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Long-term effects of an integrated microcomputer project on subsequent science and mathematics achievement in Arkansas schools

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LONG-TERM EFFECT OF AN INTEGRATED MICROCOMPUTER PROJECT ON SUBSEQUENT SCIENCE AND MATHEMATICS ACHIEVEMENT IN ARKANSAS SCHOOLS

LONG-TERM EFFECTS OF AN INTEGRATED MICROCOMPUTER PROJECT ON SUBSEQUENT SCIENCE AND MATHEMATICS ACHIEVEMENT IN ARKANSAS SCHOOLS

A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Education

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CHAPTER I

INTRODUCTION

The Nations Educational Dilemma

In the United States, students need improvement in cognitive skill levels in science and mathematics (The National Commission on Excellence in Education 1983). Melmed and Lesgold (1987) report that:

> The United States has a major shortage of scientific and technical manpower levels, from personnel who can be efficiently trained for technical occupations to engineers to doctoral level scientists. Because scientific theory and method build upon foundation mathematics and basic principles, lack of adequate science and math schooling at the pre-college level is a substantial barrier to later entry into technical and scientific positions. Accordingly, if the United States is to overcome its present status as a net importer of high technology, it must produce more scientists and make more of its work force trainable for technical positions--it must increase its science and mathematics education productivity. (p. 106)

The need for scientific literacy was addressed by Project 2061, Science for all Americans (1989) as follows,

> Education has no higher purpose than preparing people to lead personally fulfilling and responsible lives. For its part,

> science education-meaning education in science, mathematics, and technology- should help students to develop the understanding and habits of mind they need to become compassionate human beings able to think for themselves and to face life head on. It should equip them also to participate thoughtfully with fellow citizens in building and protecting a society that is open, decent, and vital. America's future-its ability to create a truly just society, to sustain its economic vitality, and to remain secure in a world torn by hostilities-depends more than ever on the character and quality of the education that the nation provides for all of its children. (p 12)

Dr. Arthur Wiebe of the AIMS (Activities to Integrate Mathematics and Science) Education Foundation stated at the September 1990 Northwest Arkansas Cooperative AIMS workshop, "NASA has no idea where it will find American engineers to replace its current people because 50% of the current PhDs awarded are to non-American citizens."

The American Association for the Advancement of Science, Science for all Americans Project 2061 (1989), states that:

> The terms and circumstances of human existence can be expected to change radically during the next human life span. Science, mathematics and technology will be at the center of that change-causing it and shaping it, responding

to it. Therefore, they will be essential to the education of today's children for tomorrow's world.

Problems For Arkansas Education in Science and Mathematics

The state of Arkansas faces many of the same problems that confront the nation. Our population must also be well educated to compete in a job market that demands higher level skills in technical fields that require science and mathematical literacy. The teachers in Arkansas recognize that this problem exists and have been searching for a teaching methodology that will help in addressing the problem.

Results of an informal poll of eight Arkansas science teachers attending the National Science Teachers Association meeting in Tulsa, Oklahoma, during September, 1989, indicated that these eight Arkansas science teachers at the secondary level felt many of their students are being educated emphasizing knowledge-level skills in the realm of science, reading and mathematics (Watkins, 1989). These in-service teachers felt that the proper use of computers in teaching reading, mathematics and science in an integrated curriculum would alleviate this problem. Computer education involves three objectives: raising the student's awareness, improving the student's problem solving abilities, and providing information and practice on application programs that have a practical use both for students and business and scientific applications (McDermott, 1987b).

The State of Arkansas is aware of these realities and has taken action to improve the educational opportunities through the implementation of a project aimed at improving the state's educational system using microcomputers as an aid to learning. The effort, Project IMPAC (Instructional Microcomputer Project For Arkansas Classrooms), has been in operation for seven years. The philosophy behind the project is that the students of Arkansas must use computers on some level to function effectively in an information based society that is becoming more dependent on computers for communications, word processing and data base manipulations (McDermott 1987a). The Arkansas Commission on Microcomputer Instruction (1983) states the following philosophy in setting up Project IMPAC:

> Our age is one of rapid scientific and technological change. All students must be prepared to use computers on at least some level in order to function effectively in a society that is becoming more dependent on computer and communications technology. IMPAC recognizes the need for computer education to be integrated into the school curriculum as a tool for instruction, problem solving and as an aide to efficiently storing, retrieving and processing data for decision making. (p. 4)

The project was implemented by an act of the Arkansas State Legislature, during the 1983 session which established a nine member commission to assist the public school system in Arkansas in determining the best educational use of microcomputers for the elementary grades (McDermott, 1987b). Technologists working with educators are creating more efficient and effective learning tools using both microcomputers and microcomputers used with interactive videos. One of the major concerns in the successful instructional integration of the computer as a learning tool is combining it with interpersonal peer group interaction and cognitive problem solving activities McDermott (1987b). This type of implementation will enhance retention of information and concepts and encourage further learning by the student. In implementing Project IMPAC, the commission (1983) stated:

> Computer education can expand the learning opportunities for all students regardless of their socio-economic status, gender, ethnic background or level of academic achievement. Care should be exercised by educators to ensure that computers are integrated as learning tools throughout the curriculum and that extensive hands-on computer experience be provided for all students. It is imperative, however, that balance be retained in the curriculum. Basic communications and problem solving skills remain a priority and computer skills should enhance and not detract from their importance. (p. 4)

To be successful, computer enhanced collaborative learning depends on time on task, peer group/teacher-principal involvement, realistic student goals and efficient targeting of objectives for Computer-Assisted Instruction (CAI) (McDermott, 1987a).

The criteria for becoming an IMPAC school begins with an application form that is mailed from the project office in the spring of each year. The application addresses the specific criteria for acceptance into the project, including a commitment to participate in all phases of the project, provision for released time for teacher in-service training, and availability of necessary space and security for the equipment, and availability of test data for evaluation purposes. Normally, 80-90 schools ask to participate in the program each year. Out of these 80-90 schools, 30 school districts are tentatively selected for an IMPAC project. An IMPAC administrator visits each school district and assists in determining the best type of project to implement depending on local conditions and needs. The program is then scheduled for installation in either the spring or fall semester (McDermott, 1987a).

Beginning in the fall of 1983, Project IMPAC has been implementing, evaluating, and improving an instructional model that combines regular classroom instruction with Computer Assisted Instruction (CAI)/Computer Managed Instruction (CMI). The model uses teacher taught basic skills instruction for 80% of the available instructional period and CAI/CMI for 20% of the time. The students in an IMPAC school work on individual lessons networked to a hard disk. This provides each student with an individualized lesson according to individual progress and skill. The students can be in a computer lab situation with 26 work stations or in their regular classroom with four to eight stations. The lessons taught in mathematics, science, reading, and language arts are correlated to the Arkansas Basic Skills Objectives list (McDermott, 1987a).

In 1987, new standards for accreditation of Arkansas public schools were adopted. These standards require that a computer science course be offered every two years beginning in 1987. Because of the new requirements, Project IMPAC began planning to provide assistance to students enrolled in grades 9-12 in the state's secondary schools. The Project IMPAC staff's highest priority has been, and will continue to be, in working with existing IMPAC schools to provide guidance, resource materials, workshops, regional conferences and on-site visitation to high schools where possible (IMPAC, 1987).

Purpose of the Study

This study will provide educators with information on (a) the educational effectiveness of "Computer Aided Instruction" (CAI) in its various forms, including (CMI), (CBI), etc., (b) the effect of Project IMPAC upon teachers' attitudes with regard to the employment of microcomputers, and (c) the effect that the use of microcomputers has had on the science curriculum and student achievement within the state of Arkansas. Specifically, the study will provide information about the introduction of an integrated computer curriculum in the elementary grades (Project IMPAC) and the carry over of reading, science and mathematics achievement gains in elementary education into science in the secondary grades. The information will help educators and administrators in adopting and implementing a similar program for utilizing microcomputers in the secondary science curriculum.

Primary Questions

Research hypothesis: The research is founded on the premise that educational achievement gains by students demonstrated in the elementary grades with Project IMPAC, and other integrated computer learning systems, lead to continued measurable, educational achievement by students in the secondary grades. As part of a complete statistical analysis, the null hypothesis must also be investigated (Borg and Gall, 1989).

Research hypothesis: Students in the secondary grades using computers for specific tasks at school and at home will exhibit higher levels of educational achievement and cognitive skill levels.

Ho: There will be no difference found between the population of students receiving integrated computer instruction, and the population receiving standard instruction in the elementary grades (K-6), and student achievement in science in the secondary grades (7-12).

Ho: There will be no difference in educational achievement or cognitive skill levels for students using computers for specific tasks in the secondary grades.

The study will attempt to provide answers and conclusions to the following questions:

1. What is the effect of Project IMPAC on student achievement in science and mathematics at the secondary educational level?
2. Are schools that have microcomputers but are not part of Project IMPAC as educationally effective?

3. What are the effects of various integrated computer learning exercises such as computer simulations, strategy games and drill and practice on secondary science and mathematics achievement?
4. What is the effect on student achievement of the use of home computers for educational purposes in science and mathematics?
5. What are the results of the utilization of microcomputers in elementary education on MAT 6 scores in the secondary schools?
6. Do students experienced in using computers exhibit positive educational achievement compared with students with little or no experience with computers on standardized tests such as the MAT-6?

Subsidiary Questions

1. Do the secondary schools surveyed have computers of their own for science and mathematics use? How many are available?
2. What is the main use of software? What kinds and type of software are available?

Definition of terms

The study will adhere to the following terms and definitions:

Adventure games.

Adventure games are computer games in which the player participates in a story or adventure through the entry of sentences or key word commands. These games present problem solving and strategy problems for the student to participate in and solve.

Arcade games.

Arcade games are graphics intensive programs in which the player's actions are expressed through the skillful use of a joy stick or trackball controller.

Computer Assisted Instruction (CAI)/Computer Managed Instruction (CMI).

Computer assisted instruction/computer managed instruction is any application of computers used to teach, directly or indirectly, science or mathematics skills or content.

Computer/personal, computer/micro-computer.

An electronic machine that may be either portable or placed on a desk top/table top that performs rapid complex calculations or compiles and correlates data.

Computer peripherals.

Computer peripherals are devices, including keyboards, printers, and monitors, that allow the computer to input or output data in usable form.

Database Activities.

Database activities are programs that allow the student to store and retrieve information.

Drill and Practice.

Drill and practice are student used programs that present a series of questions or problems where student responses are analyzed and appropriate feedback provided.

Educational effectiveness or achievement.

Educational effectiveness or achievement are measurable gains in educational achievement as substantiated by standardized tests and teacher perceptions through time.

Mainframe computers.

Physically and computationally large computer installations that utilize large amounts of memory capacity and peripheral devices to accommodate multi-user systems through time sharing and networks,

Network or Networking.

Network or networking is a group of computers that run the same program and that have a common data storage and program source. The term may also refer to a group of computers connected in a communications system for the exchange of data and graphics information, i.e. Local Area Networks (LANS), and commercial telecommunications networks such as Compuserve™ and Genie™.

Project IMPAC --Instructional Microcomputer Project For Arkansas Classrooms.

Project IMPAC begun in 1983 to provide the public education system in Arkansas with a coordinated implementation of computer aided instruction.

Simulations.

Simulations are programs that generate models of real environments or situations. Students interact with the simulation to solve problems. The program provides feedback and adjusts to any new student input as supplied.

Software.

Software refers to programs that cause the computer system to execute instructions in a step-by-step sequence. Examples include such programs as word processing, drill and practice, and databases.

Time -sharing.

Time-sharing is a process used by main frame computers to optimize the use of the central processing units computing time by allowing multiple user and program access

Word Processing.

Word precessing refers to the use of programs that allow students to write, edit, store, and print text.

CHAPTER II

REVIEW OF THE LITERATURE

Review of previous research and opinion

A 1972 publication from the Carnegie Commission on Higher Education cites four major educational revolutions: the invention of reading and writing, the emergence of the profession of the teacher/scholar, the development of movable type which led to a major increase in availability of books, and now electronic technology (Billings & Moursund, 1988). DiSessa (1987) published an article entitled "The Third Revolution in Computers and Education." He considered the first revolution to have begun with the realization that computers could reform the way that we perceive thinking and deal with learning. The second revolution was the current decrease in prices that made modern microcomputers available to the general public and the public school systems. The third revolution is just beginning and will allow educators to use computers to facilitate the understanding of the fundamentals of knowledge and learning and "turn the art of education into a principled scientific and engineering enterprise with leverage in educational achievement far beyond what we historically expect of an evolving profession." (DiSessa, 1987). Education will remain an evolving profession until the world's population realizes the true value of education in and of itself (DiSessa, 1987).

Smallen (1989) states that the computer offers the possibility of individualizing instruction and simulating the real world, and in doing so, making the learning process more interesting and effective. Nordstrom (1988) and Smallen (1989) suggest that because of the profound changes in education made possible because of the computer, it would be prudent to know the history of the computer and its accomplishments over the past quarter century.

Like many of our more important inventions, the origin of the computer is lost in the mist of time. First, exactly what is meant by the word "computer". Is a computer just any machine that helps do calculations or is there a more specific definition? The Chinese are credited with the invention of the first real computing machine, the abacus. It is not known who invented this marvel of calculation, but in the hands of a skilled user, the abacus can calculate with more speed and accuracy than modern electronic hand-held calculators. There are other mechanical computers such as the slide rule, both linear and circular, and Mr. Babbage's, circa 1870, mechanical computing device, "The Analytical Engine" (Ledgard, and Singer,1982).

The following discussion will be limited to those devices currently used in education and defined as microcomputers. Even this definition, however, could be stretched. The earliest electronic computers that appeared for instructional use were manufactured in the early 1950s and were an outgrowth of computers developed during World War II. The main purpose of these early machines in education were in university laboratories where they were used for undergraduate and graduate science and engineering projects and business research (Billings & Moursund, 1988). By the end of the 1950s, transistors started to replace vacuum tubes in computers; and the first computer programming languages (FORTRAN and COBOL) had been developed.

The microcomputer was first introduced to the general public with the advent of the SWTPC 6800 and Altair 8800 in the early 1970s (Viet, 1989a, b). The nation's educational systems first became interested in the potential of these devices during the middle 1970s, with the introduction of the Apple I and Apple II computers. Within a short time other microcomputers had appeared, and during the early 1980s individual school systems began to experiment with the best methods to utilize these machines and their programs as educational tools.

In the 1960s time sharing became the method of choice for business and educational (university) computing. This new method afforded more users the economic utilization of existing computer facilities through networking. Time-shared computing also fostered the development of electronic mail, computer bulletin boards, and communication systems for business and universities. The first integrated circuits were appearing, and computers were shrinking in size and power consumption while growing enormously in calculating power and speed. The first "Microprocessor" chip was manufactured by INTEL in the late 1960s, and some people were already building the first home computers.

The 1970s saw many improvements in computers and the development of the first of the available home computer, the Altair 8800. As the decade wore on, other brands of computers and computer peripherals such as disk drives, printers, scanners, books, and computer magazines hit the market place. Personal computers began to appear in the classroom for instructional purposes in the public schools. The appearance of the APPLE™ computer in 1976, inexpensive disk drives, dot matrix printers, and the computer spread sheet program "Visicalc™" for business helped to establish the personal computer as an important business and educational tool.

The world has seen an explosion in the use of the home computer during the 1980s. The development of fast, inexpensive microprocessors and megabyte memory packages allowed computing power into the home and classroom that could be afforded by only large businesses or universities in the late 1970s. A modern personal computer can easily compete with and frequently exceed the computational speed, reliability, versatility and cost effectiveness with less power consumption than a large mainframe computer built only ten years ago.

The educational computing literature since 1980 contains many descriptive articles, but few scientific research studies on the dramatic changes happening in education caused by the microcomputer. "After nearly 25 years of use in instruction, the impact of computer applications on education remains largely an unknown quantity" Robyler, (1988). Students at all levels are learning practical computer skills in preparation for college work and life in an information society. Of critical importance is evidence of the effect of microcomputers on the traditional measures of educational effectiveness: student achievement, attitudes, dropout rate, and learning time.

Robyler (1988) and others (e. g., Anderson, Klassen, Hanson & Johnson, 1981; Bangert-Drowns, Kulik & Kulik, 1985; Burns, 1984; Clark, 1986; Ferrell, 1986; Kulik & Bangert-Drowns, 1983; Summerville, 1984) have reported on the fact that very few studies have been completed on the effects of computers as used in science and mathematics education, and almost all studies have reported positive effects and educational gains achieved. McDermott, (1987a) has completed a preliminary report on the positive effects of using CAI in the elementary grades in the state of Arkansas. There have, however, been no reports of research completed or in progress on the effects of computer-aided instruction in the elementary grades and its effects on education in the secondary schools.

Roblyer (1988) located 38 studies and 44 dissertations from the period 1980-1987 that included either measurements of student educational achievement or attitude meta-analysis. One problem with these investigations is that few of the more recent reviews examine all the educational levels and content areas in a comparative way.

Hounshell and Hill (1989) report that research data on the use of microcomputers in secondary-school biology or any science is hard to find. Papers documenting student achievement in this science are non-existent and open for research. Those authors feel that a partial cause of the lack of research is the cost of this new technology at a time when many public schools are suffering from a lack of funds and lack of proven educational software.

A literature search in instructional computing reveals many studies done prior to 1980 on the use of older mainframe-type technology. This was the purview of business, large research organizations and universities. Very few public school systems had access to this technology except on an experimental basis. Stennett (1985) also reports no research literature to review prior to 1980 on micro-computer based instruction with most of the literature prior to 1980 containing data on mainframe and minicomputer based systems.

Because of the many educational benefits to be gained from the use of computers in educational settings, school systems and universities have begun evaluating the effectiveness of the use of computers to supplement and aid the classroom teacher in science and mathematics education (Swadener and Jarrett, 1987). These studies have found, mainly in reference to computers properly used with good educationally designed software, cause students to exhibit measurable gains in their cognitive abilities and develop positive attitudes to using computers in educational environments. Riel (1989) states that:

> Educational technology makes it possible to create learning situations in which students can be engaged in activities that they find interesting and exciting for their own reasons and accomplish the educational goals of their teachers. Teachers establish functional learning environments by relating the computer activities to other educational tasks the children were doing. (p.188)

Riel (1989) also states, "Children may find that computers enable them to participate more fully in significant activities. They may be able to place drill and practice in a more direct relationship with performance."

In Academic Computing, November 1989, Amend et al. state:

> Students learn about science in their lecture courses, but very little about the process by which scientific understanding is developed. By integrating the personal computer into the laboratory, the instructor can facilitate student comprehension of problem solving, data acquisition and data analysis facets of science. This integration can enhance the teaching and learning of science as much as word processing has enhanced writing. (p.20)

The use of the computer in science classrooms has resulted in questions about student achievement and interest from teachers and researchers. Teachers are also interested in innovative simulations, drill and practice, interactive video, and computer-aided instruction (CAI) programs on student scholarship and attention span. The computer is used for these purposes, but it can also integrate all of them into one teaching scenario. Using information networking, drill and practice, interactive video, simulation, and CAI, the student can interact with a simulated real life situation and determine a result with no real-life consequences other than the learning that happens during the interchange. Amend et. al. (1989), report that:

> Computers can help us bring introductory students into the scientific process. Given a set of experimental objectives, a computer in the laboratory can be the tool that involves the student with the design of the experiment, the gathering of information, and the organization and analysis of this

information. A well integrated software/hardware package can individualize how a student approaches all aspects of an experiment. (p. 21)

Roblyer (1988) and Glenn (1988) have reported on the results of using an educationally designed CAI system, "Wicat" by Wicat systems, Orem, Utah. This CAI system was utilized by the Linton-Stockton School Corporation in Linton, Indiana. The system was installed in October of 1986, and all students in grades 4-6 utilized the system for 25 minutes each day. The effects of "Wicat" were analyzed in terms of three components after five months of system use: student achievement as measured by standard achievement tests (SAT), student attitude to the system, and the teachers' evaluation of the system. The results of standardized tests show that science scores had increased significantly, with a gain of 0.6 average grade equivalents, with very impressive gains in reading comprehension, at 1.9 grade equivalents as compared to scores before the Wicat system was installed. Anticipated gains in mathematics, however, were not achieved. The gains measured were only achieved by those students that used the system. The study found that students liked the Wicat CAI system and the attitude of the teachers indicated that they believed the system had a positive effect on student achievement. Glenn's conclusion was that CAI at any level not only increases student achievement, but improves the environment for learning and the implementation of other CAI programs.

Roblyer has captured the essence of the problem of the effectiveness of computer-based education when she asks, "How much do computers improve instructional methods and consequently, student achievement?" (Roblyer, 1988).

McDermott (1987a) has indicated that three types of research are relevant to the study of the effectiveness of computers in education: research that is directly related to improving instruction in reading, mathematics and language arts in which traditional instructional methods facilitate learning, research that provides direction for improving instruction in the classroom, and research which involves technology, particular computers and CAI/CMI programs and instructional improvements that increase educational achievement by students.

Riel (1989) has stated that "computers extend rather than replace the teaching done by the teacher." When computers are used as a tool for exploration and creativity as described in her study, the computer enables the student to create, analyze, compare, and examine the world. Computers can also provide environments that extend the students' abilities to think in a creative fashion, engage in problem solving activities, perform systematic inquiry, and establish and perfect cooperative work with others. These skills are vital for participation in a modern world.

Burns and Bozeman (1981) have completed a review of studies in computer based education in mathematics. This review used meta-analysis to integrate the findings from many sources. Forty studies were examined with the conclusion that a significant difference did exist between computer based education and conventional methods for mathematics instruction.

Wise and Okey (1983) located and examined 12 studies that measured educational achievement where microcomputers were used as an instructional tool in science and mathematics education. The earliest of these studies was reported in 1980. This review reported an average effect size of 0.82 which would correspond to an achievement gain of 29 percentile units. Stennett (1985) found 68 potentially relevant articles on computer aided instruction. Only five of the studies were detailed critical reviews of research that employed empirical data analysis on the effectiveness of computers employed in education. Conclusions drawn from the five articles were the following: (1) Well designed and implemented drill and practice or tutorial CAI used as a supplement to conventional instruction produces an educationally significant improvement in student achievement, (2) Students exposed to CAI supplemented instruction retain the material slightly better than those experiencing conventional instruction only, (3) CAI is more efficient in the time needed to present and complete lessons, (4) CAI is more effective with learning disabled students (5) CAI appears to be less effective in the elementary to secondary to college educational progression, and (6) students exposed to CAI develop more positive attitudes to computer-aided instruction and the subject taught.

Amend, et al (1989) have discussed integrating the computer into the science laboratory. They have found that the computer helps to involve the student in the scientific process. A well integrated software/hardware package can individualize how a student approaches all aspects of a scientific experiment. The computer can also help to involve the student in the experimental design, thus increasing the students' observational and scientific interest and sense of ownership in the experiment.

In an examination of the problem solving abilities of high school biology students, Rivers and Vockell (1987) found that students using simulations with teacher-guided discovery learning outperformed groups of students in unguided computer learning situations. The study involved five simulation programs (BALANCE, PLANTS, OSOMO, MONOCROSS and MOTHS). There was no significant difference in educational achievement gain in problem solving using three of the simulations (OSOMO, MONOCROSS and MOTHS). With respect to specific subject matter, students in the guided discovery group outperformed the other groups using the PLANTS and BALANCE simulation.

Tinker (1987) speculated that the maturation of computer hardware and software technology would open new possibilities for broad scale technologically enhanced changes in the science and mathematics curriculum. He suggested that this would not happen through small-scale, application specific software packages, but through general software tools such as those revolutionizing business. Except for the productivity tools imported from business, an integrated set of software tools do not exist for science and mathematics education. Tinker argues that new opportunities created by the emerging technology can make major contributions to the educational achievement and understanding of science and mathematics by all students.

Nachmias and Linn (1987) examined evaluations by eighth grade students of computer-presented information on temperature, heat, and energy concepts in the science laboratory. The study found that a student's willingness to accept inappropriate data and graphing techniques decreased significantly through the use of CAI. After additional instructional time using the computers, student performance again increased.

In a study at Hurst Hills Elementary School, located in the Dallas/Ft. Worth Metroplex, fifth and sixth graders evidenced significant gains in academic achievement by the students using the computerized mathematics curriculum. Both the fifth and sixth grade groups showed a one-year gain over the groups using traditional mathematics instructional techniques (Goode, 1988).

Brasell (1987a) studied the ability of students to translate between a physical event and its graphic representation using a microcomputer-based laboratory (MBL). The study also investigated the effect of real time versus delayed time on the graphing abilities of the students. The results of this study on 93 physics students showed that the students in the real time MBL group outperformed all groups on post-test achievement. A reduction in errors in graphing the real time data was primarily responsible for the difference in test scores.

Bross (1989) has reported that the use of microcomputers in laboratory experiments enhances the effect of demonstrations and student experiments. The microcomputer using real time transducers and appropriate software can measure and display experimental data as the experiment occurs. Experiments in heat flow, heat of fusion/vaporization, and other high school experiments can be accomplished in the time constraints imposed by current classroom schedules. In Brasell's report, one group used an extended microcomputer-based laboratory (MBL), and the control group used traditional paper and pencil methods which paralleled the MBL activities. Results showed that students in the MBL group outperformed the traditional method paper and pencil group. A reduction in graphing errors was the major difference between the groups, and the real time graphing feature of the MBL was attributed as the principal reason. In another segment of the study, Brasell (1987b) examined the difference between male and female students in computer graphing abilities. Pre-testing revealed that female students had lower graphing skills than males for certain types of graphs. Using a MBL activity, equal groups of students constructed graphs using the computer and normal pencil and paper methods. Females in the MBL group scored significantly better on post-test items than did males. There were no gender differences found in the traditional method paper and pencil group.

Bross (1989) has listed eight advantages and five disadvantages to using a microcomputer-based laboratory. The advantages listed include the observation that computers attract the attention of students, that students do not seem to have attention span limits as short as those that exist for traditional methods, that the computer is a tireless data gatherer, and that acquired data can be displayed almost instantly in a variety of formats from tables to graphs. Because of the computer's ability to save time, further investigations may be attempted instantly or greater depth or accuracy can be attained in the present experiment. Data can be easily stored, and interfacing hardware is simple and inexpensive with the students often designing and building their own. Software can be simple and task oriented, and the students can write their own software custom designed for their experiments.

Disadvantages of the microcomputer-based laboratory include human perceptions of the computer as a magic black box that has pre-determined answers to problems. Software must be well-written and obey the rules of good pedagogy. Microcomputer-based labs must be established in an economical manner. The urge to buy peripheral hardware must be backed up by student need and utilization. In special education, the computer is of particular use because of it particular attributes of patience and the ability to respond in an instant non-threatening manner.

Rubin and Weisgerber (1985) have reported that intelligent technologies show extraordinary promise for meeting the needs of the handicapped. The microcomputer is capable of adjusting presentations and learning strategies to the abilities of the learner, instead of the normal classroom procedure that attempts to adjust the learner to the lesson. This characteristic can facilitate substantial improvements for every learner, especially the learning disabled.

Computer Uses in Arkansas

Recent reports on the educational use of computers in the United States reveal that the state of Arkansas presently has 16,228 computers in the public schools (Electronic Learning, 1987). Project IMPAC reports that in 1984 school districts in Arkansas had 9405 microcomputers of various brands in use. The student/computer ratio for the state in 1984 was 46 students per computer IMPAC (1987).

Electronic Learning (1987) reports that approximately 16,000 computers were in use by 430,000 students in 331 school districts in 1987. This is a ratio of approximately 27 students per computer. Another survey reports that Arkansas is in the medium range for computer density in public school usage for grades K-12, with between 25 and 29 students per computer (Market Target, 1989). Market Target also lists Arkansas as number 33 in the educational use of microcomputers with 15,970 microcomputers for 439,265 students.

The Market Target survey also reports that Arkansas has improved its ranking from number 42 in 1986 to number 33 in 1989. One fact obvious from the above figures is that the surveys done by Electronic Learning and Market Target either received different answers from the same people or surveyed different populations. The fact that one survey was completed in 1987 and the other in 1989 should have resulted in a net gain of computers in use in Arkansas. Another possible answer is that some obsolete computers removed from service were not reported in the 1988 survey. Those who know how public school systems work will, however, suspect that this is not the case.

Interpretative summary of the current state of knowledge

This review includes only those studies in which the effectiveness of the computer as an instructional tool or part of a curriculum is compared to the traditional methods of science and mathematics instruction as measured by student educational achievement on standardized tests. Only studies which were completed using secondary level students (grades seven through twelve) and involved the measurement of achievement in science and mathematics education were considered. Eleven studies were found that specifically evaluated either science or mathematics education that utilized computer instruction or learning systems to enhance student learning and educational achievement.

The current state of computer learning systems and computer/laboratory interface systems indicate that these systems can greatly increase the effectiveness of the way that we teach science. The computer allows even beginning students to enter into the design of the experiment and the process of science. John Scully, Chairman and Chief Operating Officer for Apple Computer, states:

> In schools where computers were backed up with a commitment in funds, training and personal effort to make technology work, the changes have been impressive. We no longer have to ask whether students can learn using computers. Instead, we need to identify when technology should be used and how to use it more effectively (Muse 1990). (p. 8)

CHAPTER III

RESEARCH METHODS AND PROCEDURES

Chapter 3 presents a description of the methods employed for sampling, data collection and the statistical procedures used to analyze the research data. Unpublished survey instruments are described and discussed and have been placed in the appendices.

The research is based on the premise that gains in educational achievement demonstrated by students participating in Project IMPAC and other integrated computer learning systems in the elementary grades, as documented by Project IMPAC staff (McDermott, 1987a), lead to continued measurable, educational achievement by students in secondary science and mathematics.

Sampling

A group of in-service science teachers from across the state of Arkansas were surveyed to determine how the teachers use computers in their classrooms and laboratories. The teachers interviewed and surveyed were selected from the following groups: current Arkansas in-service certified science teachers, in-service members of the Arkansas Science Teachers Association, and in-service science teachers who took part in the NSF grant program, Arkansas Geology for Science Teachers. Participants were selected from each group, except the NSF grant participants who all participated, by simple random sampling methods described by Borg and Gall (1989) and Jaccard (1983). The usual definition of a simple random selection is that it is a procedure in which all of the individuals in the defined population have an equal and independent chance of being selected as a member of the sample.

Data collection

Individuals selected were contacted by mail, telephone and in person and requested to participate in the study by completing a survey document as completely as possible (Appendix A). The initial mailing consisted of 275 survey documents and a cover letter (Appendix B) outlining the study and the benefits to the teaching profession that would result from the data acquired. This survey resulted in 72 surveys being returned for a 26% return rate. A follow-up mailing was completed and 34 surveys returned for a total of 106 survey documents received out of a total of 275 mailed. The final percentage received was 39%, which represents an average return.

Survey document

The survey document was designed to ascertain: (1) the teacher's perception of the student's level of educational achievement and performance after entry into the secondary science curriculum, (2) the level of use of computers in the teacher's school system, (3) if an integrated educational computer program such as Project IMPAC is in place, the teacher's attitude to the use of computers in education, and (4) the suitability of computer software currently available. Also of interest was the number of computers available to students in the home and their major use. [The teacher's opinion regarding the effect on student achievement of computers in the home were compared to the achievement of students without computers.] No standard instrument was available for use in the survey, and the document was designed by the researcher and Dr. Robert Rielly. A pilot study to establish the validity of the survey document was completed with 15 local science teachers. Comments and suggestions for improving the survey were analyzed and the document finalized.

The thirty-five item survey utilized the Likert scale for thirteen of the questions: one question on in-service training having a numerical Likert scale of from 1 to 5 with 1 being very useful and 5 being no use, six questions on student achievement utilizing a numerical scale of 1 to 5 with 5 indicating greatly improved achievement and 1 indicating much lower achievement, and six questions on student attitude using a scale of 1 to 5 with 5 indicating a much more positive attitude and 1 indicating a much more negative attitude. Although each question is subjective and deals with teacher opinion and perception, it is felt that the standard terminology used results in equal levels and interval level data for the questions. There were five levels for each of these questions with each level being equal; therefore the interval level was accepted. Average responses were computed for each survey participant. For one question, an average score of one would indicate a very useful in-service and an average score of five a useless in-service. For six of the questions, an average score of 5 would indicate greatly improved achievement and an average score of 1 would indicate much lower achievement. An average score of 3.0 would indicate little change in achievement. For the other six questions, an average score of 5 would indicate a much more positive attitude, an average of 3.0 a neutral attitude, and an average of 5 a much more negative attitude. Some questions were designed to yield data about physical quantities such as the number of computers available, the use of computers in the class, the number of students that used computers in the elementary grades, and the use that students have for computers in the home. These data were evaluated using simple percentages and are presented as histograms and pie charts in chapter four. A pilot study was conducted with the survey utilizing ten in-service science teachers in Washington county public schools. The results from the pilot study indicated that the survey document would provide the information and data needed.

Educational achievements in secondary science and mathematics

The 1979 Arkansas Legislature enacted the "Education Assessment act of 1979." This legislation established a state-wide testing program for the public school system in Arkansas (State Department of Education, 1979-1989). The state of Arkansas has used two different standardized tests to measure student educational achievement in the public school system during the period 1979 through 1990. The first of these tests was the Science Research Associates Achievement Series 1978 edition (SRA-78), administered from 1979 through 1985. The second standardized test was the Metropolitan Achievement Tests, Sixth Edition (MAT-6). The test has been in use in Arkansas schools from 1985 through the present. These tests have been administered to approximately 91,000 Arkansas students each year in grades 4, 7 and 10 (State Dept of Education, 1989).

An investigation to ascertain differences in educational achievement was completed utilizing both the MAT-6 and SRA-78 standard test scores from 90 IMPAC and 90 non-IMPAC schools. Because the scores from these tests are not directly related, the "Equating Study" was used to normalize the test scores. The State Department of Education commissioned a study equating the standardized scores from the SRA-78 tests to those obtained on the MAT-6 tests using 1985 as the normative year. Both the SRA-78 and the MAT-6 tests were administered during 1985 and the two tests equated in a study completed by The Psychological Corporation, Harcourt, Brace and Jovanovich, Inc. The study entitled "The Equating Study" was used to normalize the test scores from the two instruments for the years 1981 through 1989, for statistical analysis.

In the spring of 1985, a selected school district in the State of Arkansas participated in a research program that was designed to provide tables of equivalent scores between the 1978 edition of the SRA-78 achievement Series (SRA-78) and the Metropolitan Achievement Tests, Sixth edition (MAT-6). Both test series were administered to the same students, so that half of the students took the SRA-78 first, followed by the MAT-6; the other half took the MAT-6 first, followed by the SRA-78. Approximately 4500 students in grades 1 through 8 and grade 10 participated in the research program (Harcourt Brace Jovanovich, 1986). The SRA-78 and MAT-6 standardized tests are both used nation wide to measure educational achievement and to relate an individual schools educational level to that of its peer group.

The schools selected for analysis in this study were either participants in Project IMPAC or non-IMPAC schools. Those schools identified as IMPAC schools entered the program from 1983 through 1987. The non-IMPAC schools were selected from the State Department of Education's list of schools in Arkansas by simple random selection. Standardized test scores for each school on the MAT-6, and SRA-78 are available from the Arkansas State Department of Education, participating schools, County supervisors of Education and the Arkansas Gazette. All of the data were obtained from the Arkansas State Department of Education; no secondary sources were needed.

MAT 6 scores and SRA-78 scores were obtained for every school in the state of Arkansas for the period 1981 through 1989. The SRA-78 scores for the period 1981 through 1985 and the MAT-6 scores for the period 1985 through 1989. All the SRA-78 scores were converted to MAT-6 equivalents using the tables in "The Equating Study" for the Project IMPAC schools and the non-IMPAC schools in the study. Ninety Project IMPAC schools were identified as having participated in the project from its inception in 1983 until 1987 and were selected for analysis. Those Project IMPAC schools implementing the plan after 1987 were treated as non-IMPAC schools because of a one year lead time for elementary students to progress into the secondary schools and be retested with the MAT-6/SRA-78 instrument. The sampling procedure used to select the non-IMPAC schools were the simple random sample as defined by Jaccard (1983) and Borg and Gall

(1989). Selection of the 90 participating IMPAC schools was based on the year that they began the program. No IMPAC schools were selected that began the program after 1987. A simple random sample of 90 non-IMPAC schools were selected from the list of remaining schools using the random number tables found on pages 910-912 in Borg and Gall (1989).

The two groups, IMPAC schools and non-IMPAC schools, were statistically evaluated using the dependent t-test for the relationship between student achievement in science and mathematics in the secondary grades and the use of computers in the elementary grades for the period 1983 through 1989. The period 1981-1983 represent a control group as no treatment was in effect until the fall of 1983. The period from 1983 until the present represents the treatment for the schools involved in Project IMPAC and the period from 1981 through the present is also a control group for the non-IMPAC schools upon which no treatment was in effect. The statistical procedures used for the analysis were simple regressions and the dependent t-test. The simple regressions were computed utilizing the control group mean scores and the treatment group mean scores as computed from the MAT-6/converted SRA-78 test scores as reported by the State Department of Education for Arkansas for all schools in the state over the period 1981-1989. Proper statistical procedures were used to investigate the relationship between student academic achievement, the continued use of computers in secondary education, and the use of computers in the home for educational or other purposes. In effect, many different possibilities exist for analysis of the data depending on the method used; for instance, a trend analysis (longitudinal survey) was done on the mean of the MAT-6 test scores acquired for the Fayetteville and Little Rock School systems. Simple regression analysis and t-tests were completed for the two school systems and the mean MAT-6 scores for 90 non-IMPAC schools and the average MAT-6 scores for the state over the period 1981 through 1989. Chi Square analysis has also been used to ascertain if there is significance in changes in academic achievement between other groups (Variables), such as computer use in elementary grades, and non-use of computers in the elementary grades. A dependent t-test analysis was completed analyzing differences between membership in a particular group for the teachers surveyed and student achievement.

The statistical tests for the MAT-6/converted SRA-78 scores were computed using the computer program StatView SE+ Graphics ™ (Feldman, Hofman, Gagnon, and Simpson,1984) and Statistics with Finesse (Bolding, 1989). The computer program was used to compute the values of the t tests and simple regressions for each data point. The graphical analysis was accomplished using the values computed and the graphing portion of StatView SE+ Graphics™ on a Macintosh SE 30 computer to compare the differences in academic achievement in science and mathematics between the IMPAC group and the non-IMPAC group.

Research design

The statistical analysis was accomplished using a Nonequivalent Control-Group Design. The experimental treatment is (1) the use of computers as an integral part of the educational curriculum in the elementary grades (2) the use of computers in secondary science classes and (3) the use of computers for educational purposes in the home, by students, as reported by teachers. The pre-tests are the standardized tests (MAT-6 and SRA-78) taken before the implementation of Project IMPAC in the fall of 1983 (McDermott and Deaton, 1987b) while the post-tests are those standardized tests taken after the implementation of the project.

The control group is represented by the norm from the standardized tests administered (Bolding, April,1989), and the standardized test results from classes prior to the implementation of Project IMPAC in the fall of 1983 (McDermott and Deaton, 1987b) and the 90 randomly selected non-IMPAC schools that were not part of the treatment. The group prior to the fall of 1983 had no contact with Project IMPAC and probably little to no contact with computers in an educational sense prior to that time. The first standardized tests to be effected by Project IMPAC would have occurred in the spring of 1984; therefore standardized test scores and norms from the control group should not reflect any significant effects from the treatment. After the spring of 1984, some students entering the secondary grades (7-12) should exhibit increased achievement levels in science and mathematics due to the use of the integrated Project IMPAC computer curriculum in reading and in mathematics.

CHAPTER IV

RESEARCH FINDINGS

The purpose of this study was to provide educators with information and data on the educational effectiveness of "Computer Aided Instruction" (CAI) in its various forms (CMI) (CBI) etc. The study provides data and analysis on: (1) the effectiveness of an integrated computer program (Project IMPAC) used for educational purposes in the elementary grades (K-6), and its effect on the educational achievement of students in the secondary grades (7-12), (2) are schools using computers not in Project IMPAC, as educationally effective; and (3) the attitudes toward and the use of computers in the classroom and at home by science and mathematics teachers and students. Specifically this was done by:

1. Determining how many science and mathematics teachers use computers in their classrooms, with what software and in what courses.
2. Comparing the teacher's perception of changes in student achievement and attitude when using computers in specific classroom activities based on grades, objectives or MAT-6 scores.
3. Analyzing the teacher's perceptions of changes in cognitive levels when using computers in specific classroom activities based on grades, objectives or MAT-6 scores.
4. Comparing secondary science and mathematics scores on the MAT-6/SRA-78 standardized tests for selected IMPAC and non-IMPAC schools for the years 1981 through 1989.

The study tested the following hypotheses:

1. Educational achievement gains achieved through the use of an integrated computer learning system provided by Project IMPAC in the elementary grades and other integrated computer learning systems will lead to measurable educational achievement gain by students in the secondary grades.
2. Students using computers in the secondary grade levels for specific tasks will achieve higher educational achievement and positive changes in cognitive skill levels.

Summary

The data analyzed in the study came from two sources: (1) a questionnaire distributed by simple random selection to currently certified in-service science teachers in the state of Arkansas, participants in the National Science Foundation grant program "Arkansas Geology for Science Teachers," and in-service members of the Arkansas Science Teachers Association and (2) standardized test scores from the MAT-6 examination from 1985 to 1989 and standardized test scores from the SRA-78 examination from 1980 to 1985. The SRA-78/MAT-6 standardized test score data was obtained from the Arkansas State Department of Education. The SRA-78 results were normalized to the MAT-6 scores utilizing "The Equating Study" by Harcourt, Brace, Jovanovich (1986). School participation for the SRA-78/MAT-6 analysis was by simple random selection for the non-IMPAC schools and participation in Project IMPAC from its inception in 1983 until 1987 for the IMPAC schools. Geographic coverage of the state for both the survey and school participation is indicated by Figures 1, 2, and 3. Large population centers for the state were included automatically because these areas were included in Project IMPAC at the outset of the program.

The Survey Document

The survey questionnaire was mailed to 275 science teachers and 106 were returned (39%). Of the returned surveys, seven were completed in a manner that provided little quantifiable data, but did provide insights into the attitude of the teachers toward their students and education.

On question number one, "In your opinion, do microcomputers have potential in science education?" 86 teachers (87%) indicated positively while only eleven (11%) indicated that they see no potential for computers in education. Two respondents (2%) had no opinion on this question.

Question number two, "Do you utilize microcomputers for instruction in any way in your classroom or lab?" resulted in 99 responses of which, 36 (36%) use computers in their classrooms and 53 (54%) do not. However, on Question number three, "Do you use your computers to monitor real time experiments in labs?" of 80 total responses, five teachers answered positively (6%) and 75 (94%) teachers answered that they do not use computers for laboratory work.

One respondent listed Ph monitoring for chemistry experiments as a part time use for computers.

Question number four, "Do you or your students write any programs for use in lab situations?" resulted in five teachers (6%) out of 80 total respondents answering positively and 75 (94%) answering that neither they nor their students write programs for laboratory use. Of the five teachers that do write programs, two do their programming in BASIC and two teachers program in PASCAL.

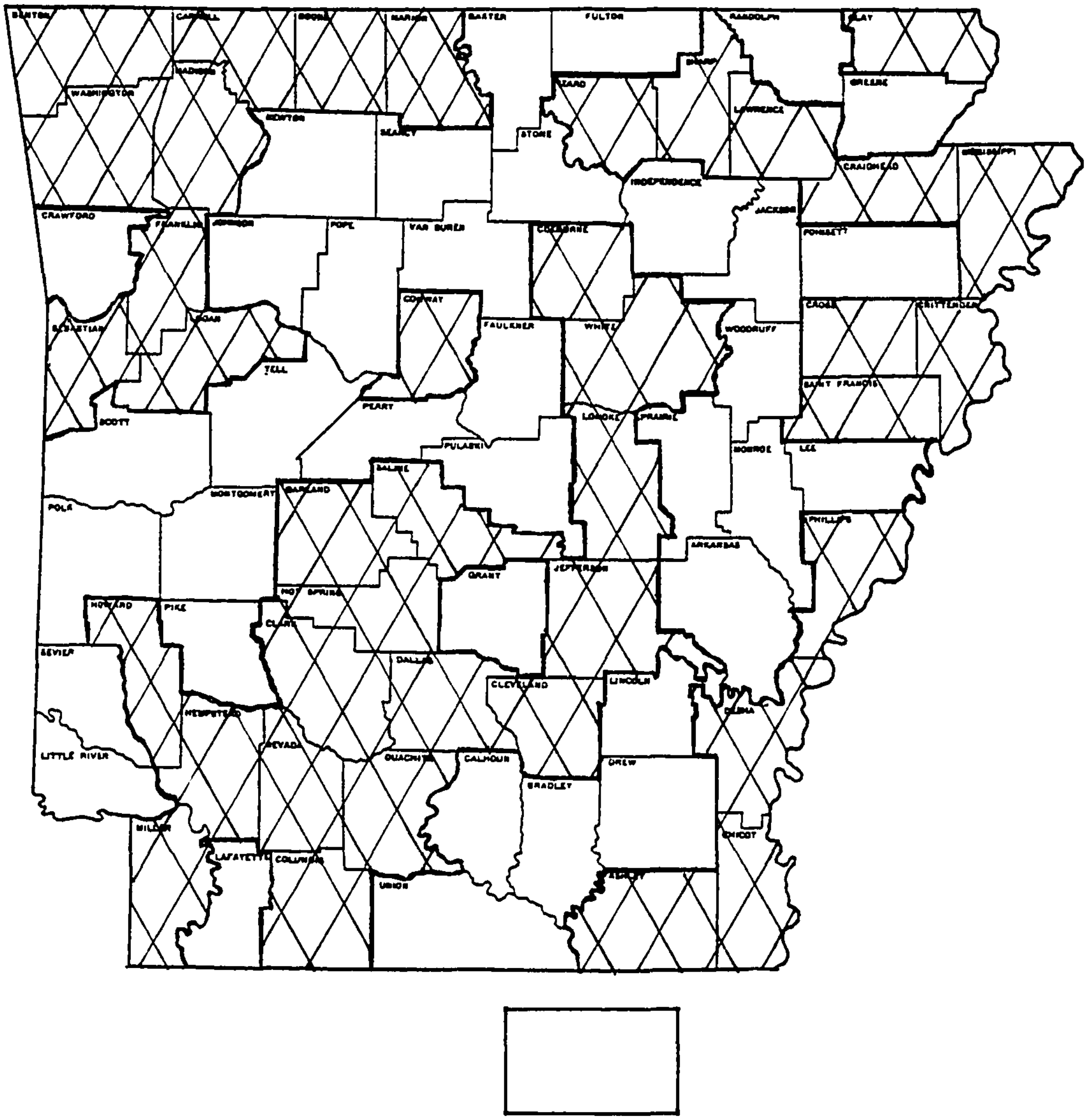
Question number five enquired into what science courses used microcomputers. Results from this question are tabulated in table 1 and figure 4.

Table 1

Use of computers in secondary science courses

Course	**Response**	**%**	**Course**	**Response**	**%**
Jr. High Earth Science	13	23	Sr. High Earth Science	5	9
Jr. High Life Science	10	18	Sr. High Biology	7	12
Sr. High Biology II	3	5	Sr. High Chemistry	5	9
Sr. High Physical Sci	4	7	Sr. High General Sci	0	0
Sr. High Physics	10	18			

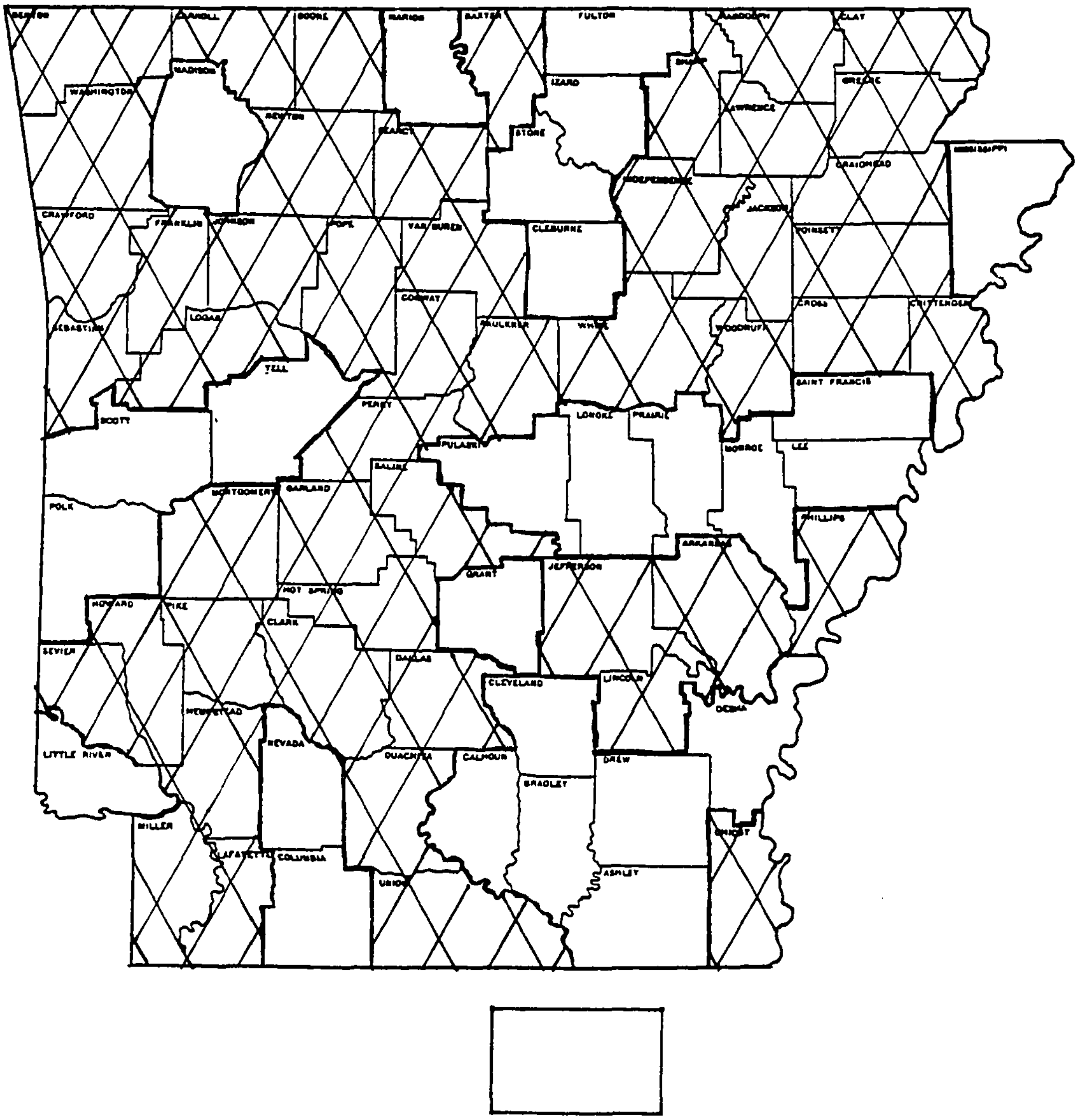
Teachers listed their favorite software programs in question number six. The most popular type software program listed is word processing (18), followed by simulations (15), data base programs (5), graphics and paint programs (4) and spread sheet programs (2). Most of the teachers noted that they use these programs for more than one



Counties not in the study

Figure 1

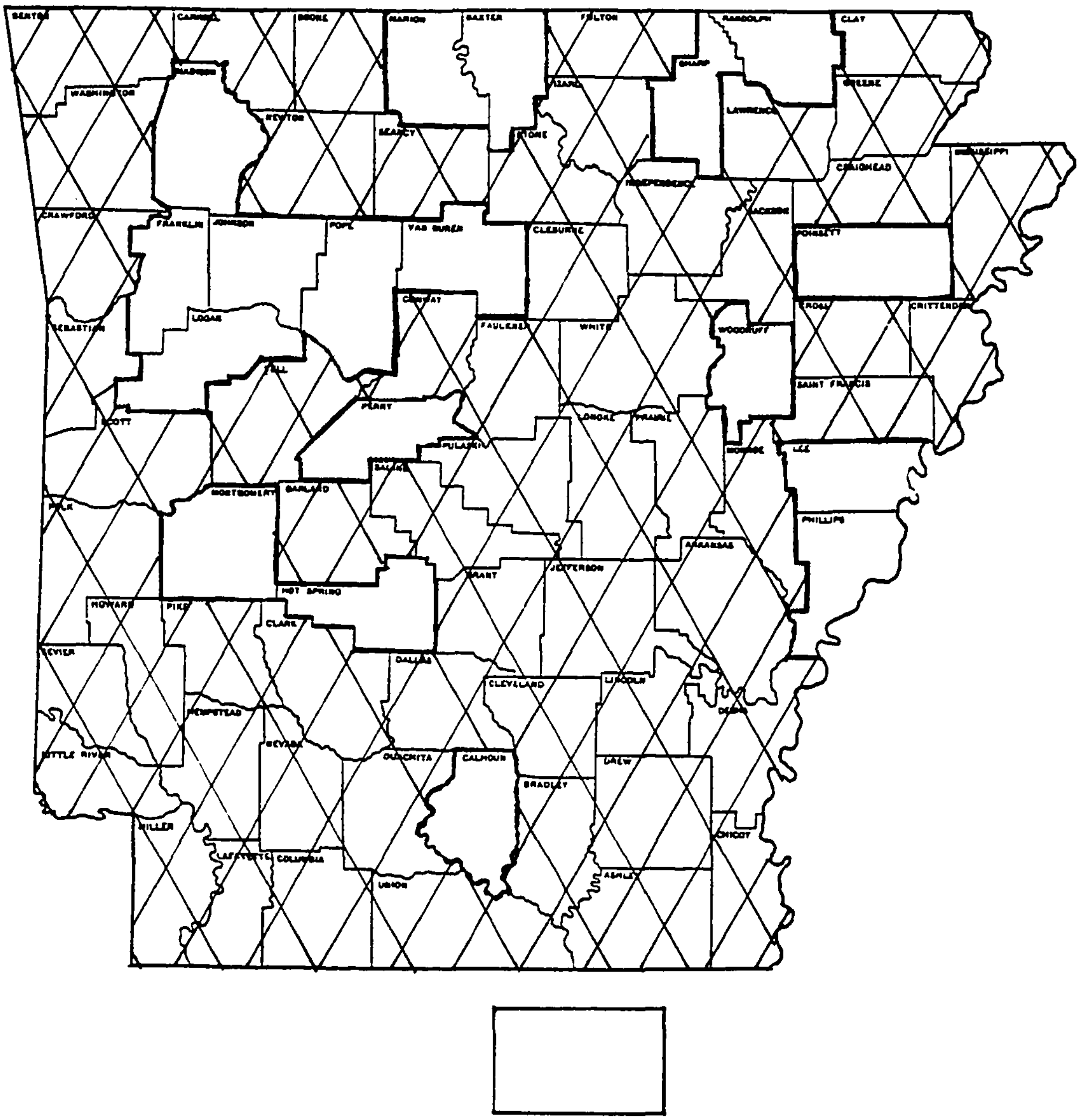
Geographic location by county of survey respondents



Counties not in the study

Figure 2

Coverage by county of IMPAC schools in the study



Counties not in the study

Figure 3

Coverage by county of non-IMPAC schools in the study

of their classes, i.e. graphics programs, paint programs, biology programs and physics simulations. The word processing programs are also listed as being used for more than one subject or class. Teacher productivity software (grade book programs) were listed by three teachers. Appendix C lists the names and publishers of these programs.

Teachers provided information on the implementation and utilization of computers in education in question number seven, "What problems have you had in implementing or utilizing microcomputers?" by ranking the following problems with one being the biggest problem and five being the least: (1) lack of in-service training, (2) lack of software, (3) lack of funds, (4) lack of hardware, (5) lack of school interest. Results are tabulated in table 2.

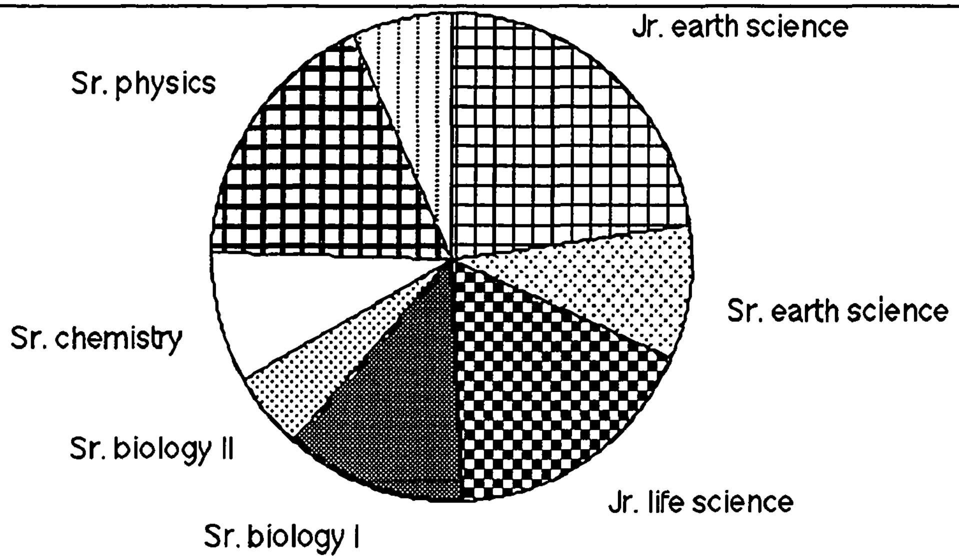


Figure 4
Use of computer applications by subject in secondary education

Responses indicate that the biggest problem schools have in implementing a system of computer instruction in science and mathematics is funding, followed, not unexpectedly, by lack of hardware and lack of training. These three problems are all capital intensive, and teachers mentioned that their school districts simply did not have the funds to support a computer learning program on their own. Teachers interviewed informally and those that wrote comments submitted with the survey document felt that software is not now a problem, but that the cost of the new computers that can run the new software is.

Table 2
Rating of Problems in Implementation and Utilization of Computers in Science and Math

Problem	**least** 1	2	3	4	**greatest** 5
			Respondents		
Lack of training	12	12	8	3	5
Lack of software	2	8	19	7	3
Lack of funds	0	1	4	8	29
Lack of hardware	3	10	7	14	7
Lack of school interest	20	8	1	8	1

Question number eight investigated how teachers utilize the computer in their classes by asking teachers to "Indicate your method of utilizing computers in your courses," from a list of seven different methods; simulation, word processing, laboratory monitoring, drill and practice, data base, interactive video, and other. Results are tabulated in table 3 and in figure 5.

Table 3
Teacher utilization of computer applications

Method	**Respondents**	**Percentage %**
Simulation	21	25
Word processing	15	18
Lab monitoring	4	5
Drill and practice	26	31
Data base	8	10
Interactive video	7	8
Other (grade book)	2	2

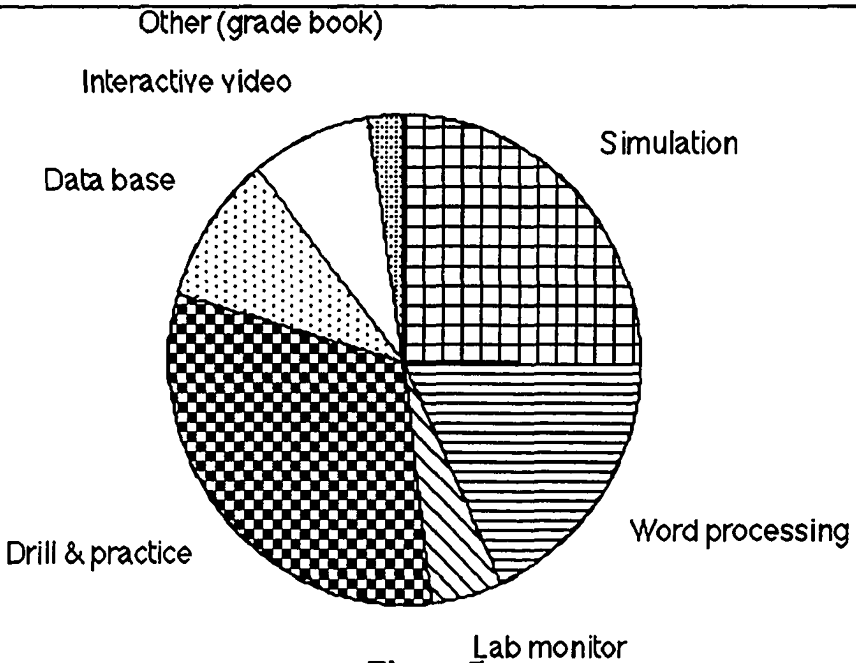


Figure 5
Computer applications in secondary education

Question number nine was designed to investigate teacher awareness of Project IMPAC and integrated computer learning systems by asking "Do you have any knowledge of what Project IMPAC is?"

Thirty-two (40%) of the respondents answered positively and 49 (60%) answered negatively. It is interesting to note that of the 49 negative responses, 30 (61%) came from teachers that are teaching at IMPAC schools. Question numbers 10 and 11 also deal with teacher knowledge of Project IMPAC and integrated computer learning systems. Question number 10 asked "Does your school system have Project IMPAC program computers in the elementary grades?". Teachers were asked to answer yes or no. Twenty-eight teachers (35%) answered that their schools had Project IMPAC and 10 (12%) answered that their school did not. Forty-three teachers (53%) answered that they did not know (fig 6), while in question 11, "Does your school system have an integrated computer learning program in the elementary grades?" 26 teachers (26%) answered that their schools had integrated computer learning systems, 28 (28%) answered negatively and 45 teachers (45%) did not know. Once again, of the 45 teachers that answered that they didn't know, 28 (61%) teach in schools that have Project IMPAC implemented in the elementary grades.

Question 12 asked, "Do you have an integrated science computer program in your Jr/Sr High School?" Thirteen teachers (13%) answered that they do have such a program, 75 (75%) answered that they do not and 11 (12%) did not know. The 13 teachers that answered positively have Project IMPAC in the elementary grades in their school system, and the integrated computer science program was implemented soon after the Project IMPAC program.

Question number 13 deals with teacher training and in-service on using computers in education. The question asked, "Have you ever attended a teacher in-service or other training course in the use of

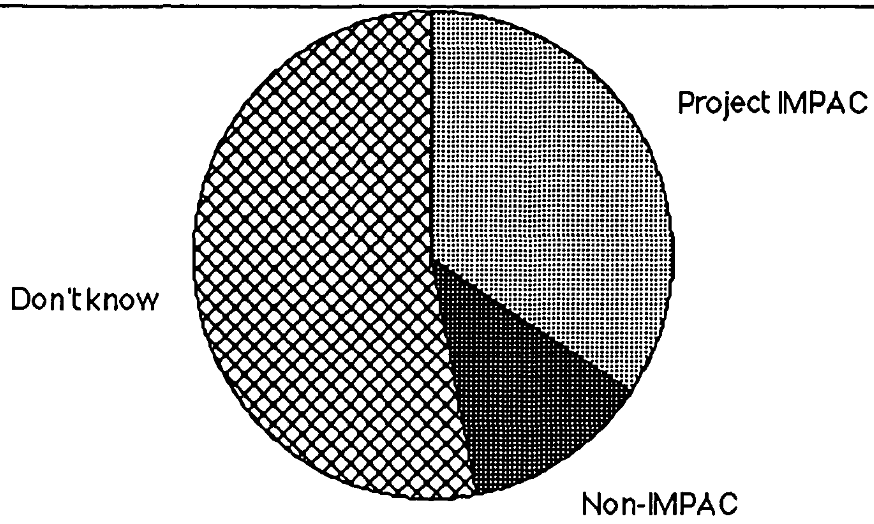


Figure 6

Teacher knowledge of integrated computer learning programs in their school

computers in education?" Fifty-three teachers responded positively and 46 negatively. The question then goes on and asks those teachers responding positively how useful the in-service was by ranking from one (very useful) to five (no use). The results of this question are tabulated in table 4 and figure 7. The average rating for the 53 respondents to this question is 2.88 indicating that the participants found these in-services to be slightly less than useful.

Question 14 A investigated the teacher's perceptions in a change in student educational achievement and attitudes since the implementation of Project IMPAC in their school by asking "Have you noticed a change in the achievement level of your science students (secondary) since the implementation of Project IMPAC, or microcomputers in your school? Has student attitude toward science

Table 4

Teacher in-service rating

Rating	Respondent	Percent
1 Very useful	13	25%
2	4	8%
3 Useful	18	35%
4	8	16%
5 No use	8	16%

changed as a result of the utilization of microcomputers?" The respondents replies are summarized in table 5, and indicate that 28 teachers perceive that student achievement has dropped since the implementation of Project IMPAC or computers in their schools. The average rating given by the teachers is 2.32 on a scale of one to five with five representing greatly improved and one indicating low achievement. Student attitude is, however, perceived to have become more positive toward science, utilizing the same rating scale, 29 teachers gave an average rating of 3.79 The respondents' replies are summarized in table 6. Part B of this question asked teachers to indicate which cognitive levels were most effected by Project IMPAC or the use of microcomputers in education. Results indicate that mainly lower cognitive levels of Bloom's taxonomy are affected with

74% of the positive effect taking place in the three lower level skills. Results are tabulated in table 7.

Teachers were asked about the evidence and methods that they used to give these ratings for questions 14 A and 14 B, in the following

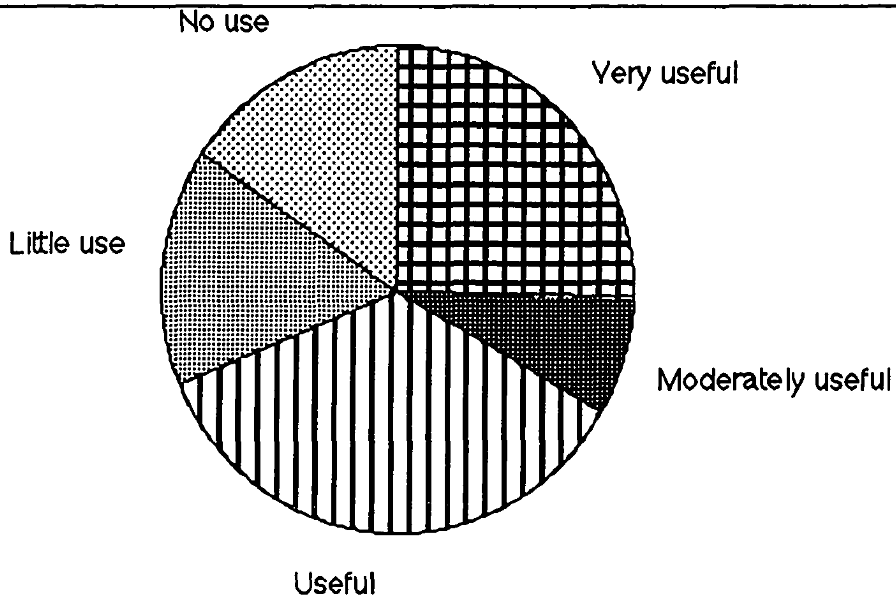


Figure 7

Teacher in-service ratings

question, "On what evidence do you base the rating given?" Twenty teachers (54%) responded that they based their rating on grades, 15 teachers (40%) based their rating on the completion of objectives and two teachers (5%) based their rating on the results from the MAT-6 test.

Table 5

Change in achievement due to the use of microcomputers in education

Rating	Respondents	
5	0	Greatly improved achievement
4	1	Somewhat improved achievement
3	12	Little change in achievement
2	13	Somewhat lower achievement
1	2	Much lower achievement

Table 6

Change in attitude toward science

Rating	Respondents	
5	7	Much more positive
4	11	Somewhat more positive
3	9	Little change
2	2	Somewhat negative
1	0	Much more negative

Table 7

Effect of computers on cognitive level of Bloom's Taxonomy

Cognitive level	Positively effected	%	No noticeable effect	Negatively effected
Knowledge	16	27	10	0
Comprehension	16	27	10	0
Application	12	20	12	0
Analysis	11	18	13	0
Synthesis	5	8	17	0
Evaluation	7	10	18	0

Evaluation of Five Computer Applications

Drill and Practice

Part two of the survey was designed as an evaluation of the use of computers for five classroom activities: drill and practice, simulations, data base activities, word processing, and interactive video. Teachers were asked to indicate whether they use computers for the activity and its effect on the educational achievement and attitude of their students. Teachers were first asked if they utilize computers for drill and practice activities and if they believe that this application has merit. Twenty-six teachers (26%) out of 99 respondents answered that they do use computers for this activity, and 39 teachers (92%) answered that they feel that the application has merit. Three teachers (7%) felt that the application has no merit.

In question 1A, "Can you detect any influence upon the achievement of student's from the use of microcomputers for drill and practice. Has the students attitude toward science changed as a result of the utilization of microcomputers for drill and practice?", three teachers (10%) indicated greatly improved achievement, 23 teachers (79%) indicated somewhat improved achievement, and three teachers (10%) indicated little change. None of the 29 teachers responding to this question indicated lower student achievement. Results are tabulated in table 8. Of the 28 teachers responding to the attitude portion of question 1A, 23 teachers (82%) of the 28 respondents indicated a positive change in student attitude toward science, while four teachers (14%) indicated little change. One teacher (3%) indicated a negative change. Results are tabulated in table 9.

Table 8

Changes in student achievement due to computer drill and practice

	ACHIEVEMENT	
Rating	Respondents	
5	3	Greatly improved achievement
4	23	Somewhat improved achievement
3	3	Little change in achievement
2	0	Somewhat lower achievement
1	0	Much lower achievement

Table 9

Changes in student attitude due to computer drill and practice

Rating	Respondents	ATTITUDE
5	0	Much more positive
4	23	Somewhat more positive
3	4	Little change
2	0	Somewhat negative
1	1	Much more negative

Respondents were asked in part 1B which cognitive levels seemed to be most affected by the use of computers for drill and practice activities. The results tabulated indicate that teachers believe that lower level cognitive skills showed more positive effect than the higher level skills for this activity. No teachers felt that computer learning exercises involving drill and practice programs adversely affected their students. Sixteen teachers (62%) of the 26 teachers that responded to this question felt that knowledge level cognitive skills were positively affected while 10 teachers (38%) saw no noticeable affect. Sixteen teachers (62%) also felt that comprehension skills were positively affected and 10 teachers (38%) saw no noticeable effect. Twelve teachers (50%) of the 24 teachers indicated a positive affect on application skills, and 12 teachers (50%) saw no effect. Eleven teachers (45%) indicate a positive result for analysis level skills while 13 teachers (55%) saw no effect at the application skill level. Five teachers (22%) of the 22 teachers responding saw a positive effect at the synthesis skill level, and 17 teachers (78%) saw no affect. On the evaluation skill level, seven teachers (28%) of the 25 teachers responding noticed a positive affect and 18 teachers (72%) saw no change. Results from this question are tabulated in table 10. Results from the teachers indicates that the lower cognitive levels are the most affected by this computer application with 82% of the positive affect occurring in the knowledge, comprehension, and application levels.

Table 10

Cognitive level effected by computer drill and practice

Cognitive level	Positively effected	%	No noticeable effect	Negatively effected
Knowledge	25	30	4	0
Comprehension	24	29	4	0
Application	19	23	8	0
Analysis	5	6	17	0
Synthesis	4	5	22	0
Evaluation	6	7	21	0

Teachers were asked, "On what evidence do you base the rating given?" for questions 1A and 1B. Fifteen teachers (50%) based their ratings on grades, 12 teachers (40%) based their ratings on the completion of objectives and three teachers (10%) based their rating on results from the MAT-6 tests. Not all teachers participated in all parts of the survey which results in a total of 30 teachers taking part in the last question.

<u>Simulations</u>

Question number two of part II of the questionnaire is "Do you utilize microcomputers for simulations? Do you think that this application has merit?" Fifteen teachers (27%) of the 55 teachers responding to this question and fifteen percent of the total respondents, answered that they do use simulations in their classrooms, and 42 teachers (100%) of those responding answered that they felt that the application has merit.

Part 2A of the question asked, "Can you detect any influence upon the achievement of students from the use of microcomputers for simulations? Has student attitude toward science changed as a result of the utilization of microcomputers for simulations?" Teacher responses indicate that somewhat improved achievement and a somewhat improved attitude toward science was achieved through the use of simulation software. Two teachers (15%) saw greatly improved achievement, while nine teachers (69%) saw somewhat improved achievement. Two teachers (15%) saw little change in their students. Results were identical for the attitude portion of this question, with two teachers (15%) reporting much more positive attitudes toward science, nine teachers (69%) reporting somewhat more positive attitudes and two teachers (15%) reporting no change. Results from this question are tabulated in table 11 and table 12.

Respondents were asked in part 2B which cognitive levels seemed to be most affected by the use of computers for microcomputer simulation activities. The results tabulated indicate that teachers believe that the lower level cognitive skills are positively affected by using microcomputers for simulations. Respondents indicated that, in general, the higher level cognitive skills were not affected adversely. Ten teachers (66%) of the 15 teachers responding indicated that knowledge level skills were positively affected.

Table 11

Changes in student achievement due to computer simulations

Rating	Respondents	ACHIEVEMENT
5	2	Greatly improved achievement
4	9	Somewhat improved achievement
3	2	Little change in achievement
2	0	Somewhat lower achievement
1	0	Much lower achievement

Table 12

Changes in student attitude due to computer simulations

Rating	Respondents	ATTITUDE
5	2	Much more positive
4	9	Somewhat more positive
3	2	Little change
2	0	Somewhat negative
1	0	Much more negative

Eleven teachers (73%) indicated that comprehension and application skills were positively affected. Seven teachers (47%) of the respondents felt that analysis skills had been positively affected and two teachers (13%) indicated that the synthesis level had shown a positive change. Three teachers (20%) indicated that the evaluation level was positively affected. One teacher observed adverse affects at the synthesis and evaluation levels for this computer application. Results from this question are tabulated in table 13. Results from the survey indicate that the teachers found that the major positive affects from using computer simulations occurred in the three lower cognitive levels with 73% of these changes occurring in the knowledge, comprehension and application levels.

The evidence for these ratings was based on five teachers (55%) using grades, three teachers (38%) using completion of objectives and one teacher (12%) using MAT-6 test scores.

Table 13

Cognitive level effected by computer simulations

Cognitive level	Positively effected	%	No noticeable effect	Negatively effected
Knowledge	10	23	5	0
Comprehension	11	25	4	0
Application	11	25	4	0
Analysis	7	16	8	0
Synthesis	2	5	12	1
Evaluation	3	7	11	1

Data Base

Question number three of part II of the questionnaire is "Do you utilize microcomputers for data base activities? Do you think that this application has merit?" Ten teachers (27%) of the 37 teachers responding to this question and ten percent of the total respondents answered that they do use data base activities in their classrooms and 26 teachers (96%) of the 27 responding answered that they felt that the application has merit.

Part 3A of the question asked, "Can you detect any influence upon the achievement of students from the use of microcomputers for data base activities? Has student attitude toward science changed as a result of the utilization of microcomputers for data base activities?" Teacher responses indicate that student achievement shows little change as the result of using microcomputers for data base activities, but a somewhat improved attitude toward science was achieved through the use of microcomputers for this activity.

Two teachers (25%) saw somewhat improved achievement. Six teachers (75%) saw little change in their students. Results for the attitude portion of this question showed an improved attitude toward science with three teachers (38%) reporting much more positive attitudes toward science, one teacher (12%) reporting somewhat more positive attitudes and four teachers (50%) reporting no change. Results from this question are tabulated in table 14 and table 15.

Respondents were asked in part 3B which cognitive levels seemed to be most affected by the use of computers for microcomputer data base activities. The results obtained indicate that teachers believe that the lower level cognitive skills are positively affected by using microcomputers for data base activities. The respondents indicated that, in general, the higher level cognitive skills were positively affected to a lesser extent than the lower level skills by this activity. Four (57%) of the seven teachers responding indicated that knowledge level skills were positively affected. Four

Table 14

Changes in student achievement due to computer data base activities

Rating	Respondents	ACHIEVEMENT
5	0	Greatly improved achievement
4	2	Somewhat improved achievement
3	6	Little change in achievement
2	0	Somewhat lower achievement
1	0	Much lower achievement

Table 15

Changes in student attitude due to computer data base activities

Rating	Respondents	ATTITUDE
5	3	Much more positive
4	1	Somewhat more positive
3	4	Little change
2	0	Somewhat negative
1	0	Much more negative

teachers (57%) indicated that comprehension level skills were positively affected, with three teachers (50%) of the six teachers responding to this question indicating that application skills were positively affected. Three teachers (43%) of the respondents felt that analysis skills had been positively affected and two teachers (40%) of those responding indicated that the synthesis level had shown a positive change. Three teachers (50%) of those responding indicated that the evaluation level was positively affected. Results from the survey on utilizing data bases for education indicate that all cognitive levels are positively affected almost equally. Results from this question are tabulated in table 16. The evidence for these ratings was based on five teachers (55%) using grades, three teachers (38%) using completion of objectives and one teacher (12%) using MAT-6 test scores.

Table 16

Cognitive level effected by computer data base activities

Cognitive level	Positively effected	%	No noticeable effect	Negatively effected
Knowledge	4	21	3	0
Comprehension	4	21	2	0
Application	3	16	3	0
Analysis	3	16	4	0
Synthesis	2	11	3	1
Evaluation	3	16	3	1

Word Processing

Question number four of part II of the questionnaire is "Do you utilize microcomputers for word processing activities? Do you think that this application has merit?" Twenty seven teachers (68%) of the 40 teachers responding to this question and 28 percent of the total respondents answered that they do use word processing activities in their classrooms and 29 teachers (96%) of the 30 responding answered that they felt that this application has merit.

Part 4A of the question asked, "Can you detect any influence upon the achievement of students from the use of microcomputers for word processing activities? Has student attitude toward science changed as a result of the utilization of microcomputers for word processing activities?" Teacher responses indicate that student achievement shows a positive change in student achievement as a result of using microcomputers for word processing. Respondents also indicate that an improved attitude toward science was achieved through the use of microcomputers for word processing.

Four (21%) of the 19 teachers responding to this question saw greatly improved achievement. Eleven teachers (58%) reported somewhat improved achievement, and four teachers (21%) saw little change in their students. Results for the attitude portion of this question showed an improved attitude toward science with eight teachers (42%) reporting much more positive attitudes toward science, five teachers (26%) reporting somewhat more positive attitudes, and six teachers (31%) reporting no change. Results from this question are tabulated in table 17 and table 18.

Respondents were asked in part 4B which cognitive levels seemed to be most affected by the use of microcomputers for word processing activities. The results obtained indicate that teachers believe that all levels of the cognitive skills are positively affected by using microcomputers for word processing activities. Nine teachers (60%) of the 15 teachers responding indicated that knowledge level skills were positively affected. Ten teachers (71%) of the 14 teachers responding indicated that comprehension level skills were positively affected. Nine teachers (64%) of the 14 teachers responding indicate that application skills were positively affected. Six teachers (46%) of the 13 respondents felt that analysis skills had been positively affected and six teachers (43%) of 14 responding indicated that the synthesis level had shown a positive change. Ten teachers (67%) of those responding indicated that the evaluation level was positively affected.

Table 17
Changes in student achievement due to computer word processing activities

Rating	Respondents	ACHIEVEMENT
5	4	Greatly improved achievement
4	11	Somewhat improved achievement
3	4	Little change in achievement
2	0	Somewhat lower achievement
1	0	Much lower achievement

Table 18

Changes in student attitude due to computer word processing activities

Rating	Respondents	ATTITUDE
5	8	Much more positive
4	5	Somewhat more positive
3	6	Little change
2	0	Somewhat negative
1	0	Much more negative

Results from the survey on utilizing word processing applications for education indicate that all cognitive levels are positively affected almost equally. Results from this question are tabulated in table 19. The evidence for these ratings was based on seven teachers (44%) using grades, four teachers (44%) using completion of objectives and two teachers (12%) using MAT-6 test scores.

Interactive Video

Question number five of part ll of the questionnaire is "Do you utilize microcomputers for interactive video? Do you think that this application has merit?" Eleven (58%) of the 19 teachers responding to this question and 11 percent of the total respondents answered that they do use interactive video in their classrooms and 13 teachers (81%) of the 16 teachers responding answered that they felt that this application has merit.

Part 5A of the question asked, "Can you detect any influence upon the achievement of students from the use of microcomputers for interactive video? Has student attitude toward science changed as a result of the utilization of microcomputers for interactive video?" Teacher responses indicate that student academic achievement shows a positive change as a result of using microcomputers for interactive video. Respondents also indicate an improved attitude toward science was achieved through the use of this computer application. Two teachers (22%) of the 9 teachers responding to this question saw greatly improved achievement. Six teachers (66%) reported somewhat improved achievement, and 1 teacher (11%) saw little

Table 19

Cognitive level effected by computer word processing activities

Cognitive level	Positively effected	%	No noticeable effect	Negatively effected
Knowledge	9	18	6	0
Comprehension	10	20	4	0
Application	9	18	5	0
Analysis	6	12	7	0
Synthesis	6	12	8	0
Evaluation	10	20	5	0

change in the achievement made by students. Results for the attitude portion of this question showed an improved attitude toward science with three teachers (33%) reporting much more positive attitudes toward science, four teachers (44%) reporting somewhat more positive attitudes, and 2 teachers (22%) reporting no change. Results from this question are tabulated in table 20 and table 21.

Respondents were asked in part 5B, "Which cognitive levels seemed to be most affected by the use of microcomputers for interactive video?" The results obtained indicate that teachers believe that all levels of cognitive skills are positively affected by using microcomputers for interactive video. All of the teachers (100%) responding indicated that knowledge level skills were positively affected. Eight teachers (89%) of the nine teachers responding indicated that comprehension level skills were positively affected. Six teachers (66%) of the nine teachers responding indicate that application skills were positively affected. Six teachers (66%) of the 9 respondents felt that analysis skills had been positively affected, and six teachers (66%) of nine teachers responding indicated that the synthesis level had shown a positive change. Four teachers (44%) of the nine teachers responding indicated that the evaluation level was positively affected.

Table 20

Changes in student achievement due to computer interactive video

		ACHIEVEMENT
Rating	Respondents	
5	4	Greatly improved achievement
4	11	Somewhat improved achievement
3	4	Little change in achievement
2	0	Somewhat lower achievement
1	0	Much lower achievement

Table 21

Changes in student attitude due to computer interactive video

Rating	Respondents	ATTITUDE
5	8	Much more positive
4	5	Somewhat more positive
3	6	Little change
2	0	Somewhat negative
1	0	Much more negative

Results from the survey on utilizing interactive video for education indicate that all cognitive levels are almost equally affected. Results from this question are tabulated in table 22. The evidence for these

Table 22

Cognitive level effected by computer interactive video

Cognitive level	Positively effected	%	No noticeable effect	Negatively effected
Knowledge	9	10	6	0
Comprehension	10	20	4	0
Application	9	18	5	0
Analysis	6	12	7	0
Synthesis	6	12	8	0
Evaluation	10	20	5	0

ratings was based on four teachers (44%) using grades, four teachers (44%) using completion of objectives and one teacher (12%) using MAT-6 test scores.

The means for student achievement by each computer application used in education and the average mean for the change in attitude due to the use of computers in education were calculated. The average mean for all of the different computer applications investigated was 3.80, indicating that teachers observed somewhat improved achievement in science. The average mean for a change in attitude due to the use of computers for educational purposes was 3.97,.indicating that teachers observed a somewhat more positive attitude toward science due to the use of computers. These results parallel those recorded in the literature and by other researchers. Mean ratings for each of the five computer applications and change in attitude due to the educational use of computers in science were also calculated. These calculations are reported in tables 23 and table 24. The individual mean ratings range from a low rating of 3.25 for the utilization of data bases to a high of 4.11 for interactive video. The range of the rating is from slightly above "Little change in achievement " to slightly above "Somewhat improved achievement." Data base usage had the lowest rating with the mean of 3.25. Drill and practice were next with a mean rating of 3.65. Word processing and simulations both had a mean rating of 4.0, and interactive video had the highest mean rating with 4.11. The literature indicates that these ratings parallel much of the recent research, except that of Russell (1989) who found that interactive video had the lowest rating in his study of the uses of computers in secondary social studies; however, all of the mean ratings from this study on mathematics and science for both achievement and attitude are lower than those recorded by Russell (1989) for social studies.

The mean ratings for changes in attitude reported in table 24, due to the use of computers for educational purposes in science, are slightly higher than those for changes in achievement. This is similar to the findings of Russell (1989). The lowest rating for changes in attitude was for drill and practice with a low rating of 3.75, followed by changes in attitudes due to the use of data base software. Once again, word processing and simulations were calculated to have mean ratings of 4.00. Interactive video was again calculated to have changed student's attitudes toward science the most with a rating of 4.11. All of these ratings are in the range of somewhat more positive on the rating scale used.

Table 23

Mean ratings of achievement due to the use of computers in science education

Method	**N.**	**Mean**	**Std. Dev**	**Low**	**High**
Word processing	19	4.00	.65	3	5
Data base	8	3.25	.43	3	4
Drill and practice	29	3.65	.57	3	5
Simulations	13	4.00	.55	3	5
Interactive video	9	4.11	.57	3	5

Table 24

Mean ratings for changes in attitude due to the use of computers in science education

Method	N.	Mean	Std. Dev	Low	High
Word processing	19	4.10	.85	3	5
Data base	8	3.87	1.12	3	5
Drill and practice	28	3.75	.63	3	5
Simulations	13	4.00	.55	3	5
Interactive video	9	4.11	.74	3	5

Effect of Computers in the Home

Part three of the survey provides data on secondary students and how they use computers for educational purposes and relaxation. The questionnaire asked the teachers to poll their classes to determine (1) how many of their students had used computers in the elementary grade, (2) how many students have computers at home, and (3) how they are used. The teachers were then asked about their perceptions as to the educational achievement levels of students that have and use computers at home for educational purposes. The student responses to questions one and two of Part III were that out of a total of 3932 students responding to these questions, 2664 (68%) of the students answered that they had used microcomputers in the elementary grades, and 949 (24%) of the students responded that they have and use microcomputers at home.

Question number three of Part III asked, "What is the primary use of computers in the home?" Teachers were asked to poll their classes and indicate whether students use a particular computer application at home. The applications asked about were: (1) word processing, (2) data base, (3) arcade games, (4) adventure games, and (5) simulations. Students were also asked if they utilized their home computers for homework. Results from this question are that 54 teachers (35%) show that their students use arcade games at home, 37 (24%) teachers indicate that their students use adventure games, 29 (19%) teachers indicate that their students use word processors, 21 (13%) teachers indicated that data base software was in use, 14 teachers (9%) show simulations in use, and 27 of the teachers indicated that 27 of the students (18%) use their computers for homework. Results from these question are summarized in table 25 and figure 8.

Question number four of Part III asks "What are the secondary uses that students make of their computers at home?" Teachers were asked to poll their classes and enquire into other (secondary) uses that home computers are used for by students. The results indicate that 32 (27%) of the students use their computers for word processing, 27 (24%) teachers showed arcade games as the next most popular use, 27 (23%) teachers indicate that students use their computers for adventure games, and 14 (12%) of the students use their computers with data base software. Twenty-four of the surveys indicated that the students use their computers for homework. Some of the teachers supplied actual numbers of students for each computer application. This data indicates that contrary to the literature and the

Table 25

Primary use of computer applications at home by students

Application	Number of teachers	Percent
Word processing	29	19
Data base	21	13
Arcade games	54	35
Adventure games	37	24
Simulations	14	9
Homework	27	15

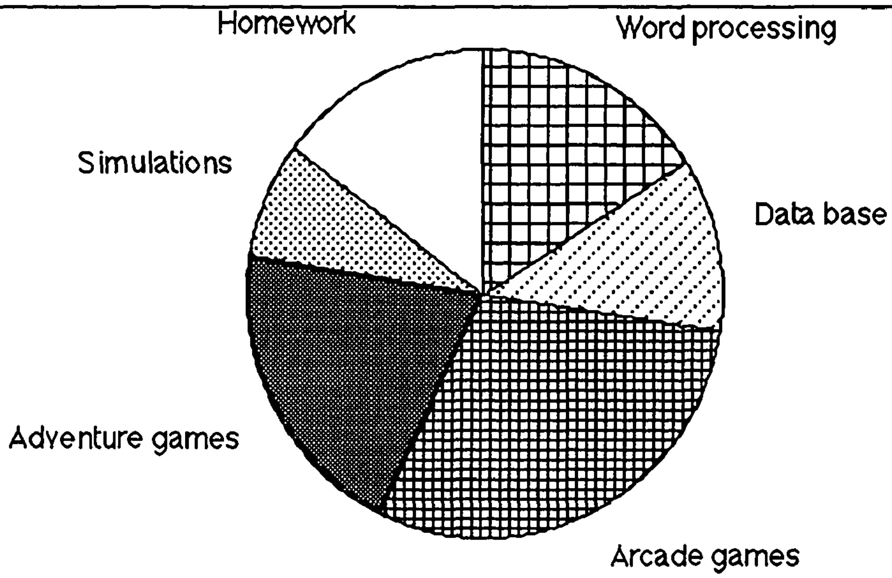


Figure 8
Primary use of computer applications at home, by students

uses that teachers put computer applications to, students use word processing and data base programs far more than they use simulations. This data is tabulated and displayed in table 26 and figure 9.

Question number five addressed the teachers perceptions as to the level of academic achievement by students that have computers at home. Of the 63 teachers that responded to the question, 36 (57%) answered that students with computers in the home have a higher academic achievement level than those students that do not. Fifteen teachers (24%) answered that there was no difference and 12 teachers (19%) did not know. (Figure 10).

Table 26

Secondary use of computer applications at home, by students

Application	Number	Percent
Word processing	27	14
Data base	30	16
Arcade games	44	23
Adventure games	51	27
Simulations	6	3
Homework	31	16

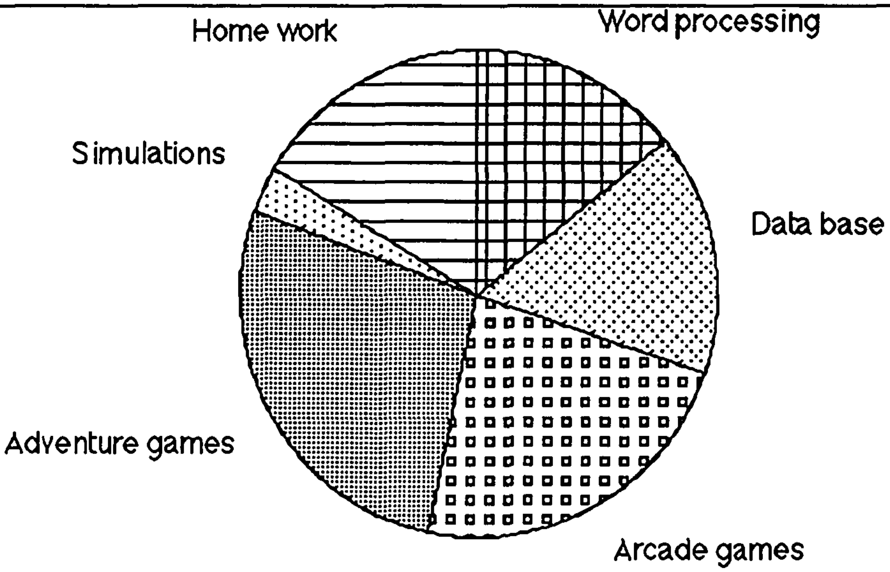


Figure 9

Secondary use of computer applications at home, by students

Statistical Analysis of Computer Application

Statistical analysis utilizing a one-way analysis of variance on the five computer applications: (1) drill and practice, (2) simulations, (3) data base, (4) word processing and (5) interactive video, found a significant difference at the .05 level in the mean ratings on the effect of these methods on academic achievement. Results of this analysis are tabulated in tables 27 and table 28. A Scheffe t-test for multiple comparisons of the means of each computer application was utilized to isolate each computer application that teachers perceived to be enhancing student academic achievement. Results of the Scheffe analysis are tabulated in table 29. The Data base application was found to be significantly less effective at improving student academic achievement in science.

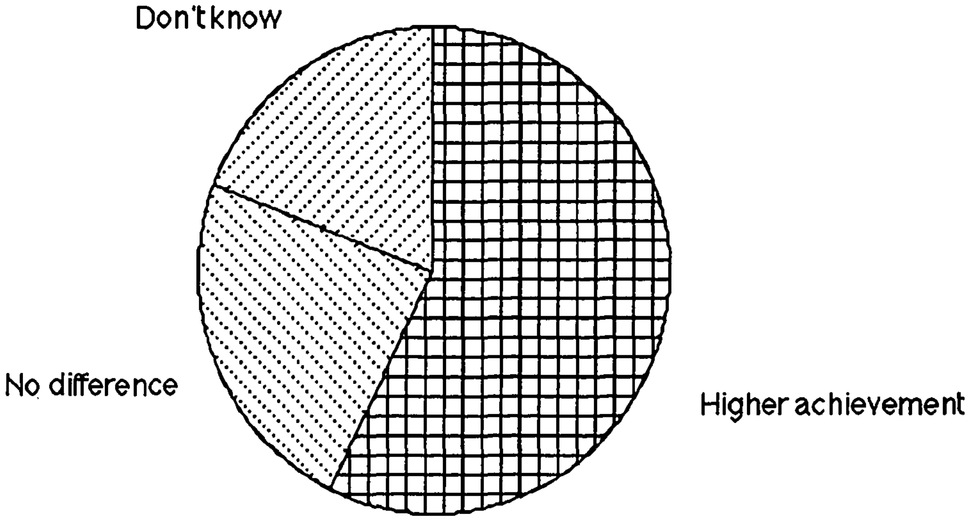


Figure 10

Teachers perception as to the effect of computers in the home on student academic achievement

Student attitude toward these five computer applications were also analyzed utilizing a one-way analysis of variance. Jaccard (1983) states that the test for the null hypothesis involves comparing the observed F value with a critical F value of pre-calculated values. The normal level of confidence used in educational research is either the .05 or .01 level. For cases where the observed F value exceeds the critical F value at the level of confidence needed, the null hypotheses of no relationship would be rejected. None of the five computer applications were found to be any better than any of the others in improving student attitude toward science at the .05 level of significance. Table 30 describes the results of this statistical analysis.

Table 27
Results of a one-way analysis of variance on mean achievement ratings

Source	SS	DF	Var. Est	F-Ratio	Prob
Among	4.29	4	1.07	3.50	0.0115
Within	22.39	73	.31		
Total	26.68	77			

p< .05

Table 28
Mean values and standard deviations for computer applications

Group	N	Mean	Std. Dev
Drill & Practice	29	4.00	0.46
Simulation	13	4.00	0.58
Data Base	8	3.25	0.46
Word Processing	19	4.00	0.67
Interactive Video	9	4.11	0.60

Table 29
Scheffe matrix of probabilities for academic achievement

	Dp	Sim	Db	Wp	Iv
Dp	1.00	1.00	.0282 *	1.00	.9881
Sim	1.00	1.00	.0689	1.00	.9918
Db	.0282 *	.0689	1.00	.0435 *	.0449 *
Wp	1.00	1.00	.0435 *	1.00	.990
Iv	.9881	.9918	.0449 *	.990	1.00

*P< .05

Table 30

Results of a one-way analysis of variance on mean attitude ratings

Source	**SS**	**DF**	**Var. Est**	**F-Ratio**	**Prob**
Among	1.87	4	.47	.83	
	0.515				
Within	40.80	73	.57		
Total	42.68	77			

$p > .05$

Analysis of the Effect of Integrated Computer Programs in 90 Schools Versus no Computer Systems

Summary

The second part of the study involved the statistical analysis of MAT-6 standardized test scores from 180 Arkansas schools. Ninety of these schools are taking part in Project IMPAC and 90 are not. The schools in this study were selected for analysis by random selection and were either participants in Project IMPAC from 1983 through 1987 or are non-IMPAC schools. The non-IMPAC schools were selected from the State Department of Education's list of schools in Arkansas. Standardized test scores for each school on the MAT-6, and SRA-78 are available from the Arkansas State Department of Education, participating schools, County supervisors of Education and the Arkansas Gazette. All of the data for the study were obtained from the Arkansas State Department of Education. No secondary sources were needed. MAT-6 and converted SRA-78 data are displayed utilizing scattergrams with a simple regression line for each subject and group (IMPAC, non-IMPAC). A one-way anova was utilized to test for a significant difference between the non-IMPAC and IMPAC schools in science and mathematics. The results from these anovas are tabulated in table form and displayed in table 31 through table 38.

The means from the MAT-6 data for the seventh grade, 1981 through 1989 and projected into 1990, is displayed in a scattergram in figure 11. The data shows a continual improvement in MAT-6 scores for mathematics from 1981 through 1989 and similar improvement for science from 1985 through 1989 for both subjects in general. The data for seventh grade mathematics indicates that IMPAC schools scored in the 34th percentile in 1981 and in the 60th percentile in 1989, a gain of 26 percentile units. The non-IMPAC schools scored in the 30th percentile in 1981 and in the 55th percentile in 1989, a gain of 25 percentile units.

The regression line for the IMPAC schools indicates that the one percentile unit difference projected for 1990 is effected mainly by the 1987 and 1988 scores. The 1989 score for the IMPAC schools is slightly above that of 1988 and below the regression line prediction. If the MAT-6 scores for 1990 remain in the 60th percentile range, the regression lines will become parallel or start to converge. If the lines become parallel, they would indicate no change in the rate of academic achievement between IMPAC and non-IMPAC schools in mathematics achievement. If the lines start to converge, it would indicate that either the IMPAC schools or non-IMPAC schools rate of academic achievement has become less. At this point in time, it is not possible to say which system will have the best rate. The non-IMPAC schools show a similar loss in their 1989 MAT-6 scores.

The science scores for the seventh grade students attending IMPAC schools indicates that IMPAC schools scored in the 54th percentile in 1985 and in the 65th percentile in 1989, a gain of 11 percentile units. The non-IMPAC schools scored in the 56th percentile in 1985 and in the 62nd percentile in 1989, a gain of six percentile units. The regression line for the IMPAC schools crosses the regression line for the non-IMPAC schools in 1987, indicating that these schools have made up any deficit in academic achievement and the regression line continues to diverge positively indicating that the gains should continue with a one percentile unit difference projected for 1990. A one-way analysis of variance, table 31, indicates that there is a significant difference at the .05 level in student academic achievement in the seventh grade for mathematics and science with the Project IMPAC students achieving at a higher level.

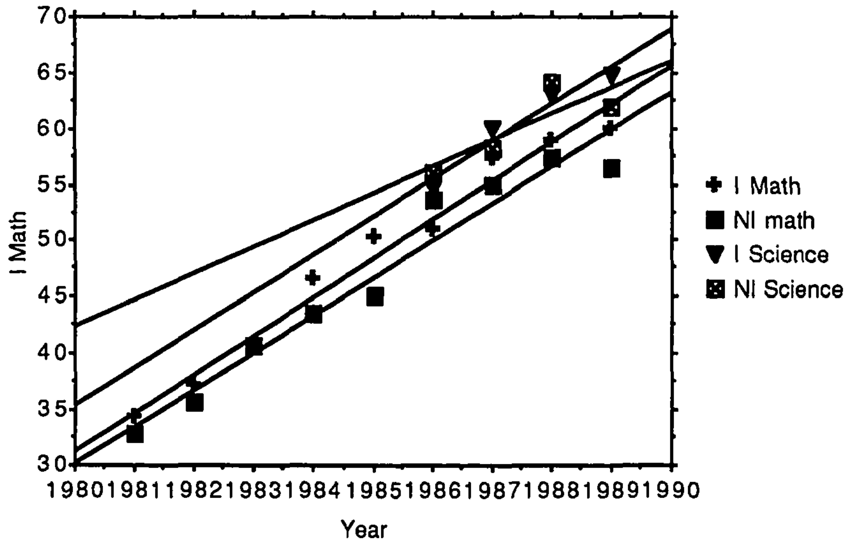


Figure 11
MAT-6 score mean values for 7th grade science and mathematics 1981 thru 1990

Table 31

Results of a one-way analysis of variance on seventh grade IMPAC MAT-6 scores and state mean MAT-6 scores for mathematics and science

Source	SS	DF	Var. Est	F-Ratio	Prob
Among	1205.85	3	401.95	4.38	0.0146
Within	2021.11	22	91.87		
Total	3226.96	25			

p< .05

Table 32

t-test results, comparison of seventh grade MAT-6 mean values, IMPAC mathematics vs non-IMPAC mathematics 1981-1989

DF:	Mean X - Y:	Paired t value:	Prob. (1-tail):
8	1.738	2.309	.0248 *

* p< .05

t-test results, comparison of seventh grade MAT-6 mean values, IMPAC science vs non IMPAC science 1985-1989

DF:	Mean X - Y:	Paired t value:	Prob. (1-tail):
3	.522	.512	.3221

The means from the MAT-6 data for the tenth grade, 1982 through 1989 and projected into 1990, is displayed in a scattergram in figure 12. The data shows a continual improvement in MAT-6 scores for mathematics from 1982 through 1990 and similar improvement for science from 1985 through 1990 for both subjects in general. The data for tenth grade mathematics indicates that IMPAC schools scored in the 39th percentile in 1981 and in the 53rd percentile in 1989, a gain of 14 percentile units. The non-IMPAC schools scored in the 37th percentile in 1981 and in the 51st percentile in 1989, a gain of 14 percentile units. The regression line for the IMPAC schools indicates that the three percentile unit difference projected for 1990 is effected mainly by the 1987 and 1988 scores. The 1989 score for the IMPAC schools is the same as for 1988 and below the regression line prediction. If the MAT-6 scores for 1990 remain in the 53rd percentile range, the regression lines will become parallel or start to converge, indicating little difference between IMPAC and non-IMPAC schools in mathematics achievement.

The science scores for the tenth grade students attending IMPAC schools indicate that IMPAC schools scored in the 54th percentile in 1985 and in the 59th percentile in 1989, a gain of five percentile units. The non-IMPAC schools scored in the 52nd percentile in 1985 and in the 58th percentile in 1989, a gain of six percentile units. The regression line for the IMPAC schools indicates that the one percentile unit difference projected for 1990 is effected mainly by the 1987 and 1988 scores. The 1989 score for the IMPAC schools is similar to that for 1988 and below the regression line prediction. If the MAT-6 scores in science for 1990 remain in the 57th percentile range, the regression lines will cross earlier than the present prediction which is sometime during the 1990 school year. The MAT-6 scores indicate little difference between IMPAC and non-IMPAC schools in science achievement. The data show that the non-IMPAC schools are increasing their rate of academic achievement faster than the IMPAC schools. A one-way analysis of variance table 33 indicates that there is a significant difference in student academic achievement at the .05 level in the tenth grade for mathematics and science with the Project IMPAC students achieving at a higher level.

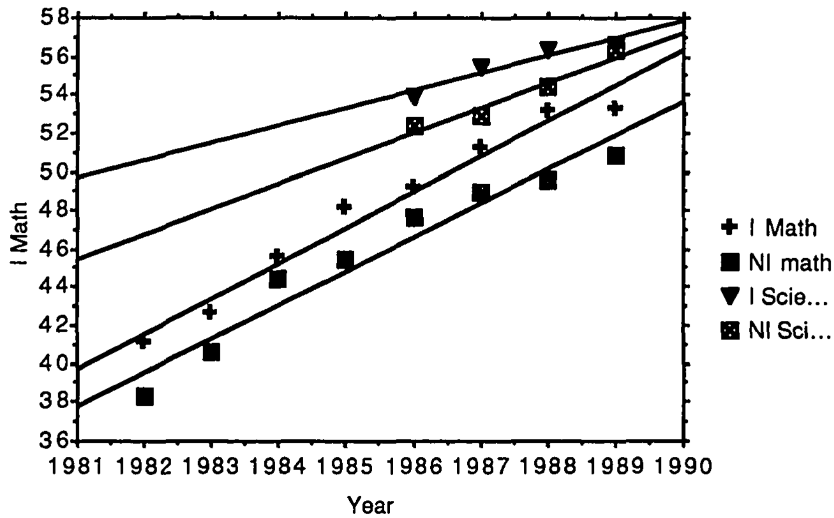


Figure 12

MAT-6 score mean values for 10th grade science and mathematics 1981 thru 1990

Table 33

Results of a one-way analysis of variance on tenth grade IMPAC MAT-6 scores and state mean MAT-6 scores for mathematics and science

Source	SS	DF	Var. Est	F-Ratio	Prob
Among	360.53	3	120.18	8.06	0.0013
Within	298.23	20	14.91		
Total	658.75	23			

$p < .05$

Table 34

t-test results, comparison of tenth grade MAT-6 mean values, IMPAC mathematics vs non-IMPAC mathematics 1981-1989

DF:	Mean X - Y:	Paired t value:	Prob. (1-tail):
7	2.355	8.678	.0001*

$p < .05$

t-test results, comparison of tenth grade MAT-6 mean values, IMPAC science vs non IMPAC science 1985-1989

DF:	Mean X - Y:	Paired t value:	Prob. (1-tail):
3	1.573	3.342	.0221*

$p < .05$

Analysis of two Large Population Areas in Arkansas as Compared to the Mean MAT-6 Scores from 90 Non-IMPAC Schools

Summary

A longitudinal analysis was completed for two large population areas that have been members of Project IMPAC since its inception in 1983. This analysis utilizes the means from MAT-6 standardized test scores for the large population IMPAC schools and the mean values calculated from MAT-6 scores for 90 non-IMPAC schools randomly selected from the Arkansas State Department of Education's lists. The two large population areas selected for analysis are: (1) Fayetteville, and (2) Little Rock.

The data used for analysis was input into the computer programs "StatView SE + Graphics ™" (Feldman, Hofman, Gagnon, and Simpson, 1984) and "Statistics with Finesse" (Bolding, 1989). A Macintosh SE/30 computer and an Apple IIgs computer were used to run the programs and generate the statistical tests. Scattergrams with simple regression lines, one-way analysis of variance and multiple factor t-tests (Scheffe) were performed on the data to investigate any relationships between academic achievement in science and mathematics and the use of computers and integrated computer educational programs.

Fayetteville Seventh Grade

The scores from the 1982 through 1989 MAT-6 data for the Fayetteville seventh grade is displayed in a scattergram in figure 13. The data shows a continual improvement in MAT-6 scores for mathematics from 1982 through 1987, with a high in the 76th percentile. The 1988 and 1989 MAT-6 scores are lower with the 1988 score in the 74th percentile and the 1989 score in the 75th percentile. Science scores on the MAT-6 show continual improvement from 1986 through 1989 with scores improving from the 67th percentile in 1986 to the 73rd percentile in 1989. In general, both mathematics and science have shown significant improvement.

Scores for seventh grade mathematics indicate that Fayetteville scored in the 45th percentile in 1982 and in the 75th percentile in 1989, a gain of 30 percentile units. The non-IMPAC school mean was in the 33rd percentile in 1982 and in the 56th percentile in 1989, a gain of 23 percentile units. Analysis of the regression lines for mathematics indicates that the lines are diverging and that the Fayetteville schools are improving academically at a faster rate than the non-IMPAC schools.

The science scores for the Fayetteville seventh grade are in the 67th percentile in 1986 and in the 73rd percentile range in 1989, a gain of eight percentile units. The non-IMPAC school mean scores for science are in the 56th percentile range in 1985 and in the 62nd percentile in 1989, a gain of six percentile units. An analysis of the regression line for Fayetteville schools and the non-IMPAC schools indicates that that the regression lines are converging. Therefore the Fayetteville schools are not improving academically at as fast a rate as the non-IMPAC schools in science. A one-way analysis of variance, table 35 indicates that there is a significant difference in student academic achievement at the .05 level in the MAT-6 scores from the Fayetteville seventh grade for mathematics and science.

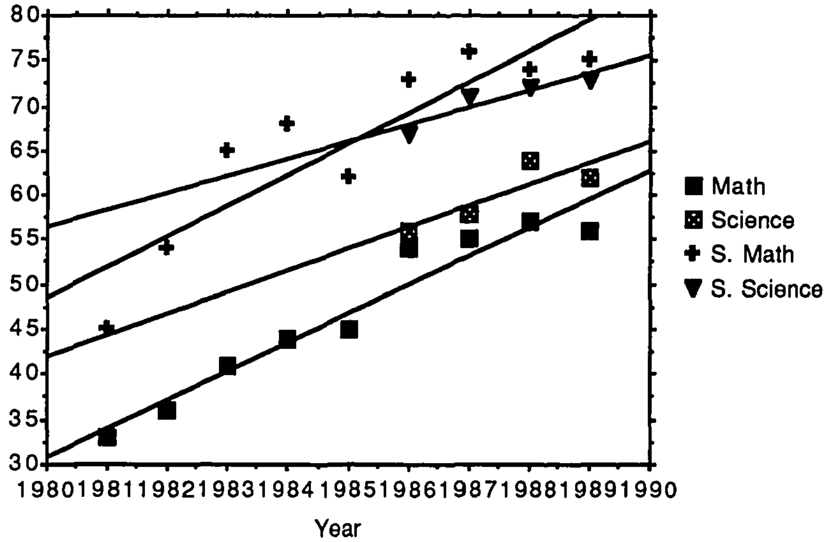


Figure 13

Arkansas non-IMPAC seventh grade mean MAT-6 scores for science and mathematics vs Fayetteville seventh grade MAT-6 scores in science and mathematics.

Table 35

Results of a one-way analysis of variance on seventh grade mean MAT-6 scores from non-IMPAC schools vs Fayetteville seventh grade MAT-6 scores.

Source	SS Prob	DF	Var. Est	F-Ratio	
Among	2313.99	3	771.33	10.48	0.0003
Within	1619.86	22	73.63		
Total	3933.85	25			

$p < .05$

Fayetteville Tenth Grade

The scores from the 1982 through 1989 MAT-6 data for the Fayetteville tenth grade is displayed in a scattergram in figure 14. The data shows a continual improvement in MAT-6 scores for mathematics from 1982 through 1989, with a high in the 68th percentile in 1989. Science scores for the Fayetteville tenth grade show similar improvement with a high in 1989 in the 74th percentile. In general, both mathematics and science have shown significant improvement.

Scores for tenth grade mathematics indicate that Fayetteville scored in the 61st percentile in 1982 and in the 68th percentile in 1989, a gain of seven percentile units. The non-IMPAC school mean for the tenth grade was in the 38th percentile in 1982 and in the 51st percentile in 1989, a gain of 13 percentile units.

The science scores for the Fayetteville tenth grade are in the 70th percentile in 1986 and in the 74th percentile in 1989, a gain of four percentile units. The non-IMPAC school mean scores for science are in the 52nd percentile in 1985 and in the 56th percentile in 1989, a gain of four percentile units. An investigation of the slopes of the regression lines for mathematics and science scores reveals that the mathematics scores for the non-IMPAC schools and Fayetteville schools scores are converging, while the regression lines for the science scores are parallel at this time. This indicates that in mathematics, Fayetteville is not improving at as fast a rate as the non-IMPAC schools and that in science, Fayetteville is improving at the same rate. A one-way analysis of variance table 36 indicates that there is a significant difference at the .05 level in student academic achievement in tenth grade mathematics and science between the

MAT-6 scores from the Fayetteville schools and the mean scores from 90 non-IMPAC schools.

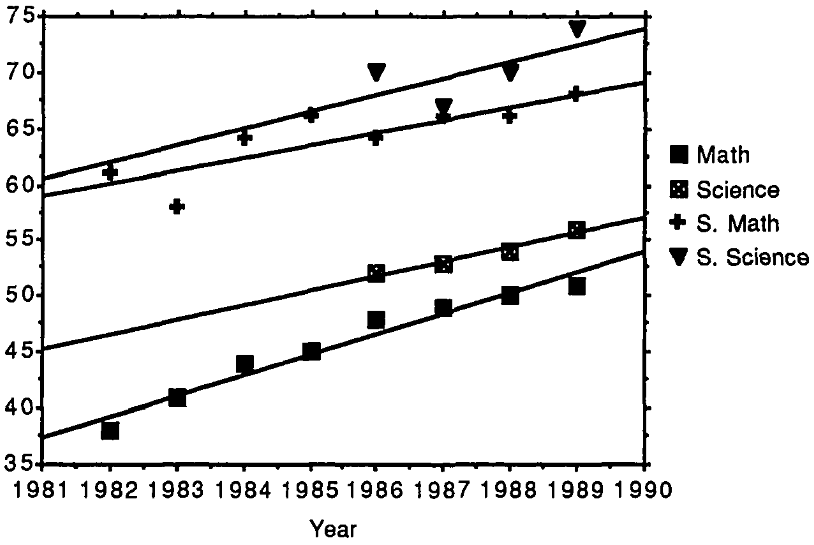


Figure 14

Arkansas non-IMPAC tenth grade mean MAT-6 scores for science and mathematics vs Fayetteville tenth grade MAT-6 scores in science and mathematics.

Table 36

Results of a one-way analysis of variance on tenth grade mean MAT-6 scores from non-IMPAC schools vs Fayetteville tenth grade MAT-6 scores.

Source	**SS**	**DF**	**Var. Est**	**F-Ratio**	**Prob**
Among	2161.08	3	720.36	56.75	0.0001
Within	253.88	20	12.96		
Total	2414.96	23			

$p < .05$

Little Rock Seventh Grade

The scores from the 1981 through 1989 MAT-6 data for the Little Rock seventh grades, are displayed in a scattergram in figure 15. The data shows an improvement in MAT-6 scores for mathematics from 1981 through 1986, with a high in the 54th percentile. The 1988 and 1989 MAT-6 scores are lower with the 1988 score in the 53rd percentile and the 1989 score in the 50th percentile. Science scores on the MAT-6 show improvement from 1986 through 1989 with scores improving from the 47th percentile in 1986 to the 52nd percentile in 1988. The 1989 score for the Little Rock schools was in the 50th percentile. In general, both mathematics and science have shown improvement.

Scores for seventh grade mathematics indicate that Little Rock students scored in the 36th percentile in 1981 and in the 50th percentile in 1989, a gain of 14 percentile units. The non-IMPAC school mean was in the 33rd percentile in 1981 and in the 56th percentile in 1989, a gain of 23 percentile units.

The science scores for the Little Rock seventh grades are in the 47th percentile in 1986, rise to the 52nd percentile in 1986 and 1987 and fall to the 50th percentile in 1989, a net gain of three percentile units. The non-IMPAC school mean scores are in the 56th percentile in 1986 and in the 62nd percentile in 1989, a gain of six percentile units. An analysis of the regression lines for the non-IMPAC and Little Rock school MAT-6 scores indicates that the Little Rock school scores started out below the non-IMPAC school scores and while showing improvement, have not progressed at as fast a rate as the non-IMPAC schools for mathematics and science. A one-way analysis of variance, table 37 indicates that there is a significant difference in student academic achievement at the .05 level in the MAT-6 scores between the Little Rock seventh grade scores and the non-IMPAC scores for mathematics and science.

<u>Little Rock Tenth Grade</u>

The scores from the 1982 through 1989 MAT-6 data for the Little Rock tenth grade, is displayed in a scattergram in figure 16. The data show an improvement in MAT-6 scores for mathematics from 1982 through 1989, with a high in the 50th percentile in 1989. Science scores for the Little Rock tenth grades show no improvement.

Scores for tenth grade mathematics indicates that Little Rock scored in the 43rd percentile in 1982 and in the 50th percentile in 1989, a gain of seven percentile units. The non-IMPAC school mean for the tenth grade was in the 38th percentile in 1982 and in the 51st percentile range in 1989, a gain of 13 percentile units.

The science scores for the Little Rock tenth grades are in the 49th percentile in 1986 and remain there with the exception of 1988 when they rose to the 50th percentile. The non-IMPAC school mean scores for science are in the 52nd percentile in 1986 and in the 56th percentile in 1989, a gain of four percentile units. Investigation of the slopes of the regression lines reveal that the non-IMPAC scores for mathematics are diverging slightly in a positive direction. An analysis of the regression lines for science scores indicates that the non-IMPAC scores are improving at a much greater rate than those of the Little Rock schools. A one-way analysis of variance, table 38, indicates that there is a significant difference at the .05 level in student academic achievement in tenth grade mathematics and science between the MAT-6 scores from the Little Rock schools and the mean scores from 90 non-IMPAC schools.

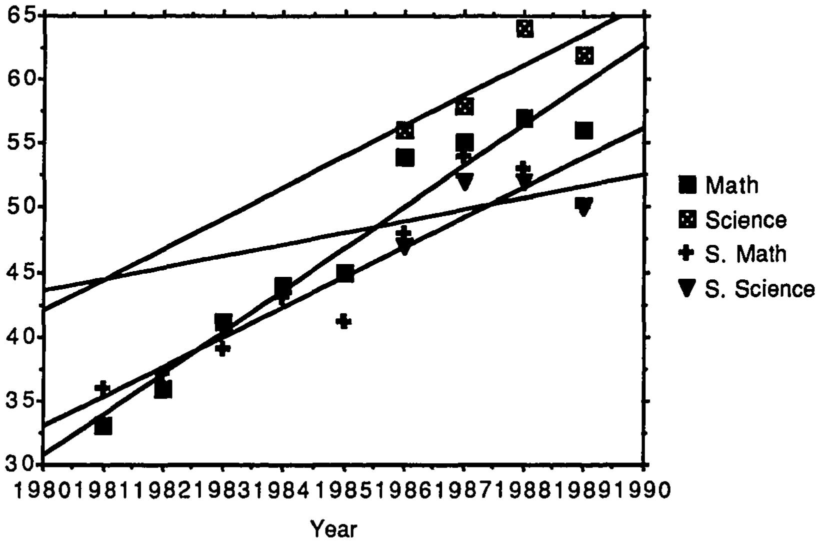


Figure 15

Arkansas non-IMPAC seventh grade mean MAT-6 scores for science and mathematics vs Little Rock seventh grade MAT-6 scores in science and mathematics.

Table 37

Results of a one-way analysis of variance on seventh grade mean MAT-6 scores from non-IMPAC schools vs Little Rock seventh grade MAT-6 scores.

Source	**SS**	**DF**	**Var. Est**	**F-Ratio**	**Prob**
Among	707.82	3	235.94	4.74	0.0107
Within	1094.53	22	49.75		
Total	1802.35	25			

$p < .05$

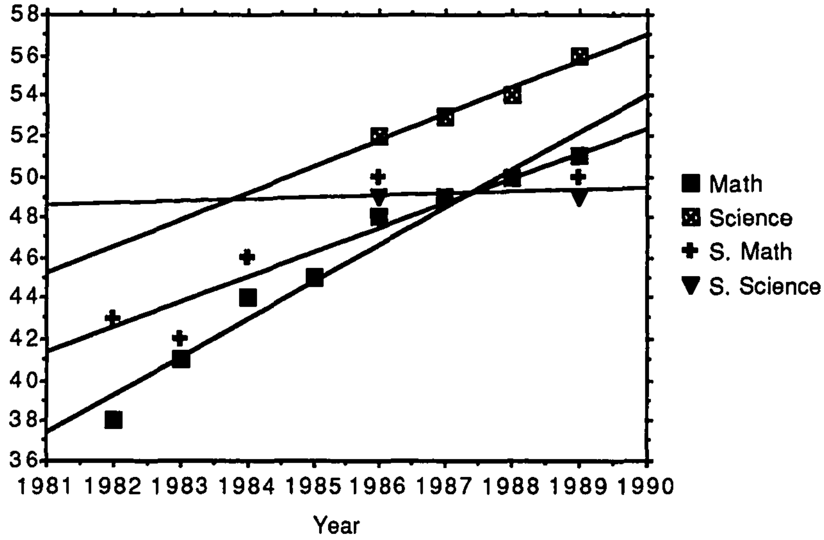


Figure 16

Arkansas non-IMPAC tenth grade mean MAT-6 scores for science and mathematics vs Little Rock tenth grade MAT-6 scores in science and mathematics.

Table 38

Results of a one-way analysis of variance on tenth grade mean MAT-6 scores from non-IMPAC schools vs Little Rock tenth grade MAT-6 scores.

Source	**SS**	**DF**	**Var. Est**	**F-Ratio**	**Prob**
Among	189.08	3	63.03	5.39	0.0071
Within	233.88	20	11.69		
Total	422.96	23			

$p < .05$

The differences between the Fayetteville school system and the Little Rock school system are quite pronounced. The Fayetteville seventh grade MAT-6 mathematics scores are 22 percentile units higher than the seventh grade MAT-6 mathematics scores from Little Rock. The tenth grade mathematics scores from Fayetteville are 18 percentile units higher than the same scores from the Little Rock schools. The seventh grade MAT-6 science scores from the Fayetteville schools show a similar pattern with the Fayetteville scores 21 percentile units above those in Little Rock. The tenth grade MAT-6 science scores from Fayetteville are 24 percentile units above the science scores from the Little Rock schools. Delving into the reason for the disparity between these standard test scores is beyond the purview of this study, but is certainly worthy of further research.

CHAPTER V
SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This chapter contains a summary of the hypotheses upon which this research is based, and the results of that research. Recommendations and suggestions are presented on avenues for further research and investigation on computer aided instruction and integrated computer learning systems, and their use in secondary mathematics and science. Further recommendations are included on methods of improving the effectiveness of Project IMPAC, or other integrated computer learning systems or projects and extending the educational benefits of these projects into the state's secondary school system.

Summary

The primary purpose of this study was to provide educators with information and data on the educational effectiveness of "Computer Aided Instruction" (CAI) in its various forms (CMI) (CBI) (etc.). The study provides data and analysis on: (1) the effectiveness of an integrated computer program (Project IMPAC) used for educational purposes in the elementary grades (K-6), and it's effect on the educational achievement of students in the secondary grades (7-12), (2) are schools not in project IMPAC, but, using computers, as educationally effective as IMPAC schools; and (3) the attitudes toward and the use of computers in the classroom and at home by science and mathematics teachers and students. The study tested the following hypotheses:

1. Educational achievement gains achieved through the use of an integrated computer learning system provided by project IMPAC in the elementary grades and other integrated computer learning systems will lead to measurable educational achievement gain by students in the secondary grades.
2. Students using computers in the secondary grade levels for specific tasks will achieve higher educational achievement and positive changes in cognitive skill levels.

The research was accomplished by providing teachers with a survey instrument that afforded them the opportunity to provide data on the number of teachers that use computers in their classrooms, what computer software they use, and the specific subject or course the computers and software are used in.

Teachers' perceptions as to the educational effectiveness of computers in changing students achievement levels in mathematics and science were measured. The survey instrument asked teachers to compare changes in the students' academic achievement levels,and attitude toward mathematics and science based on changes in grades, completion of objectives, or MAT-6 scores. Data from the survey instrument were analyzed to ascertain the teachers perceptions of changes in cognitive levels when using computers in specific classroom activities based on grades, objectives or MAT-6 scores.

A longitudinal study was completed in which 90 Arkansas school systems that are participants in Project IMPAC (Instructional Microcomputer Project For Arkansas Classrooms) were compared to 90 Arkansas school systems that are not participating in the project.

The data for the study were the standardized test scores for the 180 school systems from 1981 through 1989. The study utilized standard techniques of statistical analysis to compare the two groups for any significant difference in academic achievement that could be the result of the use of computers used for educational purposes, ie the treatment.

Conclusions

The conclusions from this study are based on the data obtained from testing the two hypotheses stated in the previous section. A summary of the two hypothesis and the results of the statistical analysis and conclusions drawn from them are presented in this section.

A summary of hypothesis one states that there will be significant gains in educational achievement in the secondary schools because of the use of an integrated computer learning system in the elementary school system. Using comparisons between Project IMPAC schools and non-IMPAC schools, analysis of variance and t tests indicate that students in Project IMPAC schools do achieve at a higher level in the seventh grade than students in non-IMPAC schools in mathematics and science. Analysis of the data for the tenth grade indicates that there is significant gain in academic achievement in mathematics for the Project IMPAC schools, but that there is little difference between Project IMPAC and non-IMPAC schools in science. It is also evident that the benefits of using computers for educational purposes in the elementary grades diminish with time. In general, the seventh grade

MAT-6 scores for the IMPAC schools are better than those of the tenth grade. From a statistical viewpoint, hypothesis one is accepted, and we fail to support the null hypothesis. However, from a practical perspective, it is obvious that the effect of using an integrated microcomputer program in the elementary grades and not continuing the program in the secondary grades is a waste of both time and resources. Analysis of the data shows that the differences in educational achievement between the IMPAC and non-IMPAC schools diminish with time and in some cases disappear. Analysis of the regression lines for the IMPAC and non-IMPAC schools show that for some of the schools studied, the non-IMPAC schools will be achieving at a higher academic level than the IMPAC schools.

A summary of hypothesis two states that students using computers for specific educational tasks in the secondary grade levels will demonstrate higher academic achievement at higher cognitive levels than students not utilizing computers for these purposes. Analysis of the data provided by the survey instrument indicate that teachers do see positive changes in all of the cognitive levels through the use of computers for specific educational purposes. These positive changes are in part because of the students choice and have nothing to do with any integrated program at the school. The students and teachers have recognized the benefits to be gained from using computers for educational purpose both in class and at home. Hypothesis two is accepted, and we fail to support the null hypothesis.

The study provided data, information and in some cases answers to the following specific questions.

1. What is the effect of Project IMPAC on student achievement in science and mathematics at the secondary educational level?
2. Are schools that have microcomputers but are not part of Project IMPAC as educationally effective?
3. What are the effects of various integrated computer learning exercises such as computer simulations, strategy games, and drill and practice on secondary science and mathematics achievement?
4. What is the effect on student achievement of the use of home computers for educational purposes in science and mathematics?
5. What are the results of the utilization of microcomputers in elementary education on MAT 6 scores in the secondary schools?
6. Do students experienced in using computers exhibit positive educational achievement compared with students with little or no experience with computers on standardized tests such as the MAT-6?

Subsidiary Questions

1. Do the secondary schools surveyed have computers of their own for science and mathematics use? How many are available?

2. What is the main use of software? What kinds and type of software are available?

Question one: The effect that Project IMPAC has had on student achievement in secondary mathematics and science has been positive.

This statement is substantiated by the results of the investigation for hypothesis one. The use of an integrated computer learning system does have benefits that persist after the treatment, with the same limitations discussed in the discussion of the investigation of hypothesis one.

Question two: Schools that do not utilize computers in an integrated learning system are not as educationally effective as measured by standardized tests such as the MAT-6. This statement is substantiated by the results from the investigation for hypothesis one and references in the literature. This effect is also subject to the time limits imposed by not following through with an integrated computer learning system for the secondary grades.

Question three: The effects of specific computer applications such as computer simulations, strategy games and drill and practice are in general positive. Each application was investigated for changes in student academic achievement, and changes in student attitude toward science and mathematics because of the use of computers for educational purposes. The investigation indicates that in all cases, positive changes in student academic achievement and attitude were demonstrated as perceived by teachers.

Question four enquired into teacher perceptions of the academic achievement levels of those students that utilize computers at home. Results indicate that a majority of teachers believe that those students that use computers at home achieve at higher levels academically than those students that do not have computers available to them in the home.

Question five: The utilization of computers may be a factor in higher MAT-6 test scores at the secondary level in Project IMPAC schools where computers are integrated into the elementary curriculum. This is supported by this research on the positive educational effects of Project IMPAC and research reported in the literature.

Question six: Students with experience in computers do score higher on the standardized tests than those students without this experience.

Answers to Subsidiary Questions

Question one: In general, secondary schools do not have computers set up in each individual classroom. The secondary schools may have a computer in a science or mathematics class, but it is not used as an integral part of the curriculum. These computers are used for enhancement activities and occasional laboratory exercises. In almost all secondary schools, computers are set up in the business classroom and cannot be used for science and mathematics activities on a regular basis.

Question two: The main use of software in the secondary schools is for word processing and data base applications. There are some teachers that utilize simulation software, especially in biology and in physics. The mathematics and physics teachers utilize programs that enable students to make graphs and display geometric figures.

Recommendations For Further Research

1- Research into the number of home computers for large population areas in the United States and the academic achievement level of this population would give a clearer picture of the educational potential of this medium. In a coordinated study, inquiry into the types of software used would also be of interest. Control and experimental groups could be set up and comparisons statistically calculated for significant differences.

2- A research project similar to that outlined in No. 1 could be done for the state of Arkansas and comparisons made between various geographic areas in the state. It would be of interest to determine the effect of socio-economic status and the availability of and type (home entertainment versus business) of computers in the home on educational achievement.

3- An investigation into the use of computers by teachers versus the amount of in-service and support for CAI use given. Many of the teachers surveyed had been provided with in-service support but had no computers to use in their classrooms, while others had the computers to use but had never had a class in their use.

4- Research into the best types of software for educational achievement for each subject would certainly be useful. The researcher might survey the students to ascertain what they use at home and how to make that type of software educationally significant.

5- Continue to monitor and evaluate the academic achievement levels of Project IMPAC and non-IMPAC schools and compare the progress of each.

6- Research into the very different rates of academic achievement between the Fayetteville school system and the Little Rock school system would be of interest. Are the differences caused by a large system versus a small system, socio-economic factors, multi-cultural populations or a combination of all of these factors and others?

7- Project IMPAC should encourage more local control and input in the implementation of the project's installations. This would allow for individualization at each school to allow for special needs in software, hardware and in-service training of teachers and administrators.

8- Elementary teachers could be surveyed as to their opinions and recommendations on the implementation of Project IMPAC. The project coordinators should be included and asked about their perceptions as to the effectiveness of the program, suitability of software and hardware and its place in the elementary curriculum.

Recommendations For Improving Our Use of Computers For Education.

1- Implement Project IMPAC in the secondary schools at those locations where Project IMPAC is already established in the elementary grades. This was proposed in 1987, but never funded. As a research project, monitor student academic achievement from K through 12 for selected schools and if possible selected students from elementary school into college.

2- Institute an in-service program in the use of computers for educational purposes at the educational cooperatives supported by the state university system and local colleges. These in-services should be of a general to specific nature and cover elementary through secondary level uses of hardware and software for mathematics and science.

3- Each school system should survey their student population as to the brand name and operating system of computers available in the home. This would make possible the purchase or production of educational software that could be made available through the school library system. A research project could then be instituted to investigate the educational benefits of of educationally effective software and home computers.

4- It is recommended that Project IMPAC review its software offerings to include more than drill and practice programs. In interviewing students and observing the IMPAC laboratories in use, it was noticed that the software available was, in general, all of the drill and practice variety. This research has shown that this type of software is the least efficient in affecting student achievement and attitude.

5- The last recommendation is that libraries in the elementary, middle schools, and high schools in Arkansas have computers installed with a selection of software for student use in both report writing and research and strategic simulation software such as that found in best selling software lists available from many of the commercial resellers. Telecommunications (modems) hooked to these computers would put the particular library in touch with the world and would allow interested students to access major data bases such as Dow Jones for economic data, Georef and Tulsa for environmental and geologic or Kosmos for the latest in physics news or information. This particular use of computers would allow students in rural locations to gain a more global outlook and could be the subject of a research program into the effects of telecommunications on global education.

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APPENDICES

APPENDIX A

Survey

Name____Phone Number__________
School____________________Grades Taught____________Course Titles____________
School District______________________City______________County____________

Please answer all questions if possible. Refer to instruction sheet to answer any questions you may have.

Part 1: Teacher Information

1. In your opinion, do microcomputers have potential in science education?
Yes_____ No_____ No opinion______

2. Do you utilize microcomputers for instruction in any way in your classroom or lab?
Yes______ No______

3. If yes above, Do you use your computers to monitor real time experiments in labs?
Yes_____ No_____ If yes, please list the use ________________

4. Do you or your students write any programs for use in lab situations. Yes____ No____ If yes, what is the program for and in what computer language__________

5. In which of the following courses do you use microcomputers? (Check those that apply.)

Jr. High Earth science	_____	Sr. High Earth science	______
Jr. High Life science	_____	Sr. High Biology I	______
Sr. High Biology II	_____	Sr. High Chemistry	______
Sr. High Physical sci	_____	Sr. High Earth science	______
Sr. High Physics	_____	General Science	______

6. List the names of your five favorite software packages. List publishers also, if possible.

7. What problems have you had in implementing or utilizing microcomputers? (Please rank in order, with 1 being the biggest problem and 5 the least) Lack of in-service training___ Lack of software___ Lack of funds ___ Lack of hardware___Lack of school interest______ Other problems ____________

8. Please indicate your method of utilizing computers in your courses. Simulation___ Word processing ___
Lab Monitoring___ Other__________ Drill & Practice _____ Data Base ______ Interactive video ___

9. Do you have any knowledge of what Project IMPAC is? Yes___ No___

10. Does your school system have Project IMPAC program computers in the elementary grades? Yes___ No___ Don't know___ If yes, what year was the program implemented _________

11. Does your school system have an integrated computer learning program in the elementary grades? Yes___ No___ Don't know___ Please list author or publisher of program, commercial or in house product. If yes, what year ___

12. Do you have an integrated science computer program in your Jr/Sr High School? Yes___ No___ Don't know___ If yes, what year was the program implemented _________

13. Have you ever attended a teacher in-service or other training course in the use of computers in education? Yes___ No___ (If yes, please indicate how useful, by circling the appropriate number.)

Very useful	Useful	No Use		
1	2	3	4	5

14. A Have you noticed a change in the achievement level of your science students (Secondary) since the implementation of project IMPAC , or microcomputers in your school? Has student attitude toward science changed as a result of the utilization of microcomputers?

ACHIEVEMENT	ATTITUDE
5___ Greatly improved achievement	5___Much more positive
4___ Somewhat improved achievement	4___Somewhat more positive
3___ Little change in achievement	3___Little change
2___ Somewhat lower achievement	2___Somewhat negative
1___ Much lower achievement	1___Much more negative

B. Which cognitive levels seem to be most effected? (Check one for each cognitive level.)

Cognitive level	Positively effected	No noticeable effect	Negatively effected
Knowledge	-------	-------	-------
Comprehension	-------	-------	-------
Application	-------	-------	-------
Analysis	-------	-------	-------
Synthesis	-------	-------	-------
Evaluation	-------	-------	-------

On what evidence do you base the rating given? Grades___ Completion of objectives___ Other___

Part II. Evaluation of computer use.
In this section, five classroom uses of the microcomputer are considered. Please indicate whether you make use of the application, then indicate the effects on student achievement.

1. Do you use computers for drill and practice? Yes___No___ Do you think this application has merit Yes __No ___

A. Can you detect any influence upon the achievement of students from the use of microcomputers for drill and practice? Has student attitude toward science changed as a result of the utilization of microcomputers for drill and practice?

ACHIEVEMENT	ATTITUDE
5___ Greatly improved achievement	5___Much more positive
4___ Somewhat improved achievement	4___Somewhat more positive
3___ Little change in achievement	3___Little change
2___ Somewhat lower achievement	2___Somewhat negative
1___ Much lower achievement	1___Much more negative

B. Which cognitive levels seem to be most effected? (Check one for each cognitive level.)

Cognitive level	Positively effected	No noticeable effect	Negatively effected
Knowledge	_______	_______	_______
Comprehension	_______	_______	_______
Application	_______	_______	_______
Analysis	_______	_______	_______
Synthesis	_______	_______	_______
Evaluation	_______	_______	_______

On what evidence do you base the rating given? Grades___ Completion of objectives___ Other__________

2. Do you utilize microcomputers for simulations? Yes___No___ Do you think this application has merit Yes __No ___

A. Can you detect any influence upon the achievement of students from the use of microcomputers for simulations? Has student attitude toward science changed as a result of the utilization of microcomputers for simulations?

ACHIEVEMENT	ATTITUDE
5___ Greatly improved achievement	5___Much more positive
4___ Somewhat improved achievement	4___Somewhat more positive
3___ Little change in achievement	3___Little change
2___ Somewhat lower achievement	2___Somewhat negative
1___ Much lower achievement	1___Much more negative

B. Which cognitive levels seem to be most effected? (Check one for each cognitive level.)

Cognitive level	Positively effected	No noticeable effect	Negatively effected
Knowledge	_______	_______	_______
Comprehension	_______	_______	_______
Application	_______	_______	_______
Analysis	_______	_______	_______
Synthesis	_______	_______	_______
Evaluation	_______	_______	_______

On what evidence do you base the rating given? Grades___ Completion of objectives___ Other_______

3. Do you utilize microcomputers for data base activities. Yes___No___ Do you think this application has merit Yes__No ___

A. Can you detect any influence upon the achievement of students from the use of microcomputers for data base activities? Has student attitude toward science changed as a result of the utilization of microcomputers for data base activities?

ACHIEVEMENT	ATTITUDE
5___ Greatly improved achievement	5___Much more positive
4___ Somewhat improved achievement	4___Somewhat more positive
3___ Little change in achievement	3___Little change
2___ Somewhat lower achievement	2___Somewhat negative
1___ Much lower achievement	1___Much more negative

B. Which cognitive levels seem to be most effected? (Check one for each cognitive level.)

Cognitive level	Positively effected	No noticeable effect	Negatively effected
Knowledge	_______	_______	_______
Comprehension	_______	_______	_______
Application	_______	_______	_______
Analysis	_______	_______	_______
Synthesis	_______	_______	_______
Evaluation	_______	_______	_______

On what evidence do you base the rating given? Grades___ Completion of objectives___ Other___

4. Do you utilize computers for word processing activities? Yes___No___ Do you think this application has merit Yes __No ___

A. Can you detect any influence upon the achievement of students from the use of microcomputers for word processing? Has student attitude toward science changed as a result of the utilization of microcomputers for word processing?

ACHIEVEMENT	ATTITUDE
5____ Greatly improved achievement	5____Much more positive
4____ Somewhat improved achievement	4____Somewhat more positive
3____ Little change in achievement	3____Little change
2____ Somewhat lower achievement	2____Somewhat negative
1____ Much lower achievement	1____Much more negative

B. Which cognitive levels seem to be most effected? (Check one for each cognitive level.)

Cognitive level	Positively effected	No noticeable effect	Negatively effected
Knowledge	_______	_______	_______
Comprehension	_______	_______	_______
Application	_______	_______	_______
Analysis	_______	_______	_______
Synthesis	_______	_______	_______
Evaluation	_______	_______	_______

On what evidence do you base the rating given? Grades___ Completion of objectives___ Other___

5. Do you utilize microcomputers for interactive video Yes___No___ Do you think this application has merit Yes __No ___

A. Can you detect any influence upon the achievement of students from the use of microcomputers for interactive video? Has student attitude toward science changed as a result of the utilization of microcomputers for interactive video?

ACHIEVEMENT	ATTITUDE
5____ Greatly improved achievement	5____Much more positive
4____ Somewhat improved achievement	4____Somewhat more positive
3____ Little change in achievement	3____Little change
2____ Somewhat lower achievement	2____Somewhat negative
1____ Much lower achievement	1____Much more negative

B. Which cognitive levels seem to be most effected?

Cognitive level	Positively effected	No noticeable effect	Negatively effected
Knowledge	-------	-------	-------
Comprehension	-------	-------	-------
Application	-------	-------	-------
Analysis	-------	-------	-------
Synthesis	-------	-------	-------
Evaluation	-------	-------	-------

On what evidence do you base the rating given? Grades__ Completion of objectives__ Other__

Part III Student Information

In this section please poll your class and record the following information. Total number of students polled ____

1. How many students used computers in the elementary grades? _

2. How many students in your classes have computers at home? __

3. What is the primary use of computers in the home? (Please check all that apply) Word processing___Data base___Arcade games___Adventure games____Simulations____Homework____

4. What are the secondary uses that students make of their computers at home? (Please check all that apply) Word processing___Data base___Arcade games____Adventure games____Simulations____ Homework____

5. In general, do the students with computers at home have a higher academic achievement than those without computers at home? Yes____ No____ Don't know_____

APPENDIX B

Survey Cover Letter

John P. Watkins
P.O. Box 712
Prairie Grove, AR 72753
(501) 846-3930

February 13, 1990

Dear Colleague,

The enclosed questionnaire is for a study involving the use of computers in the secondary science and mathematics curriculum. Data from this study will be used as part of the research for a doctoral dissertation.

The major purpose of this study is to investigate the effect on secondary science and mathematics education of project IMPAC and the use of microcomputers in grades 4 through 8. Teachers will rate the effect of various methods of microcomputer utilization in elementary and junior high school on achievement in secondary science and mathematics. Your descriptive comments would also be greatly appreciated. This information will add to the knowledge of other teachers about the use of microcomputers in science and mathematics education.

Please use the following definitions when filling out the rating section.

(1) **Drill and practice programs**. These programs present a series of questions or problems and appropriate feedback is provided.

(2) **Simulations.** These programs generate models of environments. students interact with the model to solve problems or investigate situations.

(3) **Data base programs**. These programs allow for the organization, storage, retrieval and printing of information.

(4) **Word processing.** These programs allow the student to create, edit, print and store reports and other writing.

(5) **Interactive video**. These devices permit images stored on video tape to be sequenced and presented by interaction of the student and a computer program.

Enclosed is a self addressed stamped envelope for your reply. I am looking forward to hearing from you.

Director of Study

Dr. Michael Wavering
Professor
Secondary Education
University of Arkansas

Sincerely,

John Watkins
Science Teacher
Farmington High School
Farmington, Ar 72730

APPENDIX C

Teachers Software List

TEACHERS SOFTWARE LIST

SOFTWARE	**PUBLISHER**
Blocktronic	Seraphim Software
Chemicals of Life I - III	IBM
Focus Biology	Focus Media
Genetics	IBM
Geometry	Broderbund
Grade Book	Sensible Software
Grade Keeper	Home written
Graphical Analysis	Vernier Software
Human Life Processes I - III	IBM
Light, Plants, and Photosynthesis	IBM
Microsoft Works	Microsoft
Operation Frog	Scholastic Software
PFS File	Software Publishing
PFS Write	Software Publishing
Printshop	Broderbund
Statistics With Finesse	Dr. James Bolding
The Human System	Focus Media
The Microorganism Simulator	Focus Media
The Plant Growth Simulator	Focus Media
The world of Insects	Focus Media
Thermistor Calorimetry	Seraphim Software
Voltage Plotter	Seraphim Software
Word Star	WordStar

SOFTWARE	PUBLISHER
Bank Street Speller	Bank St Software
Bank Street Writer	Bank St Software
Dbase lll	Ashton Tate
Focus on Biology	Merrill
Focus on Earth Science	Merrill
Focus on Life Science	Merrill
Focus on Physics	Merrill
Lotus 123	Lotus Development
Microsoft Word	Microsoft
P C Paintbrush	ZSoft
P C Write	IBM
PageMaker	Aldus
Right Writer	RightSoft
StatView	Abacus Concepts
Word Perfect	Word Perfect Corp

Long-Term Effects of an Integrated Microcomputer Project on Subsequent Science and Mathematics Achievement in Arkansas Schools

Abstract of dissertation submitted in partial fulfillment

of the requirements for the degree of

Doctor of Education

By

John Philip Watkins, B.A., M.S.

California State University, 1976

University of Arkansas, 1978

May, 1991

University of Arkansas

This abstract is approved by:

Dissertation Adviser:

Michael J. Wavering
Michael J. Wavering, Ph.D.

Abstract

This research is based on the premise that educational achievement gains by students demonstrated in the elementary grades using Project IMPAC (Instructional Microcomputer Project for Arkansas Classrooms), and other integrated computer learning systems, result in continued measurable, educational achievement as measured by standardized tests, by students in secondary science and mathematics. This research will provide educators with information on the effectiveness of various methods and programs of employment of microcomputers in the science and mathematics curriculum within the state of Arkansas and its effect on student achievement.

The research was accomplished by providing teachers with a survey instrument that afforded them the opportunity to provide data on computer use within their schools and their perception on its effectiveness in increasing student academic achievement and student thinking and problem solving skills, and a longitudinal study on 90 Arkansas school systems that are participants in Project IMPAC (Instructional Microcomputer Project For Arkansas Classrooms) compared to 90 Arkansas school systems that are not participating in the project. The data for the study were the standardized test scores for the 180 school systems from 1981 through 1989.

Comparisons between Project IMPAC schools and non-IMPAC schools utilizing statistical analysis indicate that Project IMPAC schools achieve higher levels of academic achievement in mathematics, but there is little difference between Project IMPAC and non-IMPAC schools in science. It is also evident that the benefits of

using computers for educational purposes only in the elementary grades diminish with time. From a statistical viewpoint, project IMPAC is a success. However, from a practical perspective, it is obvious that the effect of using an integrated microcomputer program in the elementary grades and not continuing the program in the secondary grades is a waste of both time and resources.

Analysis of the data provided by the survey instrument indicate that teachers do see positive changes at all cognitive levels from using computers for educational purposes. These positive changes are in part due to the students choosing to use computers for homework and other tasks in addition to use of computers at the school. Students and teachers have recognized the benefits to be gained from using computers in class and at home.

The conclusions of the study are that integrated computer learning systems have the potential for positive changes in the cognitive levels of learning science and mathematics, when properly implemented. Teachers and students are independently using the computer for educational uses and have realized positive educational benefit from this individualized use.