School District Planning

Grades 3-8

Computers in the Classroom

IMPAC

Instructional Microcomputer
Project for
Arkansas Classrooms

Arkansas Department of Education
1985

SCHOOL DISTRICT PLANNING

GRADES 3 - 8

COMPUTERS IN THE CLASSROOM

Instructional Microcomputer
Project for
Arkansas Classrooms

Prepared by the
Arkansas Commission on Microcomputer Instruction
Department of Education
Little Rock, Arkansas 72201

ARKANSAS COMMISSION ON MICROCOMPUTER INSTRUCTION
COMMISSION MEMBERS

Timothy Carter	- Assistant Superintendent for Curriculum & Instruction, Pine Bluff Public Schools
Jerry Linnstaedter	- Chairman, Department of Computer Science, Mathematics and Physics, Arkansas State University
Mack McLarty	- Chairman of the Board, ARKLA Gas Company
Annie Riggan	- Teacher, Corning Public Schools
Walter Smiley	- Chairman of the Board, Systematics, Inc.
J. Barry Ballard	- Director, Vocational & Technical Division
Tommy R. Venters	- Chairman & Director, General Education Division
Legislative Members:	
Carolyn Pollan	- State Representative
Stanley Russ	- State Senator

IMPAC STAFF

Cecil McDermott	- IMPAC Project Director
John Fortenberry	- IMPAC Consultant, Instructional Computing
Betty Deaton	- Education Program Administrator, Elementary
Rick Garner	- Education Program Supervisor
Jerri Rotenberry	- Education Program Administrator, Secondary
Andy Schmitz	- Maintenance Technician
Ron Shertzer	- Educational Technologist

IMPAC Mailing Address

Project IMPAC
State Department of Education
#4 Capitol Mall
Little Rock, AR 72201
(501) 371-1401

IMPAC Office Location

Project IMPAC
National Old Line Building
Room 122, 6th & Woodlane
Little Rock, AR 72201
(501) 371-1401

CONTENTS

INTRODUCTION

Technical Assistance

This document provides guidelines for the preparation of school district plans for the implementation of microcomputer instructional programs recommended by the Arkansas Commission on Microcomputer Instruction. School district planning for microcomputer instruction should be correlated with the planning done in implementing Act 7 as outlined in Guidelines for Educational Planning, Arkansas Department of Education. It is imperative that school administrators realize that any state funds for microcomputer basic skills instruction must be approved by the legislature. Therefore, school districts should commit resources to this planning effort with the realization that the scope of state funding will not be determined before the 1985 legislative session. Regardless of the availability of state funds, school districts should find this document a valuable tool for planning and implementing microcomputer instructional programs.

The IMPAC Technical Assistance Program to school districts begins with the guidelines in this document. The IMPAC staff will continue to have as its highest priority its work with the IMPAC project schools and project teachers. Therefore, much of our assistance will be by telephone, letters, resource materials, workshops, regional conferences and, when possible, on-site visitations.

School District Planning

A school district's microcomputer utilization plan should include basic data on the school district, and the school administration should provide leadership in implementing the following activities:

A. Establish a Committee on Microcomputer Instruction, under the leadership of a coordinator, to study the IMPAC approved programs and guidelines and make recommendations to the appropriate school officials. The committee should include representation from teachers and administrators in grades 3-8. Representation from local business or industry, the community and the school board is also recommended.

B. Charge the committee with securing a description of the instructional programs now in operation at all grade levels including business education, programming, literacy, special education and basic skills. The funding sources such as Vocational, Chapter 1, Chapter 2, Special Education, Business and Industry and local funds should be specified. See Appendix A for an outline that may be followed by your local Committee on Microcomputer Instruction in clearly defining each program.

C. Identify IMPAC recommended programs and develop a plan for implementation. The guidelines provided in this document should be followed and evidence given that the district can implement

the program successfully. IMPAC research in Arkansas and outside the state has provided a basis for the present guidelines, and refinements can be expected.

The type of microcomputer instructional program the district seeks to implement will determine the in-service education required, the hardware, software and maintenance needs, as well as the funds that must be allocated.

MESSAGE TO THE SUPERINTENDENT

Act 528, enacted during the 1983 legislative session, established a nine-member commission to assist Arkansas public schools in utilizing microcomputers in basic skills instruction. The Commission is providing leadership in the development, implementation and evaluation of the Instructional Microcomputer Project for Arkansas Classrooms (IMPAC). IMPAC emphasizes the instructional application of microcomputers in the teaching of basic skills in mathematics, reading and language arts.

The Commission has developed an experimental program using microcomputers for basic skills instruction in grades 3-8, developed software in the areas of instructional management, reading and language arts and worked cooperatively with colleges and universities in Arkansas in establishing guidelines for in-service training. Resource materials for school districts and the results of an annual microcomputer survey have been provided to Arkansas school districts. These research programs and evaluation activities are resulting in technological programs that are cost effective and improve instruction.

The implementation of the new standards as mandated by the legislature during the 1983 special session for education is a top priority for all Arkansas school districts. The Commission's position is that microcomputer instructional basic skills programs should be designed to complement the efforts of a school district to have quality education programs. The Commission's goal is to assist school districts in identifying educationally sound, cost effective programs that meet local needs and help implement those programs over a three-year period.

Effective learning through microcomputer instruction depends on the creation of a classroom climate that is conducive to learning. The use of computer assisted instruction (CAI) assumes the existence of a classroom environment in which the teacher serves as a catalyst to pupil interest in learning, enhances motivation through well planned lessons and establishes positive attitudes toward new learning. Learning through reinforcement is the key to the success of CAI and is more likely to occur if the above conditions are established.

In preparing a room for stand alone microcomputers or for use as a laboratory with 12-30 microcomputers, the electrical work and location of work stations are critical. Inadequate electrical power and improper grounding can cause serious maintenance problems. Please work closely with the IMPAC staff or a vendor that has extensive experience with proper room preparation. Also, maintenance has been a major concern in the 22 IMPAC schools. It would have been wise to have purchased two complete back up systems for every 24 microcomputer systems purchased to assure 24 systems operating in the classroom. Units must be repaired and back in the classroom within 7 days or instructional classroom management problems begin to affect the morale of teachers and students.

Appendix L provides a detailed summary of costs associated with each IMPAC project over a five-year period. The cost figures are based on 1984 purchases under competitive bidding.

There are a few practical considerations related to the use of microcomputers in instruction. These relate to the promise, limitations and reality of this new instructional mode. The promises of computer-assisted instruction include: more active learning, varied sensory and conceptual modes, concentrated on task learning and targeting specific student needs. Limitations and problems related to microcomputers, courseware and instructional environments include: lack of standardization of languages and disk operating systems, lack of comprehensive quality courseware especially in reading and language arts, classrooms not designed to accomodate microcomputer furniture and equipment and the increase in noise and activity related to microcomputer instruction in the classroom.

As educators, we must use common sense with respect to innovations. The human element must not be overlooked - the teacher cannot be replaced. Technology must be a servant to the teacher, and the wise use of technology by the teacher provides a way for more direct involvement between teacher and pupil - more one on one contact - not less.

Stand alone microcomputers and microcomputer networks are being used effectively as conveyors of basic skill instruction and for classroom management. Some critics of the use of the current generation of personal computers in delivering CAI suggest that their eventual role will be for problem solving, simulations, programming and word processing in grades 9-12. Because of storage, speed limitations and the lack of comprehensive basic skills courseware, except in mathematics, it is argued that microcomputer use in grades K-8 will be short term. Research by the IMPAC staff does not support that position. They predict that the future conveyor of CAI-CMI courseware will be minicomputer professional systems developed by such companies as Control Data and WICAT. Most experts in the area of computer-assisted instruction feel that serious attempts by some of these companies to market professional systems will occur during 1985-87. Courseware designed for use on minicomputer systems may have almost unlimited branching, audio, animation, and storage capabilities which provide comprehensive basic skills CAI, managment and testing. For most Arkansas school districts the cost of such systems is presently prohibitive. However, IMPAC will continue to monitor the progress of the minicomputer educational system development approach and, when feasible, give consideration to establishing an experimental site.

Arkansas school districts should continue to be cautious about implementing microcomputer instructional programs on a system wide basis. IMPAC recommends, at most, the involvement of six teachers with no more than 24 microcomputers in order to be better prepared for enhanced CMI CAI delivery systems.

IMPAC research indicates that networks for microcomputer systems connected to hard disk drives with 40+ megabytes of storage (equivalent to 150-200 floppy disks), letter quality printers and using comprehensive basic skills courseware in 3 to 5 subject areas with management features will compete with the minicomputer systems. Technology is changing rapidly and within two years the major options for system wide applications of computers should become clear. However, a 4-5 year commitment to a particular approach is the absolute maximum number of

years that one can expect a system to have appropriate software and maintenance support.

IMPAC will move with caution. A statewide comprehensive program using presently available hardware and courseware may not be the approach for IMPAC to following during 1985-87. Additional programs in 30-60 school districts in grades 3-8 and technical assistance to school districts for program planning in grades 9-12 is a plan that deserves serious consideration.

School administrators must face several realities associated with progress in the use of microcomputers in the classrooms. The decision to consider the purchase of microcomputers creates a budget priority problem. Before and after purchase, teachers must be trained and courseware selected and purchased. A decision as to how teachers and students will be initially involved and how the community will be informed can be crucial. Computers in self-contained classrooms provide the students access most of the day. Semi-departmentalization limits the amount of time that students are actually in the room with the computers and courseware. Departmentalized elementary schools generally dictate a laboratory approach and may require a teacher aide in the laboratory. In addition equipment must be inventoried, insured and on occasion repaired. Local and state leadership is needed to develop a sensible approach to decision making affecting the use of microcomputers in instruction. IMPAC provides a basis for the state leadership function.

RECOMMENDATIONS FROM THE ARKANSAS COMMISSION ON MICROCOMPUTER INSTRUCTION

The information in the appendices that follow this planning guide provide direction for the development of microcomputer instructional programs grades 3-8. This planning document is preceded with the following recommendations from the Commission.

RECOMMENDATION 1: The procedure for initiating microcomputer programs in schools is 1) select the software programs that are congruent with the curriculum materials to be taught, 2) select the hardware that is compatible with that software and 3) plan for in-service and/or staff support to assure the successful use of the software and hardware.

RECOMMENDATION 2: Computer-assisted and computer-managed instruction designed for the purpose of teaching basic skills in the elementary school provides the greatest justification for expenditure of funds for microcomputers and educational courseware.

RECOMMENDATION 3: A formal microcomputer literacy or awareness course is not recommended for learning about microcomputers in the elementary school.

Learning about computers and communications technology should be integrated into the total instructional program of the school. This suggests that students should have experiences using microcomputers through the regular instructional program which would allow for the development of computer competencies. These competencies should include loading and running a program, care of equipment and software, using editing features and interacting with an instructional program. Learning about computers should occur as students work with a computer in programs identified in computer-assisted instruction and as they use a computer in applications and programming at the high school level.

RECOMMENDATION 4: School districts might find it helpful to utilize IMPAC equipment bid specifications and maintenance agreement guidelines in the purchase of microcomputer hardware. The type of microcomputer purchased should be based on documented evidence that courseware, maintenance and training support are available to make the purchase cost effective over a five year period of use.

RECOMMENDATION 5: A program of in-service training needs to be cooperatively developed and implemented by the Arkansas Department of Education, institutions of higher education and local school district program coordinators.

RECOMMENDATION 6: Maintenance support by vendors and a program of preventive maintenance by teachers is crucial to the success of microcomputer instruction programs. School districts should budget for repairs once equipment warranties terminate. United Parcel Service, Federal Express or a comparable service is highly recommended for a one-week turn around on repairs.

IMPAC PROGRAMS AND ACTIVITIES

Act 528 relates to the establishment of pilot programs to find cost effective ways to utilize microcomputers in improving the teaching of basic skills in mathematics, reading and language arts in the elementary school grades. The Arkansas Commission on Microcomputer Instruction is carrying out that responsibility.

IMPAC has been involved in the development, implementation and evaluation of four programs in twenty-two Arkansas school districts involving 111 classroom teachers, grades 4-6. A brief description of each program is given below, and additional facts about these programs are provided in Appendix B.

Computer-Managed and Computer-Assisted Instruction (CMI-CAI)

A CMI-CAI program is being conducted to find ways to use microcomputers for basic skills instruction in mathematics, reading and language arts. Courseware and management software are on a twenty (20) megabyte Corvus hard disk networked to twenty-four (24) Apple IIe microcomputers, one teacher at each of the grade levels 4, 5 and 6 has eight (8) microcomputers in the classroom. Instruction is being managed so as to prescribe and monitor the actual lessons taken by the students. Records are kept on student performance and indicate mastery or non-mastery of specific objectives.

Computer-Assisted Instruction (CAI)

The purpose of the CAI program is similar to that of the CMI-CAI program except floppy disk drives are used with stand alone microcomputers and computer-managed instruction plays a less important role in comparison to the CMI-CAI program. Teacher management and control of access to the microcomputers is crucial in both programs. In almost all schools two teachers at each of the grade levels 4, 5 and 6 have four (4) microcomputers in their classrooms. Commodore 64 or Apple IIe microcomputers are used at each site.

Microcomputer Basic Skills Laboratories

A Commodore 64 lab has been set up in one school district using a Richvale network and a 7.5 megabyte hard disk. Twenty-four (24) microcomputer systems are in one room, and several groups of students are brought to the room each day for about 24 minutes of on task activity. A 30 unit Apple IIe lab using equipment similar to that installed in the CMI-CAI schools has been installed in another school district and functions in a similar manner as the Commodore 64 lab.

Basic Skills Testing and Prescriptive Program

Under the direction of Tom Bishop and Paul Burge from Arkansas State University, two school districts are implementing an Arkansas Basic Skills Mathematics and Reading Testing Program for the microcomputer. A

management system and CAI program are included in this project. The program, Computer-Assisted Instruction Management, is referred to as C-AIM.

Related Activities

In addition to pilot programs, the Commission has provided leadership in several other areas vital to long range goals. These activities include:

A. The development of resource materials and guidelines for Arkansas school districts;

B. Leadership conferences on in-service education related to microcomputer instruction;

C. A writing conference directed by David Loertscher and David Carl from the University of Arkansas at Fayetteville to develop course outlines for three levels of in-service training;

D. Assistance in establishing a summer institute to train consultants in the area of microcomputer instruction;

E. An annual survey of school districts to maintain data on the status of program development and hardware acquisition;

F. A feasibility study and development of comprehensive microcomputer reading and language arts courseware for general distribution to Arkansas school districts.

G. A contract to develop a method of selecting high quality courseware to be recommended for use by Arkansas school districts;

H. The securing of grants or donations of microcomputer systems from Apple, Commodore, IBM and Radio Shack which provide the basis for a teacher in-service training center and software review lab at the Little Rock IMPAC office and State Department of Education regional education centers.

Recommended Courseware List

A recommended courseware list has been developed and made available to Arkansas schools for use in selecting basic skills courseware including mathematics, reading, language arts, social studies and science. The list will be updated with a supplement published every six months.

Basic Skills Mastery Management Systems

Standards for Accreditation, Arkansas Public Schools, adopted by the State Board of Education, February 1984 requires that schools be responsible for assessing individual student progress in acquiring mastery of the competencies, skills and other subjects required by law and the standards. This requirement indicates the need for a system of evaluation

and placement of students on a basic skills continuum. IMPAC will provide information on computer-managed instruction programs that will offer a school district the option of developing a computer based assessment system. The C-AIM program is an example of such a management system.

The primary purpose of the C-AIM program is to improve the management of reading and mathematics instruction through the use of microcomputers. It does that by evaluating student progress according to Arkansas Basic Skills Objectives and providing a printout of the results.

Research Related to IMPAC

A review of 53 research reports in computer related instructional activities, 1962-1984 selected from abstracts on 360 studies, suggest some common threads among the conclusions drawn by researchers.

In particular, seven generalizations about CAI emerge from the research conducted nationally during the period of 1962-83 with enough regularity to inspire confidence in their use.

a. CAI is most successful in helping learners attain clearly specified objectives, especially in the basic skill areas.

b. CAI saves significant amounts of time over "conventional instruction", as much as 20 to 40 percent.

c. Retention rates following CAI are at least as good as, and often better than, retention following conventional instruction.

d. Students have positive attitudes toward good CAI programs and dislike poor programs, especially those over which they have no control.

e. The appropriate instructional time for CAI from both a learner and administrative standpoint is 12-20 minutes on task four days a week in a given subject.

f. Tutorial - drill - practice CAI are effective types of courseware. Courseware incorporating both Behavioral and Gestalt psychological principles increase effectiveness.

g. Achievement gains in reading are about 70% of the gains in mathematics when instruction is supplemented with basic skills CAI.

Positive attitudes about self-pacing, opportunities to correct errors in a non-threatening environment and immediate knowledge of results are features of quality CAI courseware which provide motivation that contributes to the learning of basic skills.

In almost all of the 53 studies the investigations focused on teacher instruction supplemented by computer-assisted instruction. It is clear that technology can be used to make teachers more effective. Microcomputers can transmit information, teach certain skills and help

students solve problems. In doing these things it can free the teacher from being a dispenser of information and permit her to be a manager and evaluator of instruction.

Appendix C provides a discussion of research related to microcomputer instruction and cost effective applications. Although somewhat technical, the information provides a summary of average gains from CAI and their likely effect on student performance in grades 4-6.

IMPAC Visitation Program

Arrangements have been made for on-site visitations to the IMPAC schools listed below. In general, on-site visitors will follow this schedule:

8:30 - 9:00 Arrival at project school

9:00 - 10:00 Program orientation by coordinator/IMPAC staff

10:00 - 11:30 Classroom visitation

11:30 - 1:00 Lunch

1:00 - 2:00 Question and answer session

On-site visitation will be scheduled on the date indicated at each of the project schools listed below. Superintendents wanting to arrange an on-site visit to an IMPAC school should contact the school superintendent directly and indicate the number of persons who will visit the school. The following is a list of superintendents, coordinators and principals of the schools, including telephone numbers and school addresses:

School District	Superintendent	Principal	Coordinator	Address
Corning	J. Kimbrell 857-6818	N. Cherry 857-6491	N. Cherry 857-6491	Fourth St.
Fort Smith	C. B. Garrison 785-2501	W. Freeman 452-5808	W. Floyd 785-2501	3201 Massard
Gurdon	Bobby Smithson 353-4454	G. Thompson 353-4921	Bill Moorman 353-4921	314 School Street
Hot Springs	Maurice Dunn 624-3372	G. Robinson 623-2661	G. Robinson 623-2661	301 Oaklawn
Mammoth Spring	Otey Green 625-3621	Ruth Shaw 625-7231	Ruth Shaw 625-7231	300 Goldsmith Street
Marshall	Herbert Cleek 448-3011	F. Lewis 448-3333	F. Lewis 448-3333	Box 310
Pine Bluff	Jack Robey 536-7900	M. Willett 534-5064	P. Waymack 534-5064	1519 Indiana
Pulaski Co.	Tom Hardin 490-2000	J. Naylor 851-4600	J. Naylor 851-4600	400 Pine Forest Drive

Vilonia	James Hardage 796-2113	Pat Matthews 796-2112	Mary Wells 796-2113	Box 160
Waldron	J. D. McGee 637-3170	W. Aspinwall 637-2454	J. D. McGee 637-3170	P.O Box 220

Visitation Schedule by Date

March 13, 1985	Corning
March 14, 1985	Mammoth Spring
March 27, 1985	Pulaski County
April 10, 1985	Fort Smith
April 11, 1985	Waldron
April 17, 1985	Gurdon
April 18, 1985	Pine Bluff
April 24, 1985	Vilonia
April 25, 1985	Marshall
April 30, 1985	Hot Springs

GUIDELINES FOR DEVELOPING IMPAC APPROVED PROGRAMS

Computers have been used in schools basically in two different areas, for administrative purposes and in the instructional program. In the latter area schools have used the microcomputer in diverse ways to teach: about the computer (computer awareness); computer programming and computer science; computer applications (e.g. bookkeeping); and subject areas (e.g. math). In the elementary school we recommend the use of the computer as an instructional tool to assist teachers in the delivery and management of their basic skills instructional program.

As an instructional tool, microcomputers can be a delivery system for courseware that supplements the basal instructional program. Computers need to be used in cost effective ways for instructional purposes that can raise achievement levels. Specifically, computers should be both effective and efficient tools of instruction to teach, drill, test and place children in an instructional program. This will set the stage for problem solving and management applications.

There are several different ways of using computers in the classroom. Schools should carefully study the instructional applications of computers and select the ones which will be the most efffective in the local situation.

Computer-Assisted Instruction (CAI)

1. The kinds of instructional tasks a computer can do:
   a. Tutorial tasks such as
      - giving a rule
      - defining terms
      - presenting information
      - asking questions
      - responding to the learner

   b. Drill and practice in
      - spelling skills
      - math problems
      - rote learning
      - punctuation
      - rules of grammar

   c. Problem situations in
      - simulations of real-life events
      - games which help in the discovery of new relationships
      - graphical form

2. The ways a computer can do these tasks:
   a. Give an immediate response to a student so that
      - errors can be corrected
      - errors will not be repeated

   b. Allow learning to be paced by the learner or the teacher
      - through alternatives in the speed of presentation
      - through repetition of material if needed

c. Can move from one section of a lesson to another section
   - for further instruction
   - for more practice
   - to take a test
   - for a different presentation of the same skill

d. Can present a problem to be solved
   - offers options in solving
   - responds to students input
   - offers further options (e.g., finer distinctions, more complex variables)

Computer Managed Instruction (CMI)

1. Student testing on the computer for mastery of:

   a. State basic skills

   b. School district and/or school building instructional objectives

   c. Objectives in a specific content area

2. Placement of students in a skills continuum for instructional purposes:

   a. Reteaching of skills not mastered from previous instruction

   b. Teaching new skills to be mastered at the current instructional level

   c. Instruction may or may not be delivered by the computer through CAI

3. Records management by:

   a. Storage of information about mastery of specific skills in the computer

   b. Analysis of student achievement by use of information from testing

   c. Printing of hard copy (paper copy) of this information when needed

4. Prescription of instructional activities for an individual student or groups of students:

   a. Derived from data input by teachers

   b. Generated by computer after students are tested

Basic Skills Mastery Management Systems

1. A specialized CMI system based on the Arkansas Basic Skills which will include:

   a. Diagnostic capabilities to evaluate students 3-8 in reference to their mastery of the basic skills in reading, math, language arts, science and social studies

   b. Prescriptive aspects which indicate what skills need to be taught and provide suggestions of materials that can be used to teach these skills

2. An evaluation center should be provided in the school building in a room to accommodate the following equipment:

   a. Hardware and Peripherals
      (1) Four to eight microcomputer systems on which the computer management system is designed to run

      (2) Networking equipment appropriate for the microcomputer system

      (3) Peripheral devices including two disk drives, a printer, and appropriate cables

   b. Tables for computers and other equipment

   c. Student chairs

3. The management program will:

   a. Be stored on a 5 1/4 inch floppy disk to allow speed in accessing questions, student records and prescriptions

   b. Include test questions that will adequately determine skills mastery both in the scope of their content and by the number of questions

   c. Generate records that will reflect:
      (1) each student's mastery or non-mastery of skills

      (2) a group profile indicating a group of students' mastery or non-mastery of skills. (e.g. a class roster)

   d. Generate prescriptive information from data supplied by teachers to reflect materials available in their classrooms and should include the correlation of skills to textbook materials, worksheets, computer software and learning kits

Program Coordinators and Key Operators

There are two leadership responsibilities that must be fulfilled in any school district that is effectively using microcomputers for basic skills instruction. There must be a program coordinator who provides direction for the overall program and a key operator who provides technical assistance related to hardware and software - especially maintenance and making software backups.

A program coordinator is an instructional leader, usually a principal or curriculum director, who is responsible for learning about the procedures for developing program components using computer and communications technology to enhance instruction. Identifying program types, courseware, hardware, in-service education needs and support services are the responsibility of the coordinator.

A key operator is usually a teacher or administrator who has the interest and ability to secure the technical information and skills related to a particular microcomputer or communications system and its related courseware or utility programs. The person serves as a "trouble shooter" for teachers using the microcomputer systems.

Incorporating Computers into an Instructional Program

Schools need to assess their own staff, facilities, instructional goals and budget in order to determine whether computers should be placed in the classrooms or in a computer lab. The following guidelines are presented in order to help schools make that decision. Appendix D is a teaching learning model for microcomputer instruction activities.

The number of classes in a building as well as the number of students per class will influence this decision as the cost effectiveness of computers in the classroom or in a lab is determined. Within a classroom of 20 to 30 students at least four microcomputers will be needed in order for all students to have sufficient time on the computer to significantly affect their mastery of skills.

A laboratory should have a sufficient number of computers for each student within a class to be able to work on his own computer. This probably means 24 to 30 computers. In order for each student to work on the computer 12-20 minutes four days a week, no more than 10 classes could be scheduled into a lab each day. The choice between use in class or a laboratory approach should be influenced by instructional purposes and the organizational structure of the school. It should be noted that a full-time aide, paraprofessional or community volunteer is usually needed to supervise a laboratory.

When microcomputers are placed in a classroom as an instructional tool, the teacher is faced with some instructional decisions. How should computer instruction be integrated into the instructional program? When should use of the computer be scheduled? How long should students remain on the computer? Should some instructional activities on how to use the computer be completed before a student is allowed to work on the computer?

There are research data and classroom experiences that can help in making these decisions.

Research indicates that the optional on task time for computer instruction in a given subject area is twelve to twenty minutes per day. Any less time will decrease instructional effectiveness; any more time will not increase instructional effectiveness and may eventually have the effect of over-exposure. That is, students may become bored with computer-assisted instruction if it is not used with prudence.

Experience in the classroom shows that, although four times a week is the optimal schedule for a given subject area, many teachers do not have enough time to implement that kind of schedule in their classrooms. Because of time constraints brought about by departmentalizing and pull-out programs a teacher may be able to get only half of his or her class on the computer during the reading or mathematics instructional time. Therefore, we recommend that a two-week cycle be established which insures that each student works on the computer five days out of ten.

In the context of a two-week time schedule, the computers can become a learning center through which students rotate at an established time in the instructional day. The computer is used as another way of presenting instruction to reinforce and supplement the teacher's direct instruction. If a student is placed at his appropriate instructional level he can work independently, and yet the teacher can be confident that he is receiving sound instruction with appropriate feedback.

If a school decides to establish a computer laboratory for use by several classes, some of the same instructional questions must be answered. In this case greater care must be taken to assure that computer instruction is an integral part of classroom instruction and does not "drift" into a separate subject - computer awareness or programming. However, some teachers may prefer the lab arrangement so that they can establish one time slot a day for computer instruction and have the whole class "on the computer" together. It is recommended that an aide be assigned to the laboratory full-time to assist teachers by maintaining the computers and courseware. This allows teachers to concentrate on instructional matters.

A class probably should be allotted a twenty-five to thirty minute time slot each time it is scheduled into the lab. This would assure about twenty minutes on task, allowing for time spent entering the lab, accessing the instructional program and leaving in time for the next class to enter.

Again, although research indicates that a class should be in the lab four days a week, the reality of school schedules and finances may dictate a less frequent schedule. Classes could alternate days in the lab and thus receive computer-assisted instruction five days out of ten. This would allow up to twenty classes the opportunity for computer-assisted instruction in one subject.

See Appendix E for sample classroom and laboratory schedules and Appendix F for the advantages and disadvantages of using microcomputers in the regular classroom versus in a laboratory.

Analysis of Three Major CAI Procedures Used by Teachers

1. Comprehensive Basic Skills Instructional Courseware

   a. Start each student at the beginning of the instructional program

   b. Let each student work at own pace until all lessons are mastered

   c. Correlation of CAI to the school's basal curriculum depends on how well the objectives covered by the courseware match up with the objectives of the basal textbook

Advantages	Disadvantages
- Good review for some students	- Teacher not in total control
- Good reinforcement for some students	- Students at varied levels
- Self-paced so students are experiencing success	- Student monitors may be needed
- Teacher selects the courseware	- Some programs will be below the student's instructional level

2. Specific Skills Instructional Courseware

   a. Students could be placed to work on objectives they have not mastered.

   b. The entire class or a group of students could be placed to work on the objective being introduced in the regular instructional program.

   c. Objectives could be reviewed as needed before testing.

Advantages	Disadvantages
- The teacher selects the specific objective to be mastered or reviewed and is in total control	- Cannot take full advantage of computer management features
- Computer instruction is fully integrated into broader instructional program	- May necessitate frequent loading and the running of a variety of courseware resulting in a loss of on task time

3. Drill and Practice Courseware

   a. Teacher instructs individual, small group or large group in a skill by assigning the student(s) to the computer for drill and practice on that skill (e.g. math problems or punctuation).

b. Teacher assigns students task of learning a list or a body of information; computer program drills the student (e.g. spelling words or state capitals).

Advantages	Disadvantages
- Computer work provides another way of immediately reinforcing teacher's instruction	- No computer management is available
- Teacher selects and monitors progress of students	- Will require frequent changing of disks

Courseware, Hardware, Facilities, Electricial and In-service Needs

1. Courseware

This term is used to designate the instructional programs to be used with the microcomputer. Choosing appropriate courseware is probably the single most important decision to be made. This decision should be made first. The courseware should be appropriate in the following ways:

- Educational purpose - does it fit the district's educational goals?
- Instructional objectives - does it match the objectives of the class for which it is to be used?
- Content - does it have instructional value?
- Scope - does it allow the computer to do those things that a computer does best?
- Formatting - is material presented logically and effectively?
- Instructional level - is it on the level of students with whom it is to be used?

The criteria for selection of courseware, and the sources of courseware are listed and fully discussed in the IMPAC manual entitled Evaluation of Microcomputer Courseware for Instructional Applications. There is also a preview lab located in the IMPAC office. A limited number of programs are available for preview. There is also a collection of public domain courseware that may be copied. Arrangements to copy the courseware may be made by calling the IMPAC office at least one day in advance. Recommended Courseware List, an IMPAC resource booklet, is an excellent source for basic skills courseware.

2. Hardware

Hardware refers to the microcomputer itself and the equipment needed to make it operable. In general, for schools a microcomputer system with a minimum of 64K RAM memory, a monitor and a disk drive is recommended. A

printer is helpful if the system is to use a management program. The keyboard should be similar to that on a typewriter.

If eight or more microcomputers are to be purchased, networking might be considered. That has been done successfully in some schools and with a hard disk can increase memory capacity and the speed of accessibility. A more detailed discussion of selecting microcomputers and developing bid specifications and maintenance agreements are presented in Appendices G and H.

3. Space and Furniture

If the computers are to be used in a classroom there should be space available for as many "stations" as there are computers. Each station should include table top or desk top space for the microcomputer, monitor and disk drive. Each student should have sufficient space to place tablet and pencil on the desk or table at his station. The printer should be on a table nearby so it can be used with a microcomputer as needed. Software storage must be provided in a cabinet which will keep software dust free and in a vertical position. Chairs of appropriate height will be needed.

A computer laboratory requires a room about the size of a regular classroom. Computers may be placed on tables or desks with sufficient space for each station as described above if the computers are used as stand-alones. If the computers are networked, it will not be necessary to have a disk drive at each work station. Work space and a chair must be provided for each student. Software storage space should be provided in the lab, according to specifications noted above. (See Appendix I for a more detailed consideration of varied configurations and space requirements for microcomputer systems in classrooms or laboratories.)

4. Electrical

See Appendix J for a discussion of electrical wiring.

5. In-service

The training of teachers and administrators in the effective use of microcomputers in instruction is an essential part of any well-developed computer instruction program. In-service sessions should include:

- Information on computers and their uses.
- Preview and evaluation of courseware.
- Instructional uses of computers.

In addition to training in these computer skills there is a need for further training in instructional management skills:

- Using information on student achievement which computer-managed instructional programs generate to improve classroom instruction.

- Incorporation of computer-assisted instructional programs into the instructional program of the classroom.

- Scheduling of computer use.

IMPAC, with the help of some leaders in computer instruction, has developed a plan for a statewide in-service program which includes three levels of training. Level I will provide training required for teachers who use microcomputers for computer-managed and computer-assisted instruction. Level II includes the training needed by instructional leaders to assist in a variety of computer based education programs. Level III in-service offers the training required to serve as a consultant in educational systems and software development and to serve as an in-service training instructor for Level I and II sessions.

The above information is more fully developed in Appendix K on In-service Training Level I and Level II.

Managing Microcomputer Instruction Activities

The purpose of this section is to describe classroom management procedures that seem appropriate with respect to the various applications of microcomputer instruction. The material is presented in a question and answer format because the technique provides a way of clarifying techniques that can enhance effective management related to CAI.

QUESTION: How do you label and store courseware?

ANSWER: Courseware disks may be color coded by using blue labels for mathematics, yellow for reading, green for language arts, pink for social studies and red for science. White labels may be used on all other courseware. Plastic storage boxes that hold 10 diskettes each for programs of 6-10 diskettes and storage containers holding 60 diskettes provide ways of storing diskettes by subject. The boxes of disks may be placed on the table by the computers when that courseware is being used.

QUESTION: What precautions should be taken in handling diskettes?

ANSWER: When a student finishes with a disk, it should be returned to the disk sleeve and then put back in the storage box. The metallic part of the diskette should never be touched or placed on the computer, disk drive, monitor or printer. Never take the disk out of the disk drive while it is attempting to load a program. If a program does not load properly, turn off the computer, disk drive, remove the disk from the disk drive, turn on disk drive and then after turning on the computer, try to load the program again. Students and teachers should follow these procedures.

Courseware should be stored in an air conditioned office during the summer for protection from intense heat.

QUESTION: What is the role of student classroom monitors?

ANSWER: A few students in the typical elementary school classroom have microcomputers at home. In fact, IBM-PC, Radio Shack Model IV, Apple IIe and Commodore 64 microcomputers are usually owned by some families that have students in grades 4, 5 or 6. A student that has experience with the system used in a particular classroom should be trained to help other students when they have difficulty using the computer. Such training will require about three hours. The monitor responds to requests by students for help in using a microcomputer system.

QUESTION: What is supplementary comprehensive courseware?

ANSWER: Supplementary comprehensive courseware refers to a mathematics or reading and language arts set of diskettes that usually store lessons which cover most of the basic skills in the subject at specific grade levels. For example, Fundamentals of Mathematics is a supplementary basal courseware program that has 81 lessons that relate to basic math skills in grades 4-5-6.

QUESTION: What is the role of the key operator?

ANSWER: A key operator in a school determines if a diskette needs to be replaced, make or help make backup copies of public domain courseware and determines when a piece of equipment needs to be repaired. By using equipment from various classrooms, the key operator may switch disk drives, monitors and computers around until it is determined exactly which piece of equipment is not working. Sometimes it is the diskettes and not the disk drive. Adjusting all knobs properly, checking to see if the power cords are working and that all plugs or attached cords are secure are routine activities of a key operator to minimize maintenance costs and help keep microcomputer systems operating properly.

The teachers and students in any school must be trained to handle diskettes properly and return them to their storage boxes. The equipment should be cleaned with a soft cloth once each week and all equipment covered at night and on weekends. Large plastic leaf bags or commercial plastic covers may be used to protect the equipment from dust overnight and on weekends or during vacation periods.

QUESTION: What does it mean to license courseware to a school?

ANSWER: Licensed courseware is usually related to courseware on a hard disk microcomputer network. Since a network usually has 4 to 30 microcomputers the vendor may price courseware valued at $100 for 3 to 4 times that amount if you agree to use it only in a designated laboratory situation. Courseware may be licensed to a district in such a way that you can make as many copies as you want in your school district, but copies may not be made available to other districts.

QUESTION: Should students be allowed to work problems on a tablet next to the computer while using the computer?

ANSWER: Generally the answer is yes. An exception might be memory work related to spelling or learning number facts in arithmetic. Be sure enough table space is provided so students can work problems just as they would at their desk.

QUESTION: What special preparations should be taken in wiring classrooms for computer use?

ANSWER: If the school district does not have a licensed electrician on the maintenance staff, the district should employ a licensed electrician to make any needed changes in the wiring. Check to be sure there is a good earth ground at the circuit breaker box. A power surge protection device should be installed in each classroom where the computers are to be used. Electrical wires should be run along the wall in a conduit and then an outlet receptacle installed for each microcomputer system.

A CMI-CAI network lab presents special problems because a network is sensitive to induced current and noise or "dirty" electricity. A completly dedicated circuit should be run from the switch box to the lab. The circuit should have its own ground. Power surge protection devices should also be used. All wires should be placed in conduits and the network (trunk line) should be kept away from florescent lights and extension cords.

QUESTION: Should the hardware be turned off during a heavy rain or storm in which there is severe lightning?

ANSWER: If there is lightning occurring near the school, the microcomputer should be turned off and unplugged. However, a general rain or light snow in which there is little or no lightning should not prevent the use of the computers for instruction. In an ice storm the general rule is to turn off and unplug the systems if the lights start flickering.

QUESTION: Should computers be covered by insurance?

ANSWER: A hundred dollar deductible policy is recommended. The best procedure is to include the microcomputer hardware on the school's general equipment insurance policy.

QUESTION: What is an equipment warranty?

ANSWER: A warranty means that the company will repair or replace the defective equipment at no cost within the warranty time period. In a formal bid the vendor should indicate how this will be done and the time required. An equipment warranty is usually one year for computers, monitors and disk drives and 90 days for printers.

QUESTION: How do you get your microcomputer equipment repaired?

ANSWER: When a school district takes bids on equipment, require that the vendor give a minimum of seven day service turn around time on equipment under warranty and equipment out of warranty. Arrange to call the vendor at no charge and indicate what equipment is down. The vendor calls UPS or Federal Express and the defective equipment, properly boxed and labeled for shipment, is picked up at the principal's office the next day. The vendor either repairs the equipment or sends a replacement unit within three to seven days. Any bid should cover the maintenance procedure in such a way that the vendor's bid includes the pick up and delivery cost.

QUESTION: In a self-contained classroom, except for the students that are pulled out for special instruction, students are in your room all day. What is a typical week of computer use like in that instructional setting?

ANSWER: Students can work on math 12-20 minutes each day 4 days in 10 and reading and language arts 12-20 minutes each day 4 days in 10. Two days in 10 programs that have game formats or provide problem solving lessons may be used for motivation.

QUESTION: Should a school purchase backup equipment and how many sets of courseware is needed in each classroom?

ANSWER: It is wise to purchase one complete backup system (computer, disk drive, monitor and printer) for every 10-12 systems purchased. The extra systems are used for regular instruction. However, the computers automatically are used as replacements if needed. This helps prevent downtime especially in schools located over one hundred miles from the maintenance site.

One complete set of courseware for every two computers is recommended. If management courseware is used and only one management disk is available for every four computers, two of the microcomputers should be located back to back with the other two so that students can hand each other a disk directly and eliminate passing a disk or getting up and taking it to another student. If courseware is interactive it cannot be shared during its use, one set of courseware per computer will be needed. It takes about 3-4 minutes for a student to get a lesson loaded and ready to run. It takes only about 1-2 minutes to get the computer ready for the next person.

QUESTION: Is a clock or timer needed in a classroom so students will know when to go to the computer?

ANSWER: A clock should be located near the computers so each student in the room can see the time. Students automatically move to and from the computer usually in 20 minutes time slots. Each student records the date, his name, the lesson he is working, time on and time off. The teacher should designate on the bulletin board the lessons to be worked each week. Usually lessons are related to current teaching objectives or to concept development.

QUESTION: What are teacher utility programs and authoring systems and do you use them in your school?

ANSWER: Authoring systems, for example, may be used to develop lessons in spelling, capitalization and on the metric system. The teacher actually develops and stores lessons on a disk. Grade book utility programs keep a record of grades. Some utility programs generate and print out worksheets in mathematics for drill and practice.

QUESTION: Describe how a school might use computer-managed instruction (CMI)?

ANSWER: Specifically, the C-AIM program uses four to eight micro-computers networked to a dual disk drive. Students are scheduled to be

tested on basic skills in reading and mathematics every three to six weeks. They take the test directly on the computer and a report is generated that shows the extent to which each student is mastering basic skills. The report indicates which objectives were mastered and which were not mastered in certain units. The printout also gives prescriptions that helps the teacher identify CAI and other materials that can be used to remediate the skills that haven't been mastered.

QUESTION: What are some of the most important things that have been learned in the IMPAC program about using microcomputer instruction?

ANSWER: Many things have been learned. However, five will be given as illustrations.

First, be sure you bid your equipment and courseware so that you get good service. Be sure the electrical circuits are installed properly. The morale of teachers and students is affected when equipment or courseware doesn't work.

Second, a Level I in-service training program (16-24 clock hours) is a must for all teachers directly involved in microcomputer instruction. In general, a school district may take one complete year to train teachers in the use of CAI and CMI applictions of microcomputers, select and bid courseware and hardware and gain experience with the management procedures required. At least one additional year will be needed to refine the program so that it is effectively supplementing instruction.

Third, for stand alone computers have at least one set of courseware for every two computers and enough storage boxes to keep them organized. One set of interactive courseware is required for each computer. For a network, CMI-CAI courseware on a 20 megabyte hard disk drive involving 16 or more computers must be secured under a license agreement.

Fourth, making the choice between placing microcomputers in the teacher's classroom or placing them in a laboratory determines the dynamics of how the instructional program will operate. Continuous use with a variety of applications and its associated management problems represent a plus and minus for in classroom use. Targeting specific basic skills deficiencies using comprehensive courseware on a hard disk network under the direction of a paraprofessional and being tied to a regimented schedule are a plus and a minus for laboratory use.

Finally, don't let the computer control your instructional program. Make the computer work for you. Let it do things for you that save you time and energy. Don't let computer-assisted instruction be extra - let it replace some of the activities you are presently doing through worksheets or workbooks.

APPENDIX A
PLANNING GUIDE

Basic Information

- School District
- Superintendent
- Project Director
- Names, position, training of planning committee members
- Existing programs developed using federal, state or local funds
- Programs developed for possible federal, state or local funding during the current year

Description of each Program (repeat for each program)

- Program objective
- Learner outcomes
- Visits to pilot projects and research involved in establishing objectives
- Grade levels affected
- Number of students affected
- In-service training plan
- Teachers involved and their qualifications
- Microcomputer systems to be used
- Bidding process
- Service and maintenance arrangements
- Specifications for furniture and electrical wiring
- Courseware to be used
- Calendar of activities to implement programs
- Technical liaison person
- Community involvement
- Sources of funds
- Evaluation procedures

Steps in Implementing Microcomputers in Instruction

1. Appoint a local program coordinator

2. Appoint a planning committee and begin Level I In-service Training that include:
   a. Operating skills
   b. Terms and definitions
   c. Educational uses of computers
      - Drill and practice
      - Tutorials
      - Games
      - Simulations
      - Information retrieval
      - Applications programs
      - Materials generation
   d. Ways of scheduling use in building, classroom

3. Develop goals and objectives for instructional applications of microcomputers

4. Identify software to accomplish objectives
   a. Cost of software, backups, storage and replacement disk
   b. Computer capabilities needed
   c. In-service required
   d. Classroom management requirements

5. Find hardware on which software will run
   a. Determine cost of each computer, peripherals, tables, chairs and electrical wiring
   b. Estimate cost of maintenance
   c. Identify how many computers are needed

6. Estimate number of students affected
7. How many computers are needed at each building

8. Determine how much money is available from funding sources (Local, State, Federal, PTA and Business and Industry)
   a. List funds available for current year
   b. Project funds for next 2 to 3 years

9. Order programs in priority so that greatest needs are met first

10. Develop a 2 to 3 year time line to purchase desired hardware, software, train teachers and implement programs

11. Establish plan for purchase and maintenance of hardware and software

12. Establish plan for ongoing support and training of teachers

APPENDIX B
IMPAC PROJECT SITES

Program	School District	Teachers	Hardware
CMI-CAI	Fayetteville	3	Apple IIe network
CMI-CAI	Fort Smith	3	Apple IIe network
CMI-CAI	Monticello	3	Apple IIe network
CMI-CAI	Pulaski County	3	Apple IIe network
CMI-CAI	Vilonia	3	Apple IIe network
CAI	Texarkana	6	Apple IIe
CAI	Gurdon	6	Apple IIe
CAI	El Dorado	6	Apple IIe
CAI	Corning	6	Apple IIe
CAI	So. Miss. Co.	6	Apple IIe
CAI	Mammoth Spring	6	Apple IIe
CAI	Waldron	4	Commodore-64
CAI	Hot Springs	6	Commodore-64
CAI	Gould	2	Commodore-64
CAI	Marshall	6	Commodore-64
CAI	Stuttgart	6	Commodore-64
CAI	Benton	2	Apple IIe
CAI	Conway	1	Commodore-64
C-AIM	Jonesboro	6	Commodore-64
C-AIM	West Memphis	9	Commodore-64
CAI lab	Little Rock	6	Commodore-64
CAI lab	Pine Bluff	12	Apple IIe network

APPENDIX C

COST EFFECTIVENESS BASED ON EDUCATIONAL RESEARCH

What does research say about how much a school district should invest in microcomputer instruction? Cost analysis related to four different methods of improving basic skills through supplementary activities has been reported in a study, Cost Effectiveness of Four Educational Interventions, supported by funds from NIE and published May, 1984. The four interventions include: reducing class size, increasing the length of the school day, computer-assisted instruction and tutoring. In general, tutoring approaches were found to be the most cost effective, while reducing class size and increasing the amount of time devoted to traditional instruction were found to be the least cost effective. Computer-assisted instruction ranks between these two extremes.

In this study, the cost effectiveness of supplementing any instruction was based on average gains (grade equivalent) in reading and mathematics per $200 cost per student per year. The following table gives a summary of the results.

COST EFFECTIVENESS RATIOS

Method	Cost/Student/Year	Average gain Math	Reading
Tutoring (an extra 30 minutes/day)	200	.6	.4
Computer-Assisted Instruction (an extra 30 minutes/day)	200	.4	.3
Reducing class size (by 5)	200	.3	.2
Increasing regular instructional time by an extra 30 minutes/day	200	.3	.2

There is another approach to cost effectiveness and computer-assisted instruction based on research findings the past 22 years. There are numerous research studies that support the following assumptions. However, these statistics should be viewed as averages and extreme deviations may occur unless conditions are similiar to those in schools from which the data was obtained. These assumptions form the basis for some generalizations that provide a good overview of the effect of CAI.

A. Seventy-five percent (75%) of the cost of education per student is teacher and instructional materials related.

B. Forty percent (40%) of the school day is devoted to mathematics and reading instruction.

C. Twenty percent (20%) of the innovative effect of computer-assisted instruction is related to the Hawthorne effect.

D. When basic skills instruction is supplemented with CAI, the average grade level gain in both mathematics and reading for students below grade is 0.5. The average grade level gain for students above grade level is 0.25. The average grade level gain for all students is .37.

E. The average grade level gain for all students in reading is seventy percent (70%) of the average grade level gain in mathematics.

The following application of the information in A, B, C and D is most revealing when compared to the NIE supported study.

If the cost of education per child in Arkansas in 1984 is $2100, then $2100 x .75 = $1575 is the average instructionally related cost for all subjects. $1575 x .40 = $630 is average cost of mathematics and reading instruction for which the average gain is 1.0 years. $630 x .37 = $233 is the average cost to improve reading and mathematics instruction by 0.37 of a grade level. $233 x .80 = $186 is the average cost directly related to microcomputer instruction. This suggests cost effectiveness for CAI is $186/student in order to obtain an average gain of .37 grade level. The NIE supported study indicated the cost effectiveness of CAI as 0.35 grade level gain at a cost of $200/student.

Estimating Effects of CAI on Class Average by Grade

Class average gains due to supplementary methods of instruction can be misleading. A close look at expected results of CAI on grade level gains in grades 4-6 provide a reasonable picture of what is likely to be the result.

Assume the average gain produced by CAI among students below grade level in mathematics is 0.6 and 0.4 in reading. Assume the average gain by students above grade level in mathematics is 0.3 and 0.2 in reading. These expected gains are consistent with research findings about the affects of supplementary CAI instructional and assumption D above. Assume the average gain due to regular instruction without CAI or any other intervention is 0.6 for student below grade level and 1.3 for students above grade level in grades 1-6. These assumptions are very reasonable and in line with current SRA test scores in Arkansas. The following tables reveal the projected affects of CAI on class average by grade.

*Effects in Grades 4-6

Mathematics - Below Grade Level Students

Normal Grade Level Progress	2.0	3.0	4.0	5.0	6.0	7.0
Achievement based on .6 gain/year	1.6	2.3	3.0	3.6	4.3	5.0
Gains based on .6 gain/year plus .6 gains attributed to CAI	1.6	2.3	3.0	4.3	5.6	7.0

Reading - Below Grade Level Students

Normal Grade Level Progress	2.0	3.0	4.0	5.0	6.0	7.0
Average Based on Regular Gains .6	1.6	2.3	3.0	3.6	4.3	5.0
Average Gains Due to CAI .4	1.6	2.3	3.0	4.1	5.2	6.3

Mathematics - Above Grade Level Students

Normal Grade Level Progress	2.0	3.0	4.0	5.0	6.0	7.0
Average Based on Regular Gains 1.3	2.3	3.6	5.0	6.3	7.6	9.0
Average Gains Plus .3 CAI	2.3	3.6	5.0	6.6	8.3	10.0

Reading - Above Grade Level Students

Normal Grade Level Progress	2.0	3.0	4.0	5.0	6.0	7.0
Average Based on Regular Gains 1.3	2.3	3.6	5.0	6.3	7.6	9.0
Average Additional Gains due to CAI .3	2.3	3.6	5.0	6.5	8.1	9.6

Math - All Students

Normal Grade Level Progress	2.0	3.0	4.0	5.0	6.0	7.0
Average Based on Regular Gains 1.0	2.0	3.0	4.0	5.0	6.0	7.0
Average Gains Plus .4 CAI	2.0	3.0	4.0	5.4	6.8	8.3

Reading - All Students

Normal Grade Level Progress	2.0	3.0	4.0	6.0	6.0	7.0
Average Based on Regular Gains 1.0	2.0	3.0	4.0	5.0	6.0	7.0
Average Gains Due to CAI .3	2.0	3.0	4.0	5.3	6.6	7.0

* Grade level scores should be read as grade level achieved at the end of a grade. Therefore, normal progress for a student at the end of grade 3 is 4.0 and at the end of grade 6 is 7.0. Also, .4 means a 4 month gain.

One final observation. How much of the real effects of CAI can be attributed to the fact that part of its success results because students are placed on tasks to remediate a specific objective? Research studies on time management indicate that on the average students are involved in instruction in all subjects 300 minutes per day. This means that 300 x .4 = 120 minutes are devoted to reading and mathematics. This relates to a gain of 1.0 on the average for mathematics and reading for a typical class. Thus, 30 minutes on task in reading and mathematics using CAI suggests an increase of 30/120 = .25. However, the expected gain is 0.37 grade levels. Thus, .12/.37 = .32 or 32% of this gain due to CAI may be attributed to on task targeting of specific basic skills objective. This exercise in linear relationships suggests what is likely to be happening with microcomputer instruction. This also suggests why the C-AIM project has been so effective in Jonesboro and West Memphis.

It should be noted that students below grade level by 1.0 at the end of the third grade in mathematics would be expected to be at grade level at the end of grade 6. Students below grade level by 1.0 at the end of the third grade in reading would still be .6 below grade level at the end of grade 6. The other tables provide a realistic picture of expected gains for students only if the assumptions about normal class progress are valid in a given school.

APPENDIX D

MODEL FOR MICROCOMPUTER INSTRUCTIONAL APPLICATIONS

A teaching-learning model has been developed to provide an orientation for schools in the development of programs for consideration by the Commission. Concepts related to effective instruction, classroom management and established principles of learning theory have been incorporated into the model. The following matrix indicates the relationship between good classroom instruction practices and IMPAC programs.

(X) APPLICABLE

	CMI CAI	CAI	C-AIM
Objective Based	X	X	X
Objective at Appropriate Level	X	X	X
Guided Activities (Immediate Feedback)	X	X	
Diagnostic Questions	X		X
Storage of Records	X		X
Retrieval of Records	X		X
Control of Learning	X		
Involve Learner in Learning Process	X	X	X
Positive Reinforcement	X	X	X
Drill and Practice	X	X	
Concept Development	X	X	
Knowledge of Results	X	X	X
Generate Overt Behavior	X	X	X
Problem Solving	X	X	
Mastery Questions	X	X	X

APPENDIX E
SCHEDULING COMPUTER TIME

Self-Contained Classroom Schedule 1
(4 Microcomputers to 28 students)

Large Group Instruction		All students	Every student could be receiving CAI in a given subject area four or five times a week. A second subject area could be introduced in the afternoon on a similiar schedule.
8:50	Group A	"	
9:10	Group B	"	
9:30	Group C	"	
Break			
10:10	Group D	"	
10:30	Group E	"	
10:50	Group F	"	
11:10	Group G	"	

Self-Contained Classroom Schedule 2
(To allow for some time constraints such as pull-out programs. 4 Microcomputers per 32 students)

		Week 1	Week 2
8:30	Group A	M-W-F	T-Th
	Group B	T-Th	M-W-F
8:50	Group C	M-W-F	T-Th
	Group D	T-Th	M-W-F
9:10	Group E	M-W-F	T-Th
	Group F	T-Th	M-W-F
9:30	Group G	M-W-F	T-Th
	Group H	T-Th	M-W-F

Break

10:00 Class goes to P.E. 2 days a week.

10:40 Several in class go to remedial reading.

Every student receives CAI 5 days out of 10. A second subject area could be introduced in the afternoon on a similar schedule.

Departmentalized Classroom Schedule
(4 Microcomputers - 32 students)

Mrs. Jones
Reading Class 1

		Week 1	Week 2
8:30	Group A	M-W-F	T-Th
	Group B	T-Th	M-W-F
8:50	Group C	M-W-F	T-Th
	Group D	T-Th	M-W-F
9:10	Group E	M-W-F	T-Th
	Group F	T-Th	M-W-F
9:30	Group G	M-W-F	T-Th
	Group H	T-Th	M-W-F

Mrs. Jones'
Reading Class 2

10:00 Schedule students as in Class 1. Mrs. Brown teaches math to these same students so they
10:20 receive CAI in math in her room using the same schedule.
10:40

11:00

Laboratory Schedule
(24 Microcomputers - 24 students))

Mathematics

8:00 - Warm-up computers
"Boot-up" software

8:30 - Class 1

9:00 - Class 2

9:30 - Class 3

10:00 - Class 4

10:30 - Class 5

11:00 - Class 6

11:30 - Class 7

12:00 - Class 8

12:30 - Break

1:00 - Class 9

1:30 - Class 10

2:00 - 3:00 - Open periods for make-up work.

Stay on this schedule four days out of five, or to increase the number of classes that can be involved, let classes alternate in going to the lab.

Example of a Class Schedule used by an IMPAC Sixth Grade Teacher

This is a copy of a first period class schedule. The teacher teaches five different classes each day. There are 6 microcomputers in the classroom.

8:30-8:45

Teacher: Calls roll, leads students in grading daily work, discusses new concept and assigns daily work

Monitor: Turns on all machines and loads courseware for the daily computer assignment

8:45-9:00

Teacher: Available for small group or individual help on present or past assignments - helps as needed on the computer

Monitor: Takes care of some of the daily chores (passing out student folders, etc.)

Students: One group of seven students go to their assigned computers for fifteen minutes. The other students file their daily work and start the work that is due the following day.

9:00-9:15

Teacher: Same as above

Monitor: Free to study if needed

Students: A second group of six go to the computers as the first group takes care of their daily work

9:15-9:20

Wrap up time. Time for answering questions and making preparation for dismissal

WEEKLY SCHEDULE

Monday	Tuesday	Wednesday	Thursday	Friday
Group 1	Group 3	Group 1	Group 3	Make-up time
Group 2	Group 4	Group 2	Group 4	all students

Friday is spent as "catch-up time" by students who lost time due to hardware or software problems during the week. Public domain software that is related to class objectives is loaded on the computers.

A similar schedule is followed with the third period math class at 10:20.

When the first nine week grading period ended the students averaged 40 minutes of CAI per week. A comprehensive supplementary math program was used with both classes. The programs were matched with the objective for the day. At the beginning of the second nine weeks another comprehensive supplementary math program was used with management, and students were allowed to work at their own pace.

APPENDIX F
CLASSROOM VERSUS LAB

	Classroom Model	Lab Model
A. Time Effectiveness:		
1. Teacher Instruction with Students	Computer is one of several instructional activities.	Focused on computer instruction only.
2. Student Time on Task	A few students work at computers while others do seat work or work with teacher in a small group	All students working on CAI lesson at same time
B. Cost Effectiveness:	No special aide or teacher needed in classroom.	Aide is needed. Fewer computers needed; less software needed but purchased for network use.
C. Computer Utilization:	Depends on individual	In use full time
D. Instructional Effectiveness:	CAI: an integral part of total classroom instruction	CAI: Computer instruction is separate area
	CMI: management data in classroom	CMI: teacher must schedule a time to retrieve data and make assignments.
E. In-service Training	Provided for each teacher involved	Focused on software rather than system. Special training for aide.

APPENDIX G
SELECTING A MICROCOMPUTER AND PERIPHERALS

The decision facing many educators at this time is which of the several microcomputers that are currently available should be considered for purchase by the local school district. Unfortunately, there is no precise set of factors that can lead to a "best brand" selection because there is no single microcomputer that is right for every educational situation. The identification of the specific classroom applications of a microcomputer system, a hands on familiarity or on-site observation, a detailed listing of the microcomputer configuration and the availability of quality courseware are aids to hardware selection.

The following observations do not provide a recipe for successful hardware selection. However, these statements are the result of careful thought about the essentials in selecting microcomputer systems for instructional applications at the elementary school level.

a. Sufficient basic skills courseware and educational documents are available for elementary schools to give consideration to the purchase of the Apple IIe, Commodore 64 and Radio Shack TRS-80 Model III-IV (network 2 or network 3). The IBM-PC and IBM-PC Jr. also deserve consideration since courseware is rapidly becoming available and educational discounts are available. This statement in no way is intended as an endorsement of a particular microcomputer system or considered an inclusive list. For example, companies such as ACORN and WICAT are involved in program development on microcomputers and minicomputers that deserves serious study by educators. Also, the statement only relates to instructional applications of microcomputers at the elementary school level. IBM and TRS-80 microcomputers have numerous business education and administrative applications.

b. Any microcomputer system should include at least a CPU with a minimum of 64K RAM memory, a monitor designed for use with that specific computer and a disk drive.

c. In the case of classroom configurations involving more than four (4) microcomputers consideration should be given to the inclusion of a printer. A bi-directional tractor feed printer is recommended. Investment in a letter quality printer is not recommended.

d. Except for special function keys related to graphics and data entry, the keyboard should function like a regular typewriter (QWERTY) keyboard so that good keyboarding skills may be developed.

e. Microcomputer systems purchased in quantity should be capable of networking to either a floppy disk or hard disk in sets of at least four (4) systems. Networks of up to 32 systems involving a hard disk have been effectively utilized in a school setting. Flexibility in microcomputer configurations is imperative for cost effective applications over a five (5) year period.

f. Color, sound and high resolution graphics have been essential to quality courseware. Expenditures for these features as extras should be

justified on the basis of their effectiveness in concept development courseware.

Compatibility of Software and Hardware

Software programs are stored on a diskette in such a way that only certain microcomputers, without modification, can run the programs. The program instructions are organized on the diskette according to a certain format. The microcomputer loads and runs the program using the disk operating system which is designed to read the program instructions off the diskette. The most common disk operating systems for which there are large amounts of courseware are Apple 3.3, Commodore DOS, TRSDOS, MS-DOS and CP/M. Some microcomputers with additional chips or special systems software can run programs formatted using one or more of these disk operating systems. For instructional applications, schools are advised to purchase only microcomputers that have disk operating systems that will load and run courseware that is expected to remain in abundant supply.

EVALUATION OF MICROCOMPUTER HARDWARE

Microcomputers have a variety of features and capabilities. It is important to evaluate each system under consideration in terms of its ability to meet the district's instructional needs. The following list includes the factors that should be considered in the assessment of microcomputer systems.

Cost - The cost of microcomputers for educational purposes varies greatly from less than three hundred to about four thousand dollars. Cost comparisons must be made in relationship to machine capabilities and software programs that are available. Cost most often reflects memory size, language capacity and the type of storage device available. When comparing costs of various machines, remember to be sure to compare machines with similar configurations and capabilities.

Memory - There are two kinds of memory in a computer - RAM (random access memory) and ROM (read only memory). The RAM determines the size of the programs that can be run on the microcomputer. A program requiring 64K of memory will not run on a computer that has only 48K memory. The ROM is used for storing programs that are generally put in by the manufacturer as part of the operating system of the computer. The amount of memory available will often limit the courseware that can be run on the computer. A 64K memory is considered a minumum for courseware presently being developed.

Peripherals - These are devices that are accessories to the computer; however, often the computer will not function properly without certain peripherals.

a. Floppy or hard disk drives - These are used to augment the memory capacity of the microcomputer. These devices can store and play back programs. Hard disk drives are more expensive than floppy disk drives,

but provide faster and more reliable storage and retrieval of information. Hard disk drives are usually used when microcomputers are networked together.

b. Printers - If printed hard copies of student records or instructional prescriptions are desired, or if the microcomputer is to be used for word processing, the purchase of a printer is essential. The types of printers that can be used with a given microcomputer should be determined, as should the supportive items such as an interface card that may be necesssary to use the printer. The printer's speed and ability to reproduce graphics should be considered. Basically two types of printers are available (1) a dot matrix printer and (2) the letter quality printer. The letter quality printer will be much more expensive and is only necessary if high quality manuscripts produced through word processing are to be done.

c. Monitor - The purpose of a monitor is to have a screen display of the output of the computer. In some microcomputers the monitor is built into the main unit. In others it is detached and considered a peripheral. When this is the case, the monitor selected should support the hardware purchased. Television sets can be used as monitors for some microcomputers. Generally a monitor has a higher degree of resolution and is more reliable than a television set. If the computer has color capabilities, consideration should be given to purchasing a color monitor. Generally, if the computer is to be used for word processing the green or amber screens are recommended.

d. Modems - Modems allow microcomputers to "talk" to other computers over telephone lines. A modem would give the microcomputer access to information networks as well as potentially enabling it to be used as a "dumb terminal" for communication with other computers. In Arkansas the microcomputer is currently being used to connect schools and the Department of Education through Connect*Ed. Instructional applications of modems is limited at the elementary school level.

Software - Collectively the programs that are loaded into the computer are known as software. Complete instructional packages for computer-assisted instruction/computer-managed instruction are referred to as courseware. Generally, software is available to suit a variety of educational needs. There is a wide variety in the quality and the availability of specific items for a particular machine. The software market is rapidly expanding; however, there is no assurance that educationally effective software developed for one computer will eventually be adapted for other models. An attempt should be made to determine the availability of software and materials to meet the stated objectives for the school program.

Screen Display - The options for screen display ranges from 20 to 80 characters in width and 16 to 32 lines. Many microcomputers have upper case letters only.

Graphics - The greater number of dots or blocks that can be used to display a graphic, the higher the resolution (greater the detail). Some computers are capable of character graphics programming while others have higher resolution graphics. Many programs such as LOGO will not run on machines with only character graphics.

Keyboard - There are two basic types of keyboards available on computers. The typewriter-like unit with keys you depress and a flat (membrane) unit with keys drawn on a smooth surface that is pressure sensitive. Students with any keyboarding experience will respond positively to the typewriter-like feature. Many keyboards feature special function keys - these are generally preferred if they are not accessed by the regular typewriter keyboard. Another option that is often a major consideration is the presence of a separate number pad.

Sound and/or Music - This feature comes standard on some microcomputers and can be added at additional cost on other models. Sound is usually considered a motivational feature for young users.

Color - Computers that have color capabilities display a range of 4 to 16 colors. Color is a consideration in the reinforcement and motivation of young students, for highlighting, contrasting, or increasing the appeal of the program.

Networking and/or Expansion - To lessen the cost for peripherals such as disk drives and/or printers, networking capabilities can be explored. Care must be taken in assessing the networking capabilities so that the desired courseware will in fact work on the network. Most of the "protected" programs from commercial sources will not load onto the network without modification. Several expansion capabilities are available for additional costs including interactive videotape and videodisc connections.

Languages - BASIC (Beginners' All Purpose Symbolic Instruction Code) is the most common language for the microcomputer. Microcomputers differ in the type of BASIC used. One should not assume that software written for one brand of microcomputer will run on another brand. Many computers have the capability of being programmed in other languages. To adjust the computer for use with other languages requires the purchase of a language modifying item such as a language card or cartridge. The following languages are sometimes used:

a. Pascal - This structured language is useful for those interested in more advanced computer programming.

b. Pilot (or other authoring languages) - This authoring language allows teachers with no programming experience to write computer-assisted instruction programs for use with their own classes. However, such courseware is seldom cost effective when compared to good commercial courseware.

c. Fortran (Formula Translation) - This scientific language is useful for dealing with problems in science and engineering.

d. LOGO - This highly interactive language is designed primarily for use with young children.

APPENDIX H
EQUIPMENT BID SPECIFICATIONS AND MAINTENANCE AGREEMENTS

When securing equipment, consideration should be given to the development of bid specifications and maintenance agreements. Such specifications and agreements cause the local school district to describe specifically what equipment is to be purchased, the appropriateness of functionally equivalent equipment and the type of maintenance expected.

In most cases the school district should require that a vendor bid on the entire system as a prime contractor. The selected contractor should be required to assume all responsibility for the equipment and be the primary point of contact with regard to equipment, maintenance and support. The vendor should be an authorized service dealer for the microcomputers being bid.

Criteria for evaluating microcomputer systems in the context of a bid are being used in the evaluations of bids submitted relating to IMPAC programs. You are encouraged to use this criteria in evaluating bids. Certainly the criteria reveals in part the Commission's view that evaluation of bids may be an important process especially in large equipment orders.

1. EVALUATION CRITERIA RELATED TO EQUIPMENT SPECIFICATIONS

The selection process should be based on a predetermined methodology and set of evaluation criteria. The evaluation criteria should reflect the following objectives and considerations:

a. The ability of the vendor to satisfy the school's overall computer based instruction goals

b. Meeting the minimum mandatory requirements set forth in the specifications

c. The total cost of the system, including transportation, installation, maintenance and training

d. The level of vendor assistance, aids and promptness of the installation effort

e. The level of vendor maintenance support for the hardware

f. The number and type of vendor references specified

g. Emphasis should be placed on the clarity and conciseness of vendor proposals. Failure to completely meet any one of the mandatory requirements including bid format and submission of the required number of copies at the time of bid opening, may be sufficient cause for rejection of the vendor's proposal.

In addition to the criteria noted above, the skills, facilities, experience, previous work and financial standing of the bidder; and the quality, efficiency and construction of the equipment proposed to be furnished should be considered.

2. MAINTENANCE SUPPORT REQUIREMENTS

The vendor should assume total responsibility for all the hardware purchased. Any vendor proposing the hardware in response to a bid should certify that maintenance can and will be provided in accordance with bid requirements.

Maintenance service should be available to the school on-call from 8 a.m. to 5 p.m., Monday through Friday. This plan should offer, during the principal period of maintenance, a minimum of next day response to a trouble call. The maintenance plan bid should describe how the bidder will provide maintenance service, identify all parts required, and outline all associated costs.

If any component in the computer based instruction system remains inoperative for more than seventy-two (72) hours from time of notification of failure, the school district should reserve the right to exercise the following options:

a. Suspend payment of maintenance on the malfunctioning systems(s) or machine(s) rendered unusable. Maintenance payments would resume at such time the system(s)/machine(s) are returned to an acceptable service level determined by the school district.

b. Allow the vendor to replace malfunctioning system(s) or machine(s) with equipment of equal or greater capacity at no expense to the school district.

Contracted monthly maintenance should be proposed and begin after expiration of the defined warranty period offered in the bid. If maintenance charges are to escalate from year to year during the maintenance contract period, a maximum annual percentage rate of increase should be stated and evaluated as such. Escalative charges should only be put into effect at the beginning of the school district's fiscal year (July 1) and only if preceded by 90 days written notice. Maintenance charges should be stated on a per unit basis.

Time-and-material maintenance should be proposed and begin after expiration of the warranty period offered in the bid. Bidders should state the period of time all associated costs for such service will remain in effect. A bidder should state their experience factor as regards mean time between failure for the equipment proposed.

A bidder should provide a toll-free telephone number (or one which will accept collect calls) through which the school district may obtain operational diagnostic assistance for hardware.

A bidder should provide a detailed explanation of both maintenance programs proposed by the vendor to provide service at the school district so as to insure attainment of a goal of maximum up-time. The explanation should address the following points.

a. Parts supply and availability

b. Technical personnel support giving numbers and skill levels

c. Backup support for technical personnel

d. Backup equipment availability

e. Length and terms of warranty on each system/software

f. Average turn-around time for requested remedial maintenance

g. Time and material rates

h. A list and cost of any spare parts that the bidder suggests the school district should keep on-hand

The school district should be able to select either monthly contracted or time and material maintenance plans. However, the cost of the bidders proposal should be either a monthly or time and material contract for maintenance of equipment.

Delivery and Installation of Equipment

Delivery and installation of all hardware should be completed within a specified (usually 30-45 days) time after bid award.

The bidder should assume responsibility for:

a. arranging for equipment transportation to specified school district receiving center

b. the risk of loss and/or damage during shipment of all equipment

c. the installation of all the microcomputer systems excluding preparation of the physical facility

d. outlining in detail the requirements for required modification of the physical site if any, to accommodate installation of the proposed hardware

e. all necessary cabling

f. describing in detail their methodology and criteria for acceptance testing and certification of each system as "customer ready"

Bidders should describe the remedial action to be taken following certification of system as "customer ready" in the event any system fails to meet the school district's standards. A performance (90% overall up-time) calculated as follows is recommended:

$$\frac{\text{(Productive time - Downtime)}}{\text{Productive time}} \times 100 = \text{Uptime percentage}$$

Productive time is defined as those periods during which the system is scheduled for operational use by the school district.

Acceptance of Equipment

The school district should provide a letter of acceptance when all requirements under specifications have been met.

Training

Formal customer training courses for use of the hardware should be required if needed and should be detailed as to cost and content in the vendor proposal. The bidder should provide a specified number of hours of training for the school district.

On-site training should be specified for the teachers in the operation of the hardware after the equipment has been delivered, installed and tested for operation in accordance with the manufacturers specifications. It is recommended that training be available within fifteen (15) days after the hardware becomes available for operational use.

Documentation/Manuals

Documentation for each of the microcomputer systems should include, at a minimum, the following:

a. User procedure manual for microcomputers

b. Microcomputer system manuals
   (1) System operating manual
   (2) Maintenance manual

c. Courseware manuals (if any)

The bidder should provide unit costs for all documentation identified above that would apply to subsequent school district purchases.

Bidders should state their policy as regards reproduction of manuals for the exclusive use of school district employees and students for educational purposes.

Pricing

All charges associated with the proposed hardware should be included on the Bidders Price Sheet and should be included in the costing evaluation. These prices should include the following:

a. Equipment pricing

b. All cabling costs, if additional

c. Maintenance costs

d. Maximum amount of annual increase in maintenance cost which the vendor may charge (NOTE: This should be quoted in terms of maximum dollar or percentage increase over previous year)

e. Shipping date estimate and anticipated date of installation

f. Installation charges, if any

Summary

In preparing a bid be sure to cover the following items:

A. Accept bids only from authorized service dealers.

B. Detail description of equipment

C. Vendor clarification of warranty and how equipment will be repaired or replaced

D. Clarification of maintenance available after warranty

E. Expectations for on-site installation, including electrical requirements, set up and certification that equipment is working using performance test

F. Training and orientation of staff

G. Documentation manuals and software required to use the system

H. Prices on each item in the main bid request

I. Terms of payment

J. Length of term of the bid

K. Prices of optional items that enhance the use of the system should be included since diskettes, diskette boxes, computer covers, power block switches, paper and ribbons will be needed eventually.

APPENDIX I
CLASSROOM FACILITIES

There are several types of configuration of microcomputer systems that are likely to become standard equipment in elementary and secondary classrooms. Included are the following:

A. Classrooms with 2, 4 or 6 microcomputer systems in either a small network arrangement or as stand alone units

B. A laboratory using 16, 24 or 30 microcomputer systems networked to a dual disk drive or a hard disk

C. Learning centers, either in the classroom or media center, utilizing 1-8 microcomputer systems with a variety of problem solving and simulation courseware

A microcomputer system usually includes a microcomputer, monitor and disk drive. Also, for every four systems there is one printer and an extra disk drive. There must be some consideration given for storage of courseware and printer paper.

The specifications related to each configuration described above are provided to assist in school facility planning.

REGULAR CLASSROOMS

Electrical

Each microcomputer system requires at least three electrical outlets (microcomputer - monitor - disk drive). Also, a printer (one additional electrical outlet) is usually provided for every four microcomputer systems. This is the minimum configuration recommended for an elementary school classroom. Power surges are common in most school districts. A power surge protection device with a current filter and four outlets should be plugged into the wall receptacle. An extension cord from each of these outlets should extend to each microcomputer system and provide four outlets for the systems components. Once a system is out of warranty, extensive damage from power surges caused by lightning is the school district responsibility. Insurance that covers theft and storm damage should be considered. A switch that turns all systems on or off at the same time is recommended. This is very useful at the beginning and end of each school day and during electrical storms.

Lighting

No special lighting is required. This assumes that the room meets recommended standards for a regular classroom. Microcomputer systems should not be placed near heating or cooling units, or located so that students face windows without shades.

Floor Coverings

No special floor coverings are required. However, concrete floors are not recommended due to excessive dust. If carpet is installed, it must be static free.

Furniture

Tables (with non-folding or lockable legs and wood table tops) should be at least 30 inches wide, appropriate height depends on grade level, and at least 6 feet in length. The station using the printer will need two additional feet of length. This means in a typical elementary classroom, one 6' table, one 8' table, 4 chairs and appropriate electrical wiring will be needed. Space needs for such a configuration, as well as other configurations are given below:

# Systems	# 6' Tables	# 8' Tables	Chairs	Minimum Room Space Needed
2	0	1	2	48 sq. ft.
4	1	1	4	84 sq. ft.
6	2	1	6	120 sq. ft.

MICROCOMPUTER INSTRUCTION LABORATORIES

Electrical

In addition to the electrical outlets required for each microcomputer system (microcomputer, monitor and disk drive) - an outlet is needed for at least one printer, a hard disk drive and disk server. Laboratories with 16, 24 and 30 microcomputer systems is recommended as feasible if one-half or all of the students use the lab during a given time block (usually 20-30 minutes). Microcomputers are networked together using a small trunk line or wire that carries signals. The trunk line should be secured in the back of tables so that students cannot kick the line with their feet while working on the computers. Install or ensure that dedicated circuits are used in networks. "Dedicated" means that nothing other than the computer system can be plugged into these circuits. The circuit also needs a good earth ground.

A switch that turns all the systems on or off at the same time is recommended. Such a switch should be put inside a lockable case in order to protect against accidental switching.

Lighting

Shades may be needed since, regardless of the room arrangement, glare will be a distracting factor.

Floor Covering

No special floor coverings are required. However, concrete floors are not recommended due to excessive dust. If carpet is installed, it must be static free.

Furniture

Dimensions and numbers of tables needed are comparable to those used in a regular classroom. However, an entire classroom will be needed for any given laboratory configuration. An extra 8' table is needed as a part of a teacher monitor station.

# Systems	# 6' Tables	# 8' Tables	Chairs	Minimum Floor Space
16	6	2	17	312 sq. ft.
24	10	2	25	456 sq. ft.
30	14	2	30	600 sq. ft.

MEDIA CENTER

The guidelines provided for 2, 4 or 6 microcomputer systems in a classroom apply to the media center.

APPENDIX J
ELECTRICAL REQUIREMENTS

Is the electrical power to your classroom clean? The electrical outlets for your computers should provide steady reliable power. This is most important when computers are tied together via a high speed communications "local area network" (LAN).

Electrical power utilities are often blamed for "dirty power" but most induced current affecting microcomputers and computer networks is generated after it leaves the main source and before it arrives at the classroom outlet. Most of these electrical power problems are of the following types:

1) Brown-outs (low voltage on an electrical distribution system) may be caused by localized overloads between the main commercial power system and local distribution, uncontrolled area wide reduction of voltage caused by extremely heavy demand over a large area, and controlled deliberate wide reduction of voltage by the power company to prevent a blackout.

2) Black-outs or power outages (no electrical power in a given locale or large area) may be caused by an overload condition within your school building (the circuit breaker trips), a local distribution failure (a pole mounted transformer or circuit breaker is damaged) and a power failure caused by large area wide problems.

3) Alternate current (AC) line irregularities may exist due to at least six causes: lightning discharges from a flash occurring up to several miles away; switching of nearby inductive loads from motors, air conditioners, fans or large relays; electrostatic discharges or static electricity; nearby radio and television stations; loose electrical connections and fluorescent lights.

Causes of "dirty power" or "noise" may be miles away, in the building next door or in the room down the hall. Almost never attributed to a single source, they are usually the sum of numerous disruptive influences. There is little the electric power company can do. It is the user's responsibility to protect his or her equipment against these problems.

Normally, educational microcomputer systems are not protected from brown outs and black outs. If the power goes off, fluctuates or electrical thunderstorms are in the area the teachers should turn off the computers or shut down the computer network. After it has been verified that the power is good, the teacher may turn on the computer systems again.

If the electrical power to the computers is on a dedicated circuit with little inductive noise and well-grounded, surge protectors will generally be adequate.

Line irregularities can be reduced. A licensed electrician should be used for this task. You should share the following directions with the

electrician. Feel free to contact the IMPAC office if clarification is needed.

Ensure that the electrical outlets that will be used by the computer systems are noise free and well-grounded. If they are not, take the following steps:

Install a dedicated circuit from each room back to a common circuit breaker panel. Each conduit should carry only one circuit - a hot, a neutral and a ground wire. Connect these wires to "isolated ground outlets" in the room and to the circuit breaker, a neutral bar and a ground bar in the circuit breaker panel. A good earth ground should be established at that common circuit breaker panel. We recommend driving a grounding rod below that panel. All conduits should be secured tightly. The circuit breaker panel box should be bonded to the earth ground and to the ground wire from the conduit.

It is important that all computer systems that are tied together through networks have the same ground reference (no electrical potential should exist between the ground in one outlet or plug versus another).

If possible, try to balance the electrical load by using all phases of electrical power. For example, if there are six classrooms involved, install a dedicated circuit to two of the rooms using phase A, put two rooms on phase B and two on phase C.

The quality of the electrical power is critical to a microcomputer network. The electrical wiring should be certified as acceptable by a qualified licensed electrician following network specifications. The IMPAC educational technologist should be contacted if you have any questions. Good clean electrical power is a must for a network.

APPENDIX K
IN-SERVICE PROGRAMS

Introduction to Microcomputers and their Instructional Applications In-service Training Level I

Any teacher involved in instructional applications of microcomputers needs a minimum of 24 clock hours of pre-service or in-service instruction. The training should involve one of the actual computers and other associated hardware to be used by the teacher. Software comparable to the software to be used in classroom instruction should also be available. Teachers should develop the ability to understand the capabilities of microcomputer technology as it relates to computer-managed and computer-assisted instruction in a self-contained, departmental or laboratory setting.

The following is an outline of a recommended 24 clock hour course that should meet the objectives stated above:

A. KEYBOARDING SKILLS - 2 hours
   1. Identification of the keys, the role of each and especially those that perform special functions when the student interacts with software.
   2. Break and reset
   3. Clear screen procedure
   4. Special and multiple function keys

B. INTERACTING WITH SOFTWARE - 4 hours
   1. Loading and saving a program
   2. Auto and soft disk boots
   3. Running and controlling a program
   4. Interacting with courseware
   5. Break and reset technique
   6. Obtaining and working from a menu
   7. Keying in short programs and executing

C. TERMINOLOGY - 3 hours
   1. CPU/ROM/RAM
   2. Input/output
   3. Cassette/floppy disk/hard disk
   4. Monitor: Display characteristics and capabilities
   5. Load, Save, Run, List
   6. Motherboard/bus
   7. Catalog/directory

D. MICROCOMPUTER INSTRUCTIONAL SYSTEM - 4 hours
   1. Microcomputer with ROM and RAM
   2. Monitor and keyboard
   3. External storage - floppy disk and hard disk
   4. Printer
   5. Floppy disk characteristics and usage
   6. Utility programs
   7. Clock/counter/random number generators

E. INSTRUCTIONAL USES - 4 hours
   1. Networks
   2. Categories of computers used in education
   3. Specific CAI strategies
   4. Definitions of cost effectiveness
   5. Strategies for maintaining technology awareness
   6. Selecting software keyed to objectives
   7. Classroom instructional management and organization

F. COURSEWARE EVALUATION - 4 hours
   1. Evaluation criteria/evaluation forms
   2. Sources of courseware evaluations
   3. Matching courseware and instructional objectives
   4. Pricing techniques
   5. User groups
   6. Public Domain
   7. Vertical files of courseware
   8. Backups

G. ISSUES RELATED TO COMPUTER BASED INSTRUCTION - 2 hours
   1. Cost justification
   2. Literacy
   3. High tech jobs in perspective
   4. Copyright laws
   5.. Courseware/hardware compatibility
   6. Equity in access to computers
   7. Budget priorites
   8. Privacy

H. A VIEW TO THE FUTURE - 1 hour
   1. Evolution of computers and their impact on society
   2. Authoring languages
   3. LOGO/PILOT
   4. Word processing
   5. Interactive video
   6. Minicomputer systems
   7. Textbook/courseware supplements
   8. Handheld computers/cartridges of courseware

Planning and Coordinating Instructional Applications of Microcomputers
Level II Training

Instructional coordinators should be prepared to help teachers with Level I training to use computers as instructional and management tools. The coordinator should be able to help teachers incorporate the use of computers into their instructional program. This involves the designing of unit or single lesson plans, evaluation of courseware, instructional strategies and the selection of the components of microcomputer systems. The training of the instructional coordinator should place emphasis on instructional strategies, introductory programming skills and microcomputer systems appropriate to meet specific educational objectives over a five (5) year period. A recommended course outline is given below and assumes an equivalence of prior Level I training.

A. Scope of Computer-Assisted Instruction Activities - 6 hours
   1. Drill and Practice
   2. Tutorial
   3. Simulation
   4. Gaming
   5. Problem solving
   6. Word processing
   7. Criteria for selection of appropriate instructional activity

B. Software Evaluation and Selection - 9 hours
   1. Software review guidelines
   2. Sources of reviews
   3. Selection of software relative to instructional objective
   4. Technical requirements - RAM/hardware/language
   5. Pricing
   6. Vertical files of software
   7. Organizing and maintaining a software library
   8. Maintenance of software and hardware

C. Integrating Computers into Instructional Units - 6 hours
   1. Research on CAI
   2. Laboratory/stand alone
   3. Scheduling and supervising CAI/time on task
   4. Modes of instruction - drill and practice/tutorial/games
   5. Formative and summative evaluation

D. Instructional Support Software - 9 hours
   1. Computer-managed instruction/tracking student progress
   2. Database systems
   3. Word Processing
   4. Spreadsheets
   5. Teacher Utilities
   6. Testing and evaluation programs

E. Programming Skills - 9 hours
   1. Flow charts
   2. Introduction to Basic
   3. Other instructional languages
   4. Introduction to graphics, sound and color

F. Developments in Computer Technology - 3 hours
   1. Brief history of computers
   2. Applications of computers in business, government, medicine and science and industry
   3. Limitations of computers
   4. Privacy issues
   5. Information processing and distribution
   6. Modems/Compuserve/The Source

G. Microcomputer Instructional Systems - 6 hours
   1. Types of microcomputers and standard features/hardware evaluation
   2. Peripheral devices
   3. Future trends

* Participants attending the Arkansas Leadership Conference on Microcomputer Instruction In-service Training generally agreed that three levels of training may not meet the needs of Arkansas educators. It was recommended that Level IIB training be developed to focus on the needs of the curriculum leaders in schools i.e. principals, curriculum specialists, library media specialists and superintendents. These individuals would probably have little use for programming skills now outlined in Level II, but would need the knowledge and skill to effectively integrate computer technology into the school curriculum. A format for regional conferences based on Level IIB training has been developed by the IMPAC staff. Level IIB training is essentially defined by the outline in this resource document.

APPENDIX L
ESTIMATED SYSTEM COST OVER 1984-89

Program type: CAI-Commodore 64 System
Students: 720 over 5 years # Teachers Involved: 6
Cost/5yrs/Student: $47802/720 = $66

Item - Required	#	Cost/Unit	Total	Year 2-5 Additional Cost	Five-year Cost Total
Microcomputers	24	$225	$5400	0	$5400
Monitors (color)	24	270	6480	0	6480
Single disk drives	24	250	6000	0	6000
Printers	4	250	1000	0	1000
MSD-2 Dual Drive	1	650	650	0	650
Math courseware	6	800	4800	800	5600
Reading & LA courseware	6	800	4800	800	5600
Management courseware	N/A	N/A	N/A	N/A	0
Blank Disk	500	2	1000	500	1500
6 feet tables	6	60	360	0	360
8 feet tables	6	60	360	0	360
Chairs	24	15	360	0	360
Electrical work	N/A	500	500	0	500
In-service	7	150	1050	750	1800
Disk Replacements	N/A	300	300	900	1200
Maintenance	24	75	1800	7200	9000
Disk Storage	48	4	192	180	372
Space and utilities	N/A	N/A	N/A	N/A	0
Paper and Ribbon	N/A	N/A	124	496	620
Insurance	N/A	200	200	800	1000
TOTAL			$35376	$12426	$47802

Item - Optional	#	Cost/Unit	Total	Additional Cost	Cost Total
Micro Backups	2	225	450	0	450
Monitor Backups	2	270	540	0	540
Backup drives	6	250	1500	0	1500
Printers Backups	1	250	250	0	250
6 feet tables	1	60	60	0	60
8 feet tables	1	60	60	0	60
Chairs	2	15	30	0	30
Power Surge	7	60	420	0	420
Single unit switches	14	20	280	0	280
TOTAL			$ 3590	0	$ 3590

It should be noted that the estimated cost of each system includes more than microcomputer equipment. The total cost of a system includes other items such as tables, electrical, teachers aide as needed and supplies of various types. The backup systems may be deleted if a seven day or less maintenance service is available from the vendor.

Program type: CMI-CAI Commodore 64 - Richvale Network Laboratory
Students: 1200 over 5 years # Teachers Involved: 10
Cost/5yrs/Student: $61608/1200 = $51

Item - Required	#	Cost/Unit	Total	Year 2-5 Additional Cost	Five-year Cost Total
Microcomputers	24	$225	$5400	0	$5400
Monitors	24	270	6480	0	6480
Single disk drives	6	250	1500	0	1500
Printers	1	250	250	0	250
Math courseware	6	800	4800	800	5600
Reading & LA courseware	6	800	4800	800	5600
Management courseware	1	1500	1500	0	1500
6 feet tables	11	60	660	0	660
8 feet tables	1	60	60	0	60
Chairs	24	15	360	0	360
Electrical work	N/A	700	700	0	700
In-service	7	150	1050	750	1800
Maintenance	N/A	N/A	4000	16000	20000
Space and Utilities	N/A	N/A	N/A	0	0
Hard Disk	N/A	N/A	4000	0	4000
Network	N/A	N/A	4478	0	4478
Video Backup	N/A	N/A	600	0	600
Paper and Ribbon	N/A	N/A	124	496	620
Insurance	N/A	N/A	400	1600	2000
TOTAL			$41162	$20446	$ 61608

Item - Optional	#	Cost/Unit	Total	Additional Cost	Cost Total
Micro Backups	2	225	450	0	450
Monitor Backups	2	270	540	0	540
Printers Backups	1	250	250	0	250
6 feet tables	1	60	60	0	60
8 feet tables	1	60	60	0	60
Chairs	2	15	30	0	30
Power Surge	7	60	420	0	420
Single unit switch	14	20	280	0	280
Aide	N/A	N/A	8000	32000	40000
TOTAL			$10090	$32000	$42090

Program type: CAI-Apple IIe System
Students: 720 over 5 years
Cost/5yrs/Student: $59604/720 = $83

Teachers Involved: 6

Item - Required	#	Cost/Unit	Total	Year 2-5 Additional Cost	Five-year Cost Total
Microcomputers	24	$ 655	$15720	0	$15720
Monitors	24	160	3840	0	3840
Single disk drives	30	280	8400	0	8400
Printers	6	400	2400	0	2400
Math courseware	6	800	4800	800	5600
Reading & LA courseware	6	800	4800	800	5600
Management courseware	N/A	N/A	N/A	0	0
Blank Disk	500	2	1000	500	1500
6 feet tables	6	60	360	0	360
8 feet tables	6	60	360	0	360
Chairs	24	15	360	0	360
Electrical work	N/A	500	500	0	500
In-service	7	200	1400	1000	2400
Disk Replacements	N/A	300	300	900	1200
Maintenance	24	75	1800	7200	9000
Disk Storage	54	N/A	372	372	744
Space and Utilities	N/A	N/A	N/A	0	0
Paper and Ribbon	N/A	N/A	124	496	620
Insurance	N/A	200	200	800	1000
TOTAL			$46736	$12868	$59604

Item - Optional	#	Cost/Unit	Total	Additional Cost	Cost Total
Micro Backups	2	655	1310	0	1310
Monitor Backups	2	160	320	0	320
Printers Backups	1	400	400	0	400
6 feet tables	1	60	60	0	60
8 feet tables	1	60	60	0	60
Chairs	2	15	30	0	30
Power Surge	7	60	420	0	420
Single unit switches	14	20	280	0	280
TOTAL			$2880	$ 0	$2880

Program type: CMI-CAI Apple IIe Corvus Network Classroom or Lab
Students: 1200 over 5 years # Teachers Involved: 10
Cost/5yrs/Student: $80340/1200 = $67

Item	#	Cost/Unit	Total	Year 2-5 Additional Cost	Five-year Cost Total
Microcomputers	24	$ 655	$15720	0	$15720
Monitors	24	160	3840	0	3840
Single disk drives	6	280	1680	0	1680
Printers	6	400	2400	0	2400
Math courseware	N/A	3000	3000	1000	4000
Reading & LA courseware	N/A	5500	5500	1000	6500
Management courseware	N/A	2500	2500	0	2500
6 feet tables	6	60	360	0	360
8 feet tables	6	60	360	0	360
Chairs	24	15	360	0	360
Electrical work	N/A	1300	1300	0	1300
In-service	7	200	1400	1000	2400
Maintenance	N/A	4000	4000	16000	20000
Space and Util.	N/A	N/A	N/A	0	0
Hard Disk	1	4000	4000	0	4000
Disk Server	1	900	900	0	900
Network	24	450	10800	0	10800
Video Backup	1	600	600	0	600
Paper and Ribbon	N/A	N/A	124	496	620
Insurance	N/A	400	400	1600	2000
TOTAL			$59244	$21096	$80340

Item - Optional	#	Cost/Unit	Total	Additional Cost	Cost Total
Micro Backups	2	655	1310	0	1310
Monitor Backups	2	160	320	0	320
Printers Backups	1	400	400	0	400
6 feet tables	1	60	60	0	60
8 feet tables	1	60	60	0	60
Chairs	2	15	30	0	30
Power Surge	7	60	420	0	420
Single unit switch	14	20	280	0	280
Aide	1	8000/yr	8000	32000	40000
TOTAL			$10880	$32000	42880

ESTIMATED SYSTEM COST OVER FIVE YEARS
1984-89

Program type: C-AIM
Students: 1440 over 5 years
Cost/5yrs/Student: $10281/1440=$7
Teachers Involved: 12

Item	#	Cost/Unit	Total	Year 2-5 Additional Cost	Five-year Cost Total
Commodore 4032 Microcomputers	6	$550	$3300	0	$3300
MSD SD-2 Dual Disk Drives	1	695	695	0	695
Commodore 4023 Printer	1	325	325	0	325
Management courseware	N/A	150	150	0	150
6 feet tables	3	60	180	0	180
8 feet tables	1	60	60	0	60
Chairs	8	15	120	0	120
Electrical work	N/A	500	500	0	500
Power Surge	2	60	120	0	120
Single unit switches	4	20	80	0	80
In-service	N/A	N/A	675	500	1175
Disk Replacements	N/A	N/A	N/A	40	40
Maintenance	N/A	N/A	N/A	600	600
Disk Storage	4	4	16	0	16
Mupet System	6	N/A	1300	0	1300
Paper & Ribbon	N/A	N/A	124	496	620
Insurance	N/A	N/A	200	800	1000
TOTAL			$ 7905	$ 2556	$ 10281

Appendix L includes systems which are comparable to those installed in IMPAC schools and reflects initial and long term cost. Recent price changes in microcomputer equipment could cause the totals to be adjusted down by at most 10%. It should be noted that although microcomputer systems may have decreased in price, most of the other items have either remained the same or increased in price. Projected decreases in the cost of educational microcomputer systems for each of the next four (4) years is 6%.

You should make a comparison of the Commodore 64 and Apple IIe system prices with IBM-PC, IBM-PCjr and Radio Shack microcomputers. Be sure you include all items and verify the appropriateness of the courseware when you make a comparision.

COURSEWARE USED IN IMPAC PROGRAMS

The following list of courseware is provided because it defines the courseware selected for use in the IMPAC programs. There are other courseware packages that may be just as effective. Recommended Instructional Courseware, developed by the IMPAC staff, has been mailed to each school superintendent in Arkansas. An additional copy may be requested from the IMPAC office if needed.

Title	Company	Microcomputer
Elementary Math Classroom Learning	Sterling Swift	Apple IIe
SRA Math Levels B,C, & D	Science Research Assoc.	Apple IIe.
Processing Power	I/CT Inst. Comm. Tech.	Apple IIe
Cloze-Plus	I/CT Inst. Comm. Tech.	Apple IIe
Readware	Essertier Software, Corp	Apple IIe
San Diego Basic Skills in Math	San Diego School Dist.	Apple IIe
Math Strategies	Science Research Assoc.	Apple IIe
Adding Fractions	Microcomputer Workshop	Apple IIe
1-2-3 Digit Multiplication	Microcomputer Workshop	Apple IIe
Multiplying Fractions	Microcomputer Workshop	Apple IIe
Long Division	Microcomputer Workshop	Apple IIe
Fast Facts	EDU SOFT	Apple IIe
Capitalization	Hartley Courseware	Apple IIe
Mastery of Parts of Speech	Society for Visual Ed.	Apple IIe
Skillcorp Reading	Skillcorp Software Corp.	Apple IIe
Mathware	Essertier Software Corp.	Apple IIe
Fundamentals of Math	Sterling Swift Pub.	Commodore 64
Pet Professor	Cow Bay Computing	Commodore 64
Diascriptive Reading	Educational Activities	Commodore 64
Public Domain Math	IMPAC	Commodore 64
Public Domain Language Arts	IMPAC	Commodore 64
Prime Number & Fractors	Micro Ed., Inc.	Commodore 64
Fraction Concepts	Micro Ed., Inc.	Commodore 64
Fraction Operations	Micro Ed., Inc.	Commodore 64
Money	Micro Ed., Inc.	Commodore 64
Measurement	Micro Ed., Inc.	Commodore 64
Decimals	Micro Ed., Inc.	Commodore 64
Basic Grammar One	Micro Ed., Inc.	Commodore 64
Basic Grammar Two	Micro Ed., Inc.	Commodore 64
Reference Skills	Micro Ed., Inc.	Commodore 64
Microgrames Language Arts	Microgrames, Inc.	Commodore 64
Micro-Ed Language Arts	Micro Ed., Inc.	Commodore 64

TERMINOLOGY

1. Backup copy - A duplicate copy

2. Byte - Represents one character such as a letter and is usually 8 bits in length

3. CAI - Computer-Assisted Instruction

4. C-AIM - A basic skills testing program with management features, Computer-Assisted Instruction Management

5. CMI - Computer-Managed Instruction

6. CMI-CAI - Computer-Managed Instruction with Computer-Assisted Instruction

7. Computer - Any device with a self-contained memory which can receive information, process it, store it and follow instructions to manipulate that information

8. Courseware - The computer programs together with the teacher materials, workbooks and guides

9. CPU - Central Processing Unit-- The part of a computer which controls the operation of other parts of the computer

10. CRT - Cathode Ray Tube-- The display part of a television, monitor, or video terminal

11. Cursor - A movable spot on the CRT screen. Shows the programmer or operator where the pointer is located

12. Debug - Locating and eliminating errors

13. Disk - A device that looks like a phonograph record on which large amounts of data may be stored

14. Documentation - A written description of a computer program. It allows one to understand the purpose and logic of a program

15. Drill and Practice - A type of computer program which acts as a drillmaster by providing repetitive practice on some basic skill or set of facts

16. Educational Game - A type of computer program with an instructional purpose presented in a game format

17. Execute - To run a computer program

18. Hardware - Any physical part of a computer or computer related equipment

19. Hard-copy - Output printed on paper

20. Hard disk - A disk that usually holds the equivalent of numerous floppy disks of information

21. K - A unit of measurement for memory size in computers. One K is 1024 bytes

22. Memory - The portion of a computer in which data is stored

23. Network - Two or more microcomputers connected together by a trunk-line to a disk drive and printer

24. Noise - Induced voltage that is irregular and distorts the electrical current. This causes problems with the proper operation of microcomputers and networks

25. Objectives - The results to be achieved by using the program and materials as outlined

26. Printer - A device that makes hard copies of computer output

27. Program - A list of instructions given to the computer in a language it can understand, telling it to perform a specific task

28. Programmer - A person who translates problem solution steps into computer programs

29. RAM - Random Access Memory- memory available to user

30. ROM - Read Only Memory- memory built into the computer by the manufacturer. This memory cannot be changed

31. RUN - A command telling the computer to execute the program

32. Simulation - A type of computer program which recreates a real-world situation for examination

33. Software - Refers to computer programs which instruct the computer how to operate

34. Syntax error - A computer response to a mistake in the way a command is given or spelled

35. Trunkline - The line in a network that connects the computers together with a hard disk drive and printer

36. Tutorial - A type of computer program which provides new information as well as repetitive drill and practice in the teaching of a basic skill or set of facts

BIBLIOGRAPHY

Bracy, Gerald W., "What the Research Shows," Electronic Learning, Nov/Dec 1982, pp. 51-54

Burns, Patricia K., "What Quantitative Systhesis of Research Findings Relative to the Pedagogical Effectiveness of Computer-assisted Mathematics Instruction in Elementary and Secondary Schools." Ph.D. diss., University of Iowa, 1981. Dissertation Abstracts International 42A (January 1982): 2946.

Ehly, Stewart W. and Stephen C. Larsen. 1980. Peer Tutoring for Individualized Instruction (Boston: Allyn and Bacon).

Glass, Gene V. 1984. "A Meta-Analysis of Effectiveness of Four Educational Interventions." IFG Project Paper (Stanford, CA.: Institute for Research on Educational Finance and Governance, Stanford University).

Heuston, Dustin H., Computers in Elementary and Secondary Education, WICAT Education Institute, Orem, Utah, April 1983

Heuston, Dustin H., An Analysis of Some of the Limits of the Personal Computer Networks for Eductional Usage, WICAT Education Institute, Orem, Utah, September 1984

Johnston, J. Howard, "What Research says to the Practitioner about Computer-Assisted instruction", Middle School Journal, May 1983 (review of 18 research reports)

Karweit, Nancy 1983. "Time on Task: A Research Review," Report No. 332 (Baltimore, MD.: Center for Social Organization of Schools, The Johns Hopkins University).

Levin, Henry M, 1983. Cost-Effectiveness: A Primer (Beverly Hills, CA.: Sage Publications).

Levin, Henry M. and Louis Woo, 1981. "An Evaluation of the Costs of Computer-Assisted Instruction," Economics of Education Review, Vol. 1, No. 1 (Winter), pp. 1-26.

Levin, Henry M., et al. 1984. Cost-Effectiveness of Four Educational Interventions. (Washington, DC.: National Institute of Education).

Marsh, Merle, "Computer-Assisted Instruction in Reading", Journal of Reading, Volume 26, No. 8, May 1983 (review of 25 research reports)