)

Because of the recency of the technology, studies regarding the usage and/or the effectiveness of CAI, based only on microcomputer oriented systems, in the elementary mathematics curriculum, have not been numerous. Due to this fact the research reported herein was based mainly on non-microcomputer oriented systems.

An examination of the evolution of CAI materials
revealed that the first evidence of instructional usage for mathematics began a little more than a decade ago. The Computer Curriculum Corporation (CCC), under the direction of Patrick Suppes, and the mathematics program included in Programmed Logic for Automated Teaching Operations (PLATO), under the direction of Robert Davis, represent the most extensive CAI programming and research efforts in mathematics education during the 1970's. The content of these CAI efforts has a substantial developmental history. Both Suppes and Davis were greatly involved in the development, implementation, and dissemination of mathematics programs for the schools during the period of the new math. Both worked extensively with the schools and directly with the children in those schools. Both developed school program materials that were initially supported by research and development funds. Later editions of the materials have been made available to schools through commercial publishing companies.

Several points may be made concerning these two programs. They function on two of the largest computer systems set aside for instructional use. Both programs have been analyzed throughout their development in order to ascertain their effectiveness. Suppes' data was
gathered from a wider range of the population than was Davis' research. The intended use of both programs has been that of a supplement to traditional classroom activities; Davis' program included drill and practice along with other CAI instruction while Suppes' program focused primarily on drill and practice.

Several research studies regarding the CCC mathematics instruction program have been reported (Crandall, 1977; Macken & Suppes, 1976; Poulsen & Macken, 1978; Suppes, 1979). The following four points summarize the research findings of the CCC program:

(1) Time children spent at CAI terminals was positively related to their achievement.
(2) Actual achievement gains exceeded expected gains based on previous experience of the subjects.
(3) Grade placement, as determined by the CAI program, was highly correlated with grade placement on standardized tests.
(4) Attitudes of students and teachers toward CAI were positive.

A major research project designed to determine the effectiveness of PLATO mathematics took place during the 1975-76 school year. Students in twelve classrooms using PLATO mathematics were matched with students in
classrooms that did not use the computer. At every grade level, students using the computer made significantly greater achievement gains than students in the control group on measures associated with the program as well as on computation and applications subtests of the California Test of Basic Skills (Swinton, Amarel & Morgan, 1978).

Another finding was the positive attitudes exhibited by the students and teachers using the program.

On every single attitude question used, differences strongly favorable to PLATO were observed. Pupils were enthusiastic about the mathematics lessons which the computer presented on the TV-like screens, may [sic] students sought extra sessions, their attitudes toward mathematics improved (as measured by a questionnaire), and so did their attitudes toward their own ability to deal with mathematics. Teacher assessments, though inevitably subjective, were very strongly positive, including even reports that PLATO had decreased anti-social behavior. (Davis, 1980, p. 9)

The following extremely important teacher factor in this study has been reported by the researchers: 
"Teacher effects are real, large, and idiosyncratic" (Swinton, Amarel & Morgan, 1978). The idea that this program is not teacher proof, in fact the researchers reported that the PLATO system was received differently by children in classrooms of different teachers, is a potentially large flaw in any study. The researchers acknowledged this and reported that teachers performed most effectively when they were given control over the curriculum. This is more apparent at the present time, with the use of microcomputers in individual classrooms, under individual teacher's control, than with Suppes' CCC program. In that program students were scheduled at CAI terminals out of the classroom and management diagnosis and prescription decisions were designed and built into the program.

Beyond the research and development efforts of Suppes and Davis, there were many projects reported in the 1970's. Four of these studies, comparing achievement and attitudes of students using computers with noncomputer students, are presented in Table 3.
### Table 3

<table>
<thead>
<tr>
<th>Researcher</th>
<th>Year</th>
<th>Grade</th>
<th>Program Type</th>
<th>Achievement</th>
<th>Attitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Street</td>
<td>1972</td>
<td>3-7</td>
<td>Drill &amp; practice</td>
<td>ns</td>
<td>-s</td>
</tr>
<tr>
<td>Martin</td>
<td>1973</td>
<td>3,4</td>
<td>Drill &amp; practice</td>
<td>+ *</td>
<td>+</td>
</tr>
<tr>
<td>Milner</td>
<td>1973</td>
<td>5</td>
<td>Programming</td>
<td>ns</td>
<td>+</td>
</tr>
<tr>
<td>Morgan</td>
<td>1977</td>
<td>3-6</td>
<td>Drill &amp; practice</td>
<td>s</td>
<td>+</td>
</tr>
</tbody>
</table>

**Note.**
- s = differences significantly in favor of computer students
- -s = differences significantly in favor of noncomputer students
- + = differences in favor of computer students
- ns = differences not significant
- * = fourth-grade boys and low-ability students achieved more than others

From "Computers" by M.Vere DeVault in *Mathematics Education Research: Implications for the 80's* (Ed.)

In a recent study (Burns & Bozeman, 1981), the researchers synthesized the data from previous CAI research efforts. The studies were selected according to carefully established criteria (such as: CAI utilized as a supplement to, not replacement for, traditional...
classroom instruction, CAI utilized in conjunction with mathematics instruction, outcome variable was student achievement). Forty studies were selected which met the pre-established criteria. Using the technique of meta-analysis the data from the forty studies was analyzed.

The primary findings of this study were:

1. Student achievement was greater in mathematics instructional programs supplemented with CAI than with only traditional instructional methods.
2. CAI drill-and-practice programs were significantly more effective at raising achievement among high achieving and disadvantaged students than it was for students of average achievement.
3. The inclusion of supplemental CAI significantly affected achievement gains among boys at the intermediate grade level. It was not shown to support an analogous conclusion relative to intermediate level girls' achievement.
4. Tutorial CAI supplemented instruction was significantly more effective in promoting increased mathematics achievement among disadvantaged students.
5. There was no evidence to suggest the existence
of a relationship between experimental design features and study outcomes.

Through the analysis and synthesis of many studies, Burns and Bozeman (1981) pointed out that significant enhancement of learning in mathematics can be achieved through the use of CAI. However, the authors qualified this by stating, "...the effectiveness of CAI or any other instructional support system will be influenced by a host of variables, some uncontrollable. Failure to consider the mitigating effects of such variables will lead to a wide variance in levels of success" (p. 37).

The results of the CMI and CAI research regarding elementary mathematics content showed increased student achievement and positive attitudes, both of students and teacher, toward using computers. This researcher examined factors impeding the implementation of CMI and CAI programs into the elementary mathematics curriculum. Several of these factors were presented in a review of literature done by Denyse Forman (1982). The author stated the following five impediments which had been reported in previous investigations:

(1) There is a lack of funding to support purchase of hardware, and software, and to establish the needed support services for the successful
integration of the computer programs into the educational system.

(2) The confusing diversity of computer languages and hardware systems exists due to the relative infancy of the technology.

(3) More and better CAI materials which will run on a variety of hardware systems are needed.

(4) An overall lack of knowledge among educators regarding how to effectively use CAI materials and the computer in the learning situation is prevalent.

(5) There is an attitude among educators, familiar with and comfortable using traditional instruction and testing methods, that the technology is not simply another instructional tool but a machine destined to replace them.

Four impediments to implementation were reported by Chambers and Bork in their report. In order of importance they were found to be (a) funding, (b) lack of knowledge about computer assisted learning and computers, (c) attitudes of faculty, and (d) need for more and better computer assisted learning programs (Chambers & Bork, 1980).
Dessart (1981) has reviewed the historical development of the mathematics curriculum of the elementary school. In his review, the author mentioned the modern mathematics movement of the 1950's and the 1960's, in which formalism and understanding were the emphasis, the back to the basics mathematics movement in which drill was again the primary instructional strategy, and the problem-solving focus expressed by the National Council of Teachers of Mathematics (NCTM, 1980). Also mentioned was a broadened view of basic skills, which was proposed by the National Council of Supervisors of Mathematics (NCSM, 1977).

This researcher has adopted the recommendation, as proposed by both the National Council of Teachers of Mathematics (NCTM) and the National Council of Supervisors of Mathematics (NCSM), that the mathematics curriculum of the elementary school should encompass more than computational facility. The curriculum should include the following ten areas:

(1) Problem solving

(2) Applying mathematics to everyday situations

(3) Alertness to the reasonableness of results

(4) Estimation and approximation
(5) Appropriate computational skills  
(6) Geometry  
(7) Measurement  
(8) Reading, interpreting, and constructing tables, charts, and graphs  
(9) Using mathematics to predict  
(10) Computer literacy  

Each of these ten areas relate to skills necessary for each student who wishes to be able to realize expanding educational and employment opportunities. From a pedagogical view, these ten skill areas allow for a wide variety of instructional activities and strategies.  

The NCSM position underscores the fundamental belief of the National Council of Supervisors of Mathematics that any effective program of basic mathematical skills must be directed not "back" but forward to the essential needs of adults in the present and future (NCSM, 1977).  

Literature regarding Instructional Computing in the Elementary Mathematics Curriculum  

Since 1982, the number of schools using microcomputers increased 60 percent. By 1983, there were more than 24,000 public schools using
microcomputers in instruction. Computers are finding their way into elementary classrooms in increasing numbers. In fact Market Data points out that elementary schools are the fastest growing microcomputer users. (Hashisaki, 1984, p.v)

Accompanying the introduction of microcomputers into the elementary mathematics curriculum has been the need for the development of guidelines for the utilization of this new technology. The development of these guidelines needs to be based on the following four basic curricular considerations, as stated by Trafton (1980).

1. Mathematical needs of the students
2. Organization of the curriculum
3. Instruction and learning input
4. Continuity and change in curriculum development

Several studies have noted impediments to the implementation of computers in schools (Chambers & Bork, 1980; Forman, 1982). The present investigation attempted to review studies in which the instructional usage of microcomputers in elementary mathematics curriculum was researched. Due to the implementation hinderences discussed, few studies regarding
microcomputer usage in elementary mathematics were found. What this researcher has presented was a compilation of those few studies and the opinions of experts and/or practitioners in the area of elementary mathematics.

The effectiveness of implementing changes into any existing curriculum is dependent upon the amount of planning done prior to the implementation. Focusing on microcomputers, Filliman (1983) discussed the need for each district to develop a "...well-devised" (p. 56) plan. The author stated that such a plan needs to contain, at least, the following four components: (a) long-range and short-range goals, (b) provisions for staff development, (c) software evaluation and selection, and (d) hardware evaluation and selection. This plan addressed several of the implementation impediments discussed earlier (Chamber & Bork, 1980; Forman, 1982).

Summary

This research investigated the problem of determining how microcomputers could best be incorporated into the mathematics curriculum of the elementary school.

A definition of instructional computer usage was
developed that dichotomized instructional computer usage into either computer assisted instruction (CAI) or computer managed instruction (CMI). A review of the literature regarding the effectiveness of CAI and CMI materials was reported. This researcher presented examples of previous research in which the relationships among student achievement and/or attitude and the use of either CAI or CMI materials were investigated. Although many of these studies were done prior to the invention and wide spread introduction of the microcomputer, this researcher believes that the results of these studies could be generalized to present day hardware systems and existing curriculum.

Several impediments to the implementation of CAI and CMI materials were presented. These factors were as follows: (a) a lack of funding needed for implementation, (b) a confusing diversity of hardware and software systems due to the primitive state of the technology, (c) a need for more and better software with a wider range of hardware compatibility, (d) a lack of knowledge among educators regarding instructional uses of the technology, and (e) an attitude among educators that the technology was either not tried and tested or destined to replace them in the instructional setting.
Recent developments in the elementary mathematics curriculum were reported. Included in the report were the ten basic skill areas essential to the mathematical needs of adults identified by the National Council of Teachers of Mathematics and the National Council of Supervisors of Mathematics.

Curricular concerns regarding the implementation of instructional microcomputer usage were presented. Trafton (1980) stated "...curriculum work is a never-ending process" (p. 13). This was discussed as being significant in regard to the ever changing technology and its developing role in the elementary mathematics curriculum. A model for implementing microcomputers into the elementary mathematics curriculum was discussed, with special emphasis placed on overcoming the obstacles to implementation previously presented. The disturbance caused by and possible elimination of these impediments is possibly best addressed by Taylor (1980). "We will be able to take advantage of the potential of computers...in the classroom if we put priority efforts into research and development and in-service training" (p. 157).
References


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