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AN ANALYSIS OF THE EFFECT OF SELECTED FACTORS UPON THE IMPLEMENTATION OF COMPUTER USAGE IN SECONDARY SCHOOL SCIENCE INSTRUCTION

By

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PREFACE

This study was completed to gain a better understanding of how computers are being used as instructional tools in today's schools. This was accomplished by investigating factors that may affect the extent to which science teachers use computers in the teaching of secondary school science, and by evaluating the effectiveness of an intensive in-service program for science teachers which dealt with computers and their application in the teaching of science.

A combined summer and in-service institute funded by the National Science Foundation made possible the experimental setting in which this study took place. The grant (GW:7843) was made to Wayne State University, and it was administered in conjunction with the Macomb Intermediate School District. The selected science teachers from Macomb County, Michigan were very cooperative during all aspects of the in-service program. Without their involvement this study could not have been completed.

Having received support and assistance from many individuals, I would like to particularly acknowledge the efforts of Dr. W. Eugene Foor, Dr. Donald R. Marcotte, Dr. John T. Norman, and Mr. Thomas Hartsig. But most of all, I would like to thank my wife Karen and my major adviser Dr. Frank O. Youkstetter for their patience and understanding during my entire doctoral program. Their assistance, particularly during the preparation of this manuscript, was critical, timely, and valuable.

CHAPTER I

INTRODUCTION

"In the world today the computer has ceased being an object of awe and wonder and has taken its place as a comprehensive, useful tool in our technologically-oriented society."[1] Implementation of technological innovations such as computer usage in education is relatively new. Computer usage and the factors affecting such use in science instruction in secondary schools are the topics with which this study is concerned.

Background to the Study

Computer usage has affected our society more than any other technological advancement. Hardly a day goes by in which a person does not come in contact with information that has been processed by the use of a computer. Prior to the 1950's, computers were used primarily as calculation

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[1]Herman H. Goldstine, The Computer From Pascal to Von Newmann, (Princeton: Princeton University Press, 1972), p. 346.

tools, but with the advent of stored-program capability, computer applications have found their way into nearly all aspects of society. Computer applications in science, industry, medicine, and business are extensive and are expanding each day.

The evolution of computer usage into the field of education has not occurred at the same high acceleration rate as it has in other fields. The majority of the initial use of computers in education has been in the areas of business accounting, data processing, and record keeping. With the development of technological advances such as time-sharing and remote terminals, educators have begun to find ways to implement computer usage in the instructional phase of education. Today it is not uncommon to find computers being used by classroom teachers to assist instruction in the following areas: problem solving, simulation, information retrieval, testing, research, guidance, and counseling.[1]

The computer may be used in the classroom in any of the following general ways: as an administrator, a

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[1]Leonard Miller, Computers in the Classroom, Joseph Margolin and Marion Misch, Editors (New York: Spartan Books, 1970), p. 80.

tutor, a simulator, or a calculator.[1] Of these areas, simulation seems to be the one that is the threshold of development in the field of science education. A computer may have programmed into it certain routines which could be used to simulate experimental situations, and the student can perform experiments on the computer by investigating what will happen as he inputs varying information. He can analyze the results and deduce from them relationships which have been programmed originally into the computer.[2] Using the computer to administer instruction requires a sophistication of computer know-how that few people in education now have, thus its use is presently limited. It has been reported that using the computer as a calculator to analyze laboratory data or solve problems has been, and currently is, the way in which the computer is most often used by the science teacher.[3]

The reasons for the slower adoption of computer

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[1]Ronald Blum, "The Computer and the Teaching of Physics," The Physics Teacher, Vol. 7 (September, 1969), pp. 399-401.

[2]Oran M. Kromhout, "Computer Use and Physics," American Journal of Physics, Vol. 37 (October, 1969), pp. 274-275.

[3]Goldstine, The Computer From Pascal to Von Newmann, p. 345.

usage into the field of education as contrasted to other fields such as business and industry include lack of pre-service or in-service training, lack of administrative support, and lack of facilities due to cost and location. The costs of using a computer terminal in the classroom can be divided into two categories: installation and operation. Installation costs are dependent upon such factors as the number and the location of telephones to be installed and the type of equipment to be purchased or rented. Operating costs are dependent upon the amount of supplies used, the amount of computer time used (on most computer systems), and the telephone usage costs. This last factor is dependent on the distance between the terminal being used and the computer system to which it is connected. The adoption of something new in education always carries with it a certain apprehension by those who will use it because of their lack of understanding of how the innovation will benefit the teaching process.

During 1973 a combined summer and in-service institute focusing on computers and computer applications for science teachers was supported by the National Science Foundation for secondary science teachers from member schools of the Macomb Intermediate School District, Mount Clemens, Michigan. It was the goal of the institute to familiarize science teachers with computers and computer materials available to them in an effort to encourage them to increased usage of the computer in the classroom.

Statement of the Problem

It was the goal of this research to identify factors that significantly influenced the extent of classroom computer usage by secondary science teachers who attended the 1973 National Science Foundation Institute dealing with computers and computer applications.

Questions to be Answered

Each of the following questions will be answered in an attempt to identify which factors and to what extent these factors facilitate secondary science teachers in the implementation of computer usage in their instruction. Questions that were related to similar areas were grouped into one of four categories: (1) cognitive and affective characteristics of the teachers involved, (2) personal information concerning each teacher, (3) availability of equipment and programs to each teacher for instructional usage, and (4) effectiveness of the in-service instruction.

Cognitive and Affective Characteristics:

1. Does the level of knowledge of a programming language influence the extent to which a science teacher uses the computer as an instructional tool?

2. Does the level of knowledge of computer hardware and the computer system being used influence the extent to which a science teacher uses the computer as an instructional tool?

3. Does the attitude of a science teacher toward computer usage influence the extent to which he uses the computer as an instructional tool?

Personnel Information:

1. Does the amount of previous science teaching experience influence the extent to which a science teacher uses the computer as an instructional tool?

2. Does the level of science background of a science teacher influence the extent to which he uses the computer as an instructional tool?

3. Does the level of mathematics background of a science teacher influence the extent to which he uses the computer as an instructional tool?

4. Does a science teacher at the junior high level use the computer to a greater extent than a science teacher at the senior high level?

5. Does the particular science area taught (biology, chemistry, physics, earth science, or science) influence the extent to which a science teacher uses the computer as an instructional tool?

Availability of Equipment and Programs:

1. Does the availability of computer terminals to a particular science teacher influence the extent to which he uses the computer as an instructional tool?

Effectiveness of the In-Service Instruction:

1. Did the Macomb In-Service program produce a significant increase in the participants' knowledge of the BASIC programming language?

2. Did the Macomb In-Service program produce a significant increase in the participants' knowledge of the computer system being used?

3. Did the Macomb In-Service program produce a significant favorable change in the participants' attitude toward the use of the computer as an instructional tool?

In order to answer the above questions a measurement of computer use was obtained. There are presently two ways that the individual science teacher can use the computer in the classroom: one is by using "stored" central library programs, and the other is by using programs created by the user, but not stored in the central library. The amount of computer use was obtained by measuring (1) the number of computer programs used, and (2) the frequency of use of both their own programs and central library programs.

A measurement for computer usage could have been obtained by recording the time that each user had been on the computer system. This method was not used because it would not yield a reliable estimate of use. Individuals work at different rates; typing speed is an example of a variable that influences the amount of time it takes a user to communicate with the system. The fact that individuals did use programs for instructional purposes was considered to be more important than the efficiency of that use.

Significance of the Study

If certain factors are identifiable with increased computer usage by teachers exhibiting those characteristics, such a determination could have important implications for education in computer use. Curriculum leaders would be able to better evaluate needs and plan more realistic workshops, institutes, and conferences for the purpose of assisting the in-service teacher in understanding how to use the computer as an aid to classroom instruction. Emphasis could be shifted in pre-service teacher education programs to include the development of programs that would give the college graduate more of the competencies necessary for the implementation of computer-assisted-instruction.

Limitations to the Study

1. This study was limited to those secondary science teachers who were selected as participants in the 1973 National Science Foundation Institute sponsored by Wayne State University dealing with computers and computer applications in science teaching.

2. Only Macomb County schools were represented at the Institute. The reason for that selection criteria was that the Institute was a cooperative project between Wayne State University, Detroit, Michigan, and the Macomb Intermediate School District, Mount Clemens, Michigan, expressly for Macomb County teachers.

3. Several school districts in Macomb County do not have computer terminals for instructional use. Eighteen of the twenty-one school districts have terminals available for instructional use in their secondary schools. Participants who attended the institute, but who do not have access to computer terminals for instructional usage, have been eliminated from the study.

4. The study was conducted during the summer and fall of 1973, and involved eleven biology, eight chemistry, two physics, fourteen general science, and two earth science teachers. In order to permit inferential statistics to be applied in answering research questions sample sizes must be sufficiently large. Data concerning several questions in this study were viewed from a descriptive point of view due to the insufficient number of participants involved in certain areas.

5. Other limitations were set by the biases of the participants in the study, the nature and content of the instruments, and by the amount and type of support given to the individual teachers within their own schools.

Theoretical Framework

Computers and computer systems are available for school use either through rental contracts with private companies or through the purchase of computer systems by the school systems. However, having computers and computer terminals available does not guarantee their use for classroom instruction. The production of new computer equipment and software is not the complete solution for how to increase computer usage by people involved with the education of today's youth. In fact, it is reported that computer technology is at least five years ahead of its usage.[1] The continued emphasis on computer hardware development along with the decrease in federal funding for in-service educational training of teachers indicate that new vehicles for the dissemination of computer information are needed. It appears evident that teachers must be prepared in the areas of computers and computer applications for the classroom teacher before they can be expected to implement computer assisted instruction in their classroom. This training will have to come from educational institutions and must be an integral part of programs for pre-service and in-service teacher education. Research is needed to determine what should be included in such programs to promote effective computer usage in science instruction.

Assumptions

1. Each teacher included in the study had a know-

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[1]Walter Goodman and Thomas Gould, New York Conference on Instructional Uses of the Computer: Final Report, (New York State Education Department, 1968).

ledge of the BASIC programming language sufficient to write and/or interpret computer programs for instructional use. In addition he also had an awareness of the number and type of existing computer programs available to him by the computer system being used.

2. Each teacher had the necessary computer facilities available in his school to implement computer assisted instruction in his science classes.

3. The amount of computer usage by each teacher was directly proportional to the number of computer programs used and the frequency of use of such programs.

4. The data obtained from teachers concerning computer use were reliable measurements of computer use by the teachers.

Definitions of Terms

Computer-oriented terminology:

computer . . . . . "an electronic machine which is able to perform arithmetic and logical operations in sequence and in accordance with pre-programmed instructions"

hardware . . . . . "the computer and auxiliary equipment used to process data"

simulation . . . . "use of the computer to produce artificial but realistic-appearing data or problems" software . . . . . "programs and instructions which direct the computer how to solve problems and control the operation of input and output devices"

stored program . . "program whose instructions are stored within memory locations of the computer, and available for execution"

time-sharing . . . "a computer system in which several users may be on-line with the system at the same time -- each user can be working on a separate task from a separate terminal"[1]

Others:

attitude . . . . . the tendency of the participants to act in a certain way when presented with situations involving computer usage in secondary school instruction as measured by an attitude questionnaire

background . . . . the number of semester hours of college coursework completed in appropriate subject areas as obtained from the National Science Foundation participant information sheets (both mathematics and science backgrounds were considered)

CAI . . . . (Computer Assisted Instruction) "any of a wide range of educa-

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[1]M. Clemens Johnson, Educational Uses of the Computer, (Chicago: Rand McNally, 1971).

tional techniques that rely on a computer to assist in the presentation of learning material"[1]

computer usage . .	the use of central library and individual programs by a secondary science teacher for instructional purposes - the extent of computer usage was determined by the number of programs used and frequency of use as reported by participants during the fall institute
knowledge	the recall and understanding of factual materials concerning both the BASIC programming language and the computer system used as measured by achievement tests
experience	the number of years that a science teacher has been teaching as obtained from the National Science Foundation information sheets

[1]Joseph Margolin and Marion Misch, Editors, Computers in the Classroom, (New York: Spartan Books, 1970), p. 63.

CHAPTER II

REVIEW OF THE LITERATURE

Introduction

It is the intent of this chapter to review the recent literature concerning computer usage in education today. The use of computers, rather than their existence, will be the focal point considered in this chapter. Computer facilities make possible instructional changes that are far reaching in their effects; however, these changes depend upon the manner of use of such facilities.[1] "No matter how complicated a computer may be, its value rests in the hands of those who operate it."[2] Computers are inanimate objects that perform only to the extent that they are made to perform, thus the comment "the computer did that" indicates that the computer was programmed to

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[1]Robert M. Gagne, "Educational Technology as Technique," Educational Technology Review Series: Introduction to Educational Technology, Vol. 5, (Englewood Cliffs: Educational Technology Publications, 1971).

[2]Vincent S. Darnowski, Computers - Theory and Use, (Washington: National Science Teachers Association, 1964), p. 92.

do a given operation. Computer usage is controlled by the people who program computers and they are responsible for the results derived from using computers.[1]

The utilization of computers occurs in many diverse areas of our society. A recent issue of the magazine Data Processor, published by the International Business Machines Corporation, contained references to computer implementation in the following areas: operation of hospitals, library film management, government educational programs, operation of power plants, food sales and distribution, movement of logs on rivers, training of gasoline sales managers, and usage in the daily operations of insurance, investment, and manufacturing companies.[2] These examples have been cited for two reasons: 1) to illustrate the necessity for restricting this study to computer usage in education, and 2) to emphasize the need for educators to realize that computers are an integral part of our present day world.

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[1]Paul T. Smith, How to Live with Your Computer, (Scranton, Pa.: American Management Association, 1965), p. 24.

[2]Cynthia A. Carlin, ed., Data Processor, (White Plains, New York: International Business Machines Corporation), Vol. XVI, No. 3, July, 1973.

The remainder of this chapter will be divided into three sections, each reviewing a different, but related facet of computer usage in secondary school instruction. These areas are: Adoption/Implementation of Computer-Assisted-Instruction (CAI), Examples of CAI in Science, and Developments/Trends in CAI.

Adoption/Implementation of CAI

Educational establishments are not as advanced as industry and business in adopting new, more effective methods of applying computer technology to their needs. Many factors affect the acceptance, implementation, and development of CAI for classroom use. Two important factors are the opinions held about CAI by school personnel and the cost of obtaining and operating an instructional-based computer system.

The positive attitude of school administrators concerning CAI is critical since it is generally this group of educators that will decide if their school organization will incorporate CAI into their school program. Results of a national poll in 1968 indicated 70% of the school administrators polled felt that CAI would improve their educational program and that 28% had already considered implementing CAI.[1] A state-wide survey in 1972 revealed that 33% of all Illinois schools used computers in some way. Ninety-five percent of those schools using computers used them for administrative purposes; 59% also used them for instruction assistance.[2] Perhaps the major reason for the increase in computer usage in schools is that the administrators have realized that most of the paper-work involved in running a school can now be done with the assistance of computers. In nearly all instances school systems use computers for administrative purposes before incorporating them into their instructional programs. Only 5% of the schools reported in the Illinois survey used computers solely for instructional activities.[3]

The problems related to implementing CAI into various curriculum areas fall into five main categories:

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[1]L.C. Hickman, "Opinion Poll on CAI," Nation's Schools, Vol. 82, No. 4 (October, 1968), pp. 66-67.

[2]Eleanore L. Rudolph, "A Survey of Data Processing and Computer Use in Instruction in Illinois Secondary Schools," (unpublished doctoral dissertation, Northern Illinois University, 1972) as taken from Dissertation Abstracts International, Vol. 33-A, (Ann Arbor: Xerox University Microfilms, 1972), p. 505A.

[3]Ibid.

purchasing delays, cost factors, technical factors, public relations, and future administrative responsibilities.[1] Realistic planning should include anticipating delays in obtaining hardware from manufacturers and in developing and validating software. The cost of hardware is probably given more consideration than that of software, program development, or personnel. The major costs to schools implementing CAI are terminals and the accompanying acoustical couplers, which are the primary computer hardware devices used at time-sharing sites. The important cost figure that needs to be considered by CAI users is the cost per student per terminal hour. This figure is approximately $4.00 per student per terminal hour.[2] This figure is significant because as the total number of CAI users increases, so does the total cost, but the cost per student per terminal hour decreases.

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[1]Donald Reynolds, "Computer-Assisted Instruction: Problems and Potentials" (paper), (Fort Worth, Texas: Instructional Systems Institute; Texas Christian University, October, 1967).

[2]Jack G. Nelson, "A Model of Cost Estimation for Establishing Computer Assisted Instruction in Public School Districts," (unpublished doctoral dissertation, University of Iowa, 1971) as taken from Dissertation Abstracts International, Vol. 32-A, (Ann Arbor: Xerox University Microfilms, 1971), p. 2362A.

Dr. Fixel states that school systems should incorporate in time-sharing ventures, even though they are great distances from computer centers, rather than purchasing their own computer systems.[1] The reasons for this not only include initial costs and maintenance, but also with the accelerating rate of technological advancements in computer design, consideration must be given to the fact that newer systems are being developed that can do more at a faster rate and cost less than systems presently in use. The cost of time-sharing has steadily decreased due to new computer hardware capabilities and competition in the time-sharing market.[2] Costs can also be lowered by the method in which time-sharing is used. It has been recommended that all terminals be located in an easily accessible area for use after school, in addition to

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[1]Arthur R. Fixel, "Computer Time-Sharing in Educational Administration: An Electronic Package for Florida School Districts," (unpublished doctoral dissertation, Florida State University, 1972) as taken from Dissertation Abstracts International, Vol. 33-A, (Ann Arbor: Xerox University Microfilms, 1972), p. 522-A.

[2]Walter F. Bauer and Richard H. Hill, "Economics of Time-Shared Computing Systems (Part II)," Datamation, (December, 1967), pp. 41-49.

during the school day, to reduce the overall cost of CAI.[1]

School personnel must be informed of what the computer can and cannot do. Public relations campaigns are needed to overcome myths about computer usage. Examples of such myths include: that computers will replace teachers, that computers are merely calculators and as such belong only in the area of mathematics, and that computers are cold, impersonal devices that have no place in the education of children.[2]

Finally, the implementation of CAI also includes an administrative commitment to it that will influence future program decisions.[3] Criteria for the selection of new staff and the adoption of new texts and programs are two areas that would be influenced by a school's commitment to CAI.

Examples of CAI in Science Education

The type of instructional logic used in the computer

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[1]Cornelius F. Butler, "CAI in New York City: Report on the First Year's Operations," Educational Technology, Vol. IX, No. 10 (October, 1969), pp. 85-86.

[2]Reynolds, "Computer-Assisted Instruction: Problems and Potentials."

[3]Ibid.

programs was the criteria for grouping the illustrations included in this chapter. This was done in order to cite examples of computer usage in the teaching of secondary school science. Other methods of grouping could have been subject matter, central processor, programming language, or source of program(s). The most complete classification of computer programs by subject matter is Lekan's Index to Computer Assisted Instruction.[1] In it some 1,000 classroom-oriented computer programs are classified into one of more than fifty subject areas. Each subject area is reviewed with sufficient detail so that classroom teachers can decide if the programs are suitable for local needs and also be able to obtain many of them via this source.

The type of instructional logic employed in a computer program follows specific models and determines the way in which that program should be used. Classification by instructional logic can be done using any of the following as the criteria for grouping: adaptive, dialogue, drill and practice, gaming, inquiry, investigation, problem

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[1]Helen A. Lekan, ed., Index to Computer Assisted Instruction, (Boston: Sterling Institute, 1970).

solving, simulation, testing, or tutorial. Since many computer programs are classified in several of the above categories and because science related computer programs tend to fall in certain divisions, the following groupings were used: tutorial, drill and practice, and simulation.

CAI: Tutorial Applications

One of the trends in science education today is the movement toward individualized instruction. Many computer programs have been written that use the computer as a tutor, thus serving individual student needs. Dr. Atkinson describes tutorial programs as those having the capability for real-time decision making and instructional branching contingent on a single response or some subset of the student's response history.[1] In order for teachers to write such computer programs not only is a sophisticated knowledge of a computer programming language required, but the ideas and principles of programmed instruction should be followed. Dr. Atkinson concludes that of

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[1]Richard C. Atkinson, Computerized Instruction and the Learning Process, Address at meeting of the American Psychological Association, Washington, D.C., September, 1967; (Technical report no. 22, September 15, 1967, Institute for Mathematical Studies in the Social Sciences, Stanford University, Stanford, California).

all the factors affecting the growth of CAI, perhaps the most important is the development of programmed instruction.[1] Tutorial computer programs should be designed to include the following characteristics:

1. Students are able to identify their area of difficulty and request assistance from the computer in that area.

2. Answers are immediately followed by an indication of accuracy.

3. Incorrect answers are followed by the explanation of the concepts involved.

4. The least amount of repetition is used.[2]

It should be emphasized that tutorial type CAI, like other uses of CAI, should supplement the regular classroom instruction of science, not replace it. An unpublished doctoral dissertation at the University of Maryland supports this position in reporting that students receiving only tutorial type CAI in high school chemistry did not achieve as well as did those receiving regular

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[1]Richard C. Atkinson, and H.A. Wilson, Computer Assisted Instruction, (New York: Academic Press, 1969), pp. 3, 6.

[2]A.F. Vierling, J.F. Kropt, and J.D. Nixon, An Experiment in Physics Tutorial by Computer, Interim Report, U.S. Naval Academy, Department of Physics and Academic Computer Center, January 26, 1968.

classroom instruction.[1] However, the groups receiving the CAI were able to complete the units in one-third to one-half the time required by the control groups. The suggestion was given by Summerlin that short tutorial type CAI programs be used to complement regular classroom instruction, specifically for the slow and the advanced student.

CAI: Drill and Practice Applications

"The advantages of computers over calculators lie in their ability to replicate calculations rapidly whenever new or additional data are available. . . ."[2] This capability has enabled computer users in all instructional areas, particularly mathematics, to do problem solving with minimal programming sophistication. Not only can computers be used to solve problems once they are programmed, it is also possible to program them to develop the problems as they are presented.

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[1]Lee R. Summerlin, "A Feasibility Study of Tutorial Type Computer Assisted Instruction in Selected Topics in High School Chemistry," (unpublished doctoral dissertation, University of Maryland, 1971), pp. 130-134.

[2]Rudy P. Elmer, "Computers," Science Teacher, Vol. 36, No. 8 (November, 1969), p. 69.

If a student is continually presented problems of a certain type until a pre-determined level of achievement is obtained, such usage is called drill and practice. Jerman states that there are two general types of drill and practice computer programs. "One is a further modification of the concept unit program, which permits a student to branch from one unit to another in the same concept area at a higher or lower grade level. The second is one in which the curriculum is organized in a concept-strand method. A strand is a series of problems of the same operation type."[1]

Many of the large scale drill and practice programs have been aimed at the elementary school level in subjects such as mathematics, spelling, and reading. Suppes reported in 1968 on the progress of federally-funded elementary school CAI projects.[2] Most projects began as drill and practice programs or evolved into drill and practice

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[1]Max Jerman, "Promising Developments in Computer Assisted Instruction," Educational Technology Review Series: The Computer and Education, (Englewood Cliffs: Educational Technology Publications, 1971).

[2]Patrick Suppes, "How Far Have We Come? What's Just Ahead?", Nation's Schools, Vol. 82, No. 4 (October, 1968), pp. 52-53.

applications, and it is Suppes' prediction that drill and practice will be the major instructional mode of CAI in the elementary schools for at least the next five years. The Stanford-Brentwood project is an example in which a tutorial system was disregarded because of cost and sophistication for a drill and practice system using only teletypes.[1] Drill and practice CAI can generally be accomplished with less software and hardware than other CAI modes of instruction. Classroom teachers can be instructed to develop CAI drill and practice materials as was the case during the INDICOM Project.[2] INDICOM (Individual Communications System) was a multi-year CAI project in the Waterford School District (Pontiac, Michigan) and was the first major public school CAI project in the midwest.

It is not possible to obtain from publishers complete curriculum guides that have been developed solely

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[1]Jenness Keene, "Brentwood Revisited: CAI's Two-Year Trail," Nation's Schools, Vol. 82, No. 4 (October, 1968), pp. 57-61.

[2]INDICOM (Individual Communications System), Final Report for the Period August 1, 1967 through November 30, 1970, as taken from Entelek CAI Research Abstracts, Card No. 71-1097/44, (Newburyport, Mass.: Entelek Incorporated, 1971).

for drill and practice.[1] Not only has very little been written concerning CAI drill and practice at the secondary level, but even less is available in the area of secondary school science. Perhaps this is because most science applications fall into CAI problem solving or simulation. Very little has been written concerning problem solving; however, simulation is the mode of instruction which holds the greatest potential for development in the immediate future.

CAI: Simulations

Any learning situation which can be described by a mathematical model can be simulated. Thus, many science laboratory activities are suitable for computer simulation.[2] A simulation creates a situation in which participants apply their knowledge and skills, and obtain immediate feedback on the appropriateness of their behavior.[3]

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[1] 2000C/2000F Mathematics Drill and Practice: Curriculum Guide, (Cupertino, California: Hewlett-Packard Company, 1972).

[2] John M. Boblick, "The Use of Computer Simulations in the Teaching of High School Physics," Science Education, Vol. 54, No. 1 (1970), pp. 77-81.

[3] Scott B. Parry, "The Name of the Game . . . is Simulation," Training and Development Journal, (February, 1971), p. 5.

"Computer simulations provide learning experiences which might not be available to students because of factors such as safety, equipment cost or availability, prohibitive set-up time, or other factors of cost or convenience."[1] It should be emphasized that teachers should not use computer simulation programs to replace regular science laboratory activities for which they have the materials, time, and methodology. Nevertheless, when employed, computer simulations in science can generate data in a range where only extrapolation can be used under normal circumstances.

The number of CAI science-oriented simulation programs is large and increasing at an accelerating rate. The ENTELEK CAI Research Abstracts contains many cards describing examples of computer simulations in science instruction, not only in the United States, but in other countries as well. England, France, and Germany have reported many instructional uses of computers, including the area of science simulations.[2] Federally funded

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[1]John M. Boblick, "The Use of Computer Simulations in the Teaching of High School Physics," p. 79.

[2]CAI Research Abstracts, Vols. 36-44, (Newburyport, Mass.: Entelek Corporation, 1968-1973).

projects have been responsible for numerous simulation programs that are now available for science instruction. An example of these programs is the Huntington Project which developed computer simulations in science and other instructional areas using writing teams of scientists and educators.[1] During the 1973 National Science Foundation project in Computers and Computer Applications for Secondary Science Teachers of Macomb County, Michigan, approximately one-fourth of the participants developed programs that would be classified as science simulations.

Two recent doctoral dissertations at different universities were concerned with computer simulated experiments in high school science instruction. Under very similar conditions, both James E. Jones at Iowa State University[2] and Vincent N. Lunetta[3] at the University of

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[1]Ludwig Braun, Digital Simulation in Education, Final Report presented to the National Science Foundation, Polytechnic Institute of Brooklyn, November, 1971, p. 9.

[2]James Edward Jones, Ph.D., "Computer-Simulated Experiments in High School Physics and Chemistry," (unpublished doctoral dissertation, Iowa State University, 1972), pp. 86-92.

[3]Vincent Normal Lunetta, Ph.D., "The Design and Evaluation of a Series of Computer Simulated Experiments for Use in High School Physics," (unpublished doctoral dissertation, University of Connecticut, 1972), pp. 115-117.

Connecticut reported no significant differences in achievement when comparing groups receiving only CAI simulation-type materials and groups using the conventional materials. However, the groups working with the CAI materials did complete their work in less than one-half the time that the control groups required. These studies emphasized the need to incorporate CAI materials into science lessons whenever appropriate, to facilitate and enhance the learning environment for both students and teachers.

Developments/Trends in CAI

In this section current developments and trends in two areas, technological innovations affecting CAI and in-service and pre-service education in the use of CAI, will be reviewed. Both of these topics will have a major impact on the future of CAI. Reports of research in these areas are few and tend to be limited to nationally funded CAI projects.

Technological Innovations Affecting CAI

New technology can facilitate the implementation of CAI in secondary schools by producing any or all of the following: faster central processors for computers, smaller computers that are less expensive, terminals that involve several modes of input-output, and peripheral equipment to make various computer systems compatible. Both the quantity and the quality of service to time-share users can be improved by having faster central processors. The mini-computer market has greatly increased because the smaller computers can often do what a user requires and they cost only a fraction of what a large computer system would cost.

The various types of computer terminals in use today offer capabilities not imagined several years ago. Most terminals are still connected to a computer via acoustical couplers which use standard telephones as the transmission device. Terminals display visual and/or audio output and generate the visual output through any of the following: standard paper, heat sensitive paper, a cathode-ray tube, or via television screen. Cathode-ray tube (CRT) terminals have been designed that not only display output on a television-like screen, but also accept input via the screen. Either physical contact or a beam of light can be used to trigger a certain section of the screen which is then converted to an electrical signal and sent to the computer.[1]

The national distribution of software would be greatly enhanced if all computer systems were compatible. Many programs which have been designed to run on one computer system can not run on another because of different hardware configurations. For example, additional computer hardware is needed to make an IBM computer system compatible with a CDC computer system.

The establishment of computer networks is an attempt to share computer resources by more than one computer center. Michigan State University, Wayne State University, and the University of Michigan have established a computer network called MERIT.[2] Through MERIT, any person with the appropriate computer account number can gain access to any of the three above mentioned university computers. In this way it is not necessary for each university to duplicate software that can be obtained on

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[1]James G. Holland and Judith Doran, "Teaching Classification by Computer," Educational Technology, Vol. 12, No. 12 (December, 1972), pp. 58-60.

[2]Harry Eick, Seymour Wolfson, and Karl Zinn, Facilities and Resources Available Via the MERIT Host Computing Centers, Publication No. MCN-0573-GE-14, (Detroit, Michigan: Merit Computer Network, Wayne State University), May, 1973.

one of the other MERIT participating systems.

Another technique of circumventing the various systems compatibility problem is to design a CAI language that could be used on most major computer systems. "From a computing point of view most CAI language development has been extremely machine dependent . . . ."[1] A machine dependent language in which many CAI programs have been written is Coursewriter, which was designed specifically for the IBM 1500 series computers. Examples of high level CAI languages which are not machine dependent are BASIC (Basic All-purpose Symbolic Instruction Code) and APL (A Programming Language). In view of the fact that increasing numbers of CAI authors are choosing APL for authoring CAI programs, and because of APL's increasing availability, a new CAI meta-language could most advantageously be implemented by using APL as its basis.[2]

Several national projects have been funded whose aim has been the development of new technology for use

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[1]Robert E. Schaulis, "The Rise and Fall of CAI Languages," AEDS Monitor, (June, 1973), p. 9.

[2]Peter Braun, "Reflections on CAI Language Design," Address given at the Association of Educational Data Systems Annual Convention, New Orleans, Louisiana, April 19, 1973.

in CAI. The two largest ongoing projects are the PLATO (Programmed Logic for Automatic Teaching Operations) and the TICCIT (Time-shared Interactive Computer-Controlled Information Television) projects.[1]

TICCIT revolves around the use of small decentralized computers with self-contained hardware and software appropriate for the particular school situation. Students interact with the TICCIT system via color television-type terminals. The individual classroom teacher has little opportunity to alter the TICCIT programs which are programmed to manage the instruction depending on the progress and desires of the individual student. TICCIT is still in the formulative planning stages and is due to be tested in 1974.[2]

PLATO has been an on-going project for over ten years and has evolved through several stages. Currently PLATO III is the large centralized computer system that serves over 4,000 terminals in the state of Illinois. Interactive plasma display-type terminals have been

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[1]Allen L. Hammond, "Computer-Assisted-Instruction: Two Major Demonstrations," Science, Vol. 176, No. 4039 (June 9, 1972), pp. 1110-1112.

[2]*Ibid.*

designed through PLATO that enable students from the primary through the university levels to respond to computer generated questions by either typing the correct choice, or by pointing a light beam at the appropriate answer being displayed on the screen.[1] The design of PLATO IV envisions a computer-based system which could reduce the total cost per student-contact hour to $.15 at the PLATO site and $.35 at other CAI locations where terminal rentals and communication line costs are included.[2] PLATO also has the capacity to allow individual teachers to design their own course materials which would then be presented through the PLATO CAI lessons. Major projects such as PLATO and TICCIT have produced hardware and software that are now being incorporated in other CAI installations across the country.

In-Service and Pre-Service Training in the Use of CAI

The need for preparing teachers in the use of

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[1] *Ibid.*

[2] Donald L. Bitzer, "A Large-Scale Facility for University Instruction," *Interface*, Vol. 4, No. 4 (August, 1970), as taken from *Entelek CAI Research Abstracts*, Card No. 70-1092/38, (Newburyport, Mass.: Entelek Incorporated, 1971).

CAI is becoming a major concern in regions where computer services are becoming available to classroom teachers. Teachers in these areas find themselves having access to facilities that they do not know how to use. Students are proceeding from courses in their schooling where they have been exposed to CAI to new levels where the instructional staff do not use or know how to use CAI to complement their instruction, even though it is available to them.

The request for programs to satisfy this need for in-service and pre-service training in the use of CAI is being voiced at all educational levels. A classroom teacher recently wrote, "Teacher training institutions should provide courses which will insure that future science teachers have adequate understanding of computer applications."[1] A national committee on the use of computers in education also recommended "that the National Science Foundation provide financial support for the development of a variety of programs for the

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[1]Vincent N. Lunetta and Oduard E. Dyrli, "Computers in the Science Curriculum--Some Concrete Applications in the Physical Sciences," Science Education, Vol. 54, No. 2 (April-June, 1970), p. 153.

training of teachers and of teachers of teachers of high school courses involving computers."[1] It is interesting to note the part of this statement that concerns "teachers of teachers:" if college personnel are to conduct courses to train secondary teachers in the use of CAI, they must first obtain the experiences and training necessary to teach such courses. There is a definite shortage of faculty qualified to teach such courses. There are many qualified staff members who can teach general computer programming and computer science, but the number who are familiar with the application of CAI to specific disciplines is relatively small. A doctoral dissertation at the University of Wyoming stated that the following components, listed in order of importance, should be included in computer science courses for educators:

1. Hands-on Experience
2. Computer Applications for Educators
3. Knowledge of Computer Hardware
4. Mechanics of Computer Use

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[1]"Recommendations Regarding Computers in High School Education," Conference Board of the Mathematical Sciences--Committee on Computer Education, Washington, D.C., April, 1972, (prepared with the support of the National Science Foundation.

5. Knowledge of Computer Software[1]

However, knowledge of a programming language sufficient to write instructional programs would seem to be more important than knowing about the computer hardware.

Colleges and universities have begun to offer courses and programs to fulfill the needs stated above. Very few colleges have implemented complete CAI packages because the cost is presently prohibitive and it is too great a deviation from tradition. A survey in the state of Colorado revealed that CAI can be economically justified in institutions of higher education only if the demand for CAI instructional time is extremely large.[2]

The Illinois State University at Normal, Illinois has implemented a computer based learning program where approximately 2000 prospective secondary school teachers are providing themselves with a pre-service education via a self-paced, competency-based teacher education

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[1]James L. Mikesell, "Aspects of Computer Science that Would Provide Valid Curricula in Computer Science for Educators," (unpublished doctoral dissertation, University of Wyoming, 1971).

[2]Robert M. Lynch, "A Cost Effectiveness Analysis of Computer Assisted Instruction," (unpublished doctoral dissertation, University of Northern Colorado, 1971).

program.[1] The program, known as the Professional Sequence, is one of the largest operational programs of its kind in the country, and the fact that it is operational and is enabling nearly 2000 undergraduates to learn at rates commensurate with their individual abilities is due in a large way to the extensive utilization of computers.

However, the above illustration is not typical, nor should it be. The use of a computer in the instruction of students, regardless of the level, should be optional. An ideal situation is one in which both teachers and students know how to use the computer to assist instruction if they have the need.

Title III of the Elementary and Secondary Education Act helped interested school systems in obtaining facilities and equipment for CAI, while other federal funding, such as the National Science Foundation Summer Institute Program, has assisted colleges in establishing courses and programs for training of teachers in the use of CAI. Between 1960 and 1967 the United States Office

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[1]Michael A. Lorber, "A Computer Helps 2000 Students Self-Pace Their Learning," Address given at the Association of Educational Data Systems Annual Convention, New Orleans, Louisiana, April 18, 1973.

of Education provided an estimated $13.3 million for over 100 research related projects dealing with educational uses of computers.[1] Most of these projects were funded through the Cooperative Research Act (amended by Title IV of the Elementary and Secondary Education Act, 1965) and others were funded through Title VII of the National Defense Education Act and Vocational Act of 1963.

Although the National Science Foundation's Office for Instructional Improvement and Implementation's budget has been reduced considerably, it continues to be responsible for the preparation of many secondary school teachers in ways to implement CAI in the regular classroom instruction. During 1973, when the National Science Foundation summer institute program was still in existence, approximately twenty-five summer institutes were funded that involved the use of computers and computing.[2]

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[1]Andrew R. Molnar, Kenneth J. Neubeck, and Eugene Percha, "Office of Education Support for Educational Uses of Computers," Mimeographed Publication, (Washington, D.C.: U.S. Office of Education, Bureau of Research), August 10, 1967.

[2]"Summer Institutes for Secondary School Teachers of Science, Mathematics, and Social Science," 1973 Directory, Publication No. E 72-P-11, (Washington, D.C.: National Science Foundation), December, 1972.

<u>Summary</u>

The intent of this chapter was to present a review of the major developments in the area of instructional uses of computers in today's schools. The findings were grouped into one of three classifications: adoption/implementation of CAI, examples of CAI in science education, and developments/trends in CAI.

The problems of implementation are many, but even before implementation, acceptance of CAI by school personnel, including administrators, must be obtained. Once computer services are available for instructional use in secondary science, consideration must be given to the reasons for usage, when to use the services, and the extent of such usage. The majority of computer usage in science classrooms deals with computer simulations of experimental situations and problem solving applications. The use of computers in the teaching of secondary science should assist or complement the instruction process, not replace it.

The growth of CAI and the type of CAI available in the future will depend upon many factors: new technology (computer equipment), new software, and the amount of training for users of CAI. Computer time-sharing has resulted in a greater movement of terminals into the classroom. Educational programs need to be established by colleges for the pre-service and in-service training of teachers in the use of CAI.

The goal of this research is to obtain information to facilitate the planning of new education programs for training CAI users.

CHAPTER III

METHODS AND MATERIALS UTILIZED IN THE STUDY

The methodology and materials utilized in identifying which factors significantly influence the extent of classroom computer usage by secondary science teachers who have previously received in-service instruction in the use of CAI are discussed in this chapter. The need, the source, and the method for obtaining and analyzing the necessary data and information are the major divisions of this chapter.

Data/Information Sought

Since the amount of computer usage is affected by many different variables, the information that was obtained from the participants in this study was categorized in the following four general areas:

1. Cognitive and affective characteristics of the teachers involved.

2. Personal data concerning the teacher.

3. Availability of computer equipment to the teacher.

4. Effectiveness of the in-service instruction.

The first three categories listed concerned the individual teacher, while the fourth category dealt with evaluating the teachers involved as a group. The first category included information about each teacher's level of knowledge of a programming language and of the computer system being utilized. It also included data concerning each teacher's attitude toward computer usage in the classroom. The second category contained information concerning the amount of teaching experience, the depth of science background, and the extent of mathematics background for each teacher. Information about secondary school employment level and science subject taught were included for each teacher. The third category consisted of information concerning terminal access. A measurement for terminal access was sought from data concerning the number of computer terminals available to each teacher and if each teacher had terminal capability in his classroom. The final category dealt with the effectiveness of the in-service instruction and incorporated data given in the first category which was obtained at both the beginning and the end of the in-service instruction.

A measurement of the amount of computer usage by each teacher included in the study was crucial in order to study the effect that selected factors have on such usage. It was necessary to obtain information about both the type and the number of computer programs used.

Source of Data/Information

Population Utilized

Forty-two secondary science teachers from member schools of the Macomb Intermediate School District, Mount Clemens, Michigan who were selected as participants in a combined summer and in-service institute comprise the population studied. The National Science Foundation sponsored the institute which concentrated on computers and computer applications for secondary school science teachers.

The major criteria used in the selection of the participants were the following: amount of teaching experience, interest in computer usage, amount of prior computer training, currently teaching science, geographic distribution, and leadership capability. The selection process resulted in participants from sixteen school districts and twenty-two buildings. Thirty-one men and eleven women were selected as participants.

The Macomb Intermediate School District serves as a county-wide district intermediate between the Department of Education of the State of Michigan and the local public school districts, as well as the parochial and private schools within the district. Currently there are twenty-one local public school districts representing 182,295 students, and thirty-two Catholic and Lutheran schools representing 11,295 students enrolled as members of the Macomb Intermediate School District. It acts as a coordinating agency for the local school and district interests with the State and Federal agencies and provides services which are common to all of the individual member districts on a more economical and efficient basis. These services include providing consultants in curriculum, developing exemplary and/or model programs for inclusion in the curriculum of the local schools, and training teachers through special programs.

The Macomb Intermediate School District has excellent computer facilities available to each of the twenty-six high schools in the twenty-one participating public school districts through the use of remote terminals. Seven of the local districts also have terminals in their junior high schools. As of September, 1973, 190-200 terminals were in use in the member schools. The Macomb Intermediate School District presently has three Hewlett-Packard computers for instructional use and is purchasing an additional system to supplement existing equipment. This hardware configuration will be capable of handling 128 ports simultaneously. The primary programming language on these systems is the BASIC language. Many instructional programs currently in the central library are available to users of this computer system. Included among these are the Hewlett-Packard contributed programs in mathematics, science, and statistics, and the Huntington One and Huntington Two Simulation Programs in mathematics, science, and social science. A recent report listed over 600 classroom-oriented public programs available to users of the Hewlett-Packard computers at the Macomb Intermediate School District building.

Experimental Setting

Computers and computer applications for science teachers were the main topics studied during a combined summer and in-service institute funded by the National Science Foundation for secondary school science teachers of Macomb County, Michigan. The primary purpose of the project was to develop an increased awareness of computer applications and to expand the use of computers in secondary school science instruction.

The project was planned with the continuous consultation between the Macomb Intermediate School District, school teachers from the target area, the coordinator of the Computer Science Department at Wayne State University, members of the Science Education Department at Wayne State University, and the Wayne State University Office of Grants and Contracts.

The planners deemed it necessary to divide the project into two phases. The first phase consisted of an intensive six-week institute during the summer of 1973 conducted jointly by the staffs of Wayne State University and the Macomb Intermediate School District. The second phase was an in-service institute timed to coincide with the 1973 fall quarter at Wayne State University. Responsibilities for instruction, consultation, and evaluation during this implementation stage were also shared between the two participating institutions. All formal meetings during both phases were held at the Macomb Intermediate School District Building.

Sample

Due to extenuating circumstances the sample utilized in this study did not include all members of the population described earlier in this chapter. Three teachers were eliminated from the study because their schools did not have terminals available for instructional use during the implementation period when data concerning computer usage for the study was obtained. One teacher unofficially withdrew from the institute at the end of the summer phase and another resigned his teaching position at the end of the third week of the fall semester. A total of five teachers from the population were not included as part of the sample studied.

The general characteristics of the sample were the same as those given earlier for the population. However, the final sample (N=37) studied had the following characteristics: 27.0% women, 73.0% men; 37.8%

junior high school science teachers, 62.2% senior high school science teachers. The science disciplines represented included: biology (11), chemistry (8), earth science (2), physics (2), and general science (14).

Methods Utilized in Data Collection

In this section the methodology utilized in collecting the data for each of the eleven independent variables (factors which may affect computer usage) and the dependent variable (amount of computer usage) will be discussed. The instrument selected, when it was used, what information was collected, and the type of data obtained will be discussed for each of the variables included in this study. Some of the data were used in the analyses of more than one hypothesis. The methodology used in testing each hypothesis and the hypothesis itself are included later in this chapter.

Independent Variables

Various means were used in obtaining the data from each teacher included in the sample for each of the eleven independent variables. Data were obtained from six types of instruments before the summer institute began, at the beginning and the end of the institute, and at the end of the fall in-service implementation period. The specific information that was collected for each variable will be discussed by variable. Table 1 gives a summary of the above information for each of the independent variables.

The first variable listed in table 1 is the knowledge of the BASIC programming language. In order to measure each subject's knowledge of the elementary components of the BASIC language, a test instrument was developed and used at the beginning and at the end of the summer institute. This instrument was developed because no standardized national examinations were available that were not either mathematics-oriented or keyed to a particular text and these tests were not appropriate for use during the institute. Several items on the examination instrument were re-written or eliminated following administration to both undergraduate and graduate students who were students in science education classes during the 1973 winter and spring quarters at Wayne State University. The final version used for this examination has been included as appendix A.

TABLE 1

SUMMARY OF (INDEPENDENT) VARIABLES, INSTRUMENTS, AND DATA

Variable Explanation	Instrument[a]	When Used[b]	What Collected[c]	Data Form[d] (Type)
1. Knowledge of the BASIC programming language	Exam1	Pre- & Post Institute	Test Score	Standardized Score (Interval)
2. Knowledge of computer hardware and the computer system being used	Exam2	Pre- & Post Institute	Test Score	Standardized Score (Interval)
3. Attitude toward computer usage as a supplement to instruction	Questionnaire	Pre- & Post Institute	Total Score	Real # > 0 (Ordinal)
4. Amount of teaching experience	N.S.F. Application	During Institute	# of years	1-2-3 (Nominal)
5. College science course work completed	N.S.F. Application	During Institute	# of hours	1-2-3 (Nominal)
6. College mathematics course work completed	N.S.F. Application	During Institute	# of hours	1-2-3 (Nominal)
7. Secondary school classification	N.S.F. Application	During Institute	S.H. or J.H.	0 or 1 (Nominal)

TABLE 1--Continued

Variable Explanation	Instrument[a]	When Used[b]	What Collected[c]	Data Form[d] (Type)
8. # of terminals available for the individual teachers' use	Feedback Form	End of Fall In-Service	Number of Terminals	Integer > 0 (Ratio)
9. Terminal capability in classroom	Feedback Form	End of Fall In-Service	Yes or No	0 or 1 (Nominal)
10. # of minutes of terminal time used during summer institute	Computer Print-out	Post Institute	Number of Minutes	Integer > 0 (Ratio)
11. Major science teaching responsibility	N.S.F. Application	During Institute	Bio., Ch., Earth Science, Ph., Science	1 - 5 (Nominal)

[a]The instrument utilized to obtain the data for the given variable.

[b]The approximate time that the data were collected.

[c]The specific data obtained from each subject involved in the study.

[d]The actual form of the data used in the analysis procedures and the type of data (nominal, ordinal, interval, or ratio).

The second variable listed in table 1 is the knowledge of the computer hardware and the computer system being used. The computer hardware involved in the experimental setting was an ASR-teletype model 33. The computer system used was a 2000-C Hewlett-Packard system. An instrument was developed to test minimal competencies necessary to use both the teletypes and the computer system via remote access. The instrument (Exam2) was administered at the beginning and the end of the summer institute. Computer science personnel from Wayne State University and the Macomb Intermediate School District reviewed the instrument prior to its use to check accuracy and completeness. A copy of this instrument has been included as appendix B.

In considering attitude toward computer usage as a variable, a measurement was taken of each teacher's meaning of the term "computer usage" at the beginning and the end of the summer institute. The behavior of a teacher in a particular situation depends upon what that situation means or signifies to him.[1] Since the function

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[1]Charles E. Osgood, George Suci, and Percy Tannenbaum, The Measurement of Meaning, (Urbana: University of Illinois Press, 1957), p. 1.

of language is to communicate meaning, a semantic-oriented instrument was developed in order to measure each teacher's attitude toward computer usage.

This instrument, a semantic differential evaluation form, provided each subject with a concept to be differentiated and a set of bipolar adjectival scales against which to do it.[1] The three concepts presented were computer usage in society, computer usage in education, and computer usage in the classroom. Nine sets of bipolar adjectives were used for each concept, of which three were directed at an evaluation of the concept, three at measuring the potency of the concept, and three at determining the activity associated with the concept. The selection of adjective pairs was made from Osgood's Measurement of Meaning,[2] a book devoted entirely to the use of the semantic differential technique for attitude measurement. The order of placement on the page was randomly decided and several pairs were reversed in order to improve instrument reliability. The instrument was administered to both undergraduate and graduate students in science

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[1] Ibid., p. 20.

[2] Ibid., pp. 50-64.

education classes during the 1973 winter and spring quarters at Wayne State University for the purpose of evaluating its usefulness. The instrument used for this study has been included as appendix C.

Data concerning five of the independent variables listed in table 1 were obtained from the National Science Foundation summer institute application forms. Each teacher who attended the institute was accepted on the basis of information obtained from their applications. The variables for which data were obtained in this manner include: teaching experience (measured in years), college science course work completed (measured in semester hours), college mathematics course work completed (measured in semester hours), secondary school classification (junior high or senior high), and science teaching responsibility (biology, chemistry, earth science, physics, or general science).

Data concerning two of the independent variables were not obtained until the end of the fall in-service institute. Two different measurements were used to determine terminal availability: terminal access in the classroom (yes or no) and the number of terminals available for teacher and/or student use. Data for each of these variables were obtained from a feedback form designed to get a measurement for terminal availability and the amount of computer usage.

The final independent variable for which data were obtained was the amount of computer terminal time used by each subject during the summer institute. This data was obtained directly from the computer system on the last day of the summer institute. Each participant in the institute had been given a computer sign-on ID and password enabling the above information to be obtained.

Dependent Variables

In order to study the effect that various factors had on the amount of computer usage by those secondary school science teachers who received in-service instruction in CAI during the institute, it was necessary to obtain data about the amount of computer usage. Two variables were considered in obtaining measurements for the amount of computer usage. A summary of what they consisted of is given in table 2 on the following page. Both the number of computer programs used and the

TABLE 2

SUMMARY OF DEPENDENT VARIABLES, INSTRUMENTS, AND DATA

Variable Explanation	Instrument[a]	When Used[b]	What Collected[c]	Data Form[d] (Type)
1. # of computer programs used for instructional purposes during the implementation period	Feedback Form	Bi-monthly during Fall In-Service	# of programs used	Integer ≥ 0 (Ratio)
2. # of times computer programs were 'run' during the implementation period	Feedback Form	During Fall In-Service	# of program 'runs'	Integer ≥ 0 (Ratio)

[a]The instrument utilized to obtain the data for the given variable.

[b]The approximate time that the data were collected.

[c]The specific data obtained from each subject involved in the study.

[d]The actual form of the data used in the analysis procedures and the type of data (nominal, ordinal, interval, or ratio).

frequency of use of computer programs by each subject were obtained for the first nine consecutive weeks of the school year. The time period was approximately one-fourth of the school year for most of the schools involved. Each teacher was asked to maintain a daily log of computer usage recording both the number of computer programs used and the number of times computer programs were used.

A copy of the daily log form used to obtain this data has been included as appendix D. Any computer usage by the teacher or for the teacher by students who were doing regular classroom assignments was counted as instructional use of the computer. The various ways that the computer could have been used have been listed in chapters 1 and 2. If one computer program was used by each of thirty students during a class period, it was counted as one program used and thirty "runs" of the program.

Methods Used in Analyzing Data/Information

As the data was collected it was organized in a manner to allow for statistical tests of null hypotheses in order to make decisions about the acceptability of research hypotheses. Included below are each of the null hypotheses followed by a brief statement of how that hypothesis will be tested.

Null Hypothesis 1
programming knowledge versus computer usage

> There is no relationship between the level of knowledge of a programming language and the frequency of use of computer programs.

Based upon achievement as measured by the post-test on the BASIC programming language two groups were formed (high achievers - low achievers). Means were obtained for the total number of computer programs that were "run" during the nine week implementation period, including both central library and individually developed programs. A t-test was done to determine if there were significant differences between the means (computer usage during implementation period) of the two groups. A copy of the instrument used to assess individual programming achievement using the BASIC language has been included as appendix A.

Null Hypothesis 2
knowledge of computer systems versus computer usage

> There is no relationship between the level of knowledge of computer hardware, the computer system being used, and the frequency of use of computer programs.

The analysis procedures for this hypothesis were identical to that used for hypothesis 1 except the two groups were formed on the basis of their achievement as measured by the post-test on the computer system and hardware being used. A copy of the instrument used for this purpose has been included as appendix B.

Null Hypothesis 3
attitude versus computer usage

> There is no relationship between the attitude toward computer usage and the frequency of use of computer programs.

The analysis procedures for this hypothesis were the same as those used for hypotheses 1 and 2 except that the two groups were formed on the basis of their scores obtained on the attitude questionnaire administered at the end of the summer institute. A copy of the attitude questionnaire used has been included as appendix C.

Null Hypothesis 4
teaching experience versus computer usage

> There is no relationship between the amount of teaching experience and the frequency of use of computer programs.

The teachers were divided into four groups according to the number of years that each person had taught. Teachers with zero-three years experience composed group one, four-six years experience was the criteria for group two, seven-nine years experience--group three, and those teachers with more than ten years teaching experience formed group four. A one-way analysis of variance test was used to determine if the group means (computer usage during implementation period) differed significantly.

Null Hypothesis 5
science background versus computer usage

> There is no relationship between the level of science background and the frequency of use of computer programs.

The analysis procedures for this hypothesis were the same as that used for hypothesis 4 except that the three groups were formed on the basis of how much college course work had been completed in the science teaching area being taught. If the teacher had completed forty-five semester hours in his teaching area, he was assigned to group one, forty-five - ninety semester hours--group two, and if he had completed more than ninety semester hours in his teaching area he was assigned to group three.

Null Hypothesis 6
mathematics background versus computer usage

> There is no relationship between the level of mathematics background and the frequency of use of computer programs.

The analysis procedures for this hypothesis were the same as those for hypotheses 4 and 5 except that the three groups were formed on the amount of college mathematics courses completed. Group one was composed of teachers with less than 7.5 semester hours of college level mathematics, group two, 7.5 - 15 semester hours, and group three consisted of those teachers who had completed more than 15 semester hours of college level mathematics.

Null Hypothesis 7
teaching level versus computer usage

> There is no difference in the frequency of use of computer programs used by junior high school science teachers as compared to senior high school science teachers.

The teachers were divided into two groups for this analysis. Junior high school science teachers comprised one group and senior high school science teachers the second group. A t-test was used to test if the means (computer usage during implementation period) differed significantly.

Null Hypothesis 8
terminal availability versus computer usage

> There is no relationship between the number of terminals available for use and the frequency of use of computer programs.

The sample was divided into three groups according to the number of terminals each teacher had available for instructional usage. Teachers who had access to one terminal composed group one, two or three terminals was the criteria for group two, four terminals--group three, and those teachers with more than four terminals formed group four. A one-way analysis of variance test was used to determine if the group means (computer usage during implementation period) differed significantly.

Null Hypothesis 9
terminal availability versus computer usage

> There is no difference in the frequency of use of computer programs by teachers who have terminal capability in their classrooms as compared to those teachers who do not have terminal capability in their classrooms.

The sample was divided into two groups for these analyses. Teachers who had telephone capability in their classroom were placed in one group and teachers who did not have a telephone in their classroom comprised the second group. A t-test was used to determine if the means (computer usage during implementation period) differed significantly.

Null Hypothesis 10
change in programming knowledge

> The Macomb in-service program had no effect upon the participant's knowledge of the BASIC programming language.

A correlated t-test was done to determine if a significant increase occurred in the mean score obtained on the pre and post-test given to assess achievement in the BASIC programming language.

Null Hypothesis 11
change in computer system knowledge

> The Macomb in-service program had no effect upon the participant's knowledge of the computer hardware and computer systems being used.

Analysis procedures for the above were identical to those for hypothesis 8 except that scores were obtained from an exam given to assess achievement on the knowledge of the computer system being used instead of a programming language.

Null Hypothesis 12
change in attitude concerning CAI

> The Macomb in-service program had no effect upon the attitude of each participant toward computer usage in secondary school science instruction.

A correlated t-test was done to determine if a significant increase occurred in the mean score obtained on the pre and post administration of the attitude questionnaire.

Additional Analyses

An additional hypothesis was added to the study during the analyses of the hypotheses listed above. The analysis of this new hypothesis does not answer a question as posed in chapter 1. However, it should relay information to planners of in-service computer training programs concerning the amount of hands-on terminal time allotted to individual participants.

Null Hypothesis 13
terminal experience versus computer usage

> There is no relationship between the amount of terminal time used during the in-service instruction and the frequency of use of computer programs.

Based upon the number of minutes of terminal time used during the six week summer institute, each teacher was placed in one of two groups. The half who used the greater amount of time were placed in one group and the remaining teachers were placed in the second group. A t-test was done to determine if there were significant differences between the means (computer usage during implementation period) of the two groups.

A null hypothesis was not established for one of the questions to be answered in this study because sample size restrictions prevented any valid inferential test of such a hypothesis. The question as stated in chapter 1 was: "Does the particular science area taught (biology, chemistry, physics, earth science, or science) influence the extent to which a science teacher uses the computer as an instruction tool?" This question will be answered from a descriptive point of view due to the fact that only two physics and earth science teachers were included in the sample studied.

Summary

Descriptive information was presented in this chapter concerning the methods and materials utilized in this study. The order and format for the analyses in chapter 4 will be the same as presented in this chapter. The analyses and their results are the focus of the following chapter.

CHAPTER IV

FINDINGS AND ANALYSES

Introduction

This chapter presents the results obtained from the analyses of the data in this study. A description of the data processing services utilized will be followed by the analysis of data concerning each null hypothesis discussed in chapter 3. The general procedure used in determining each experimental conclusion will also be given.

Description of Data Processing

Data were collected for seventeen variables from each teacher included in this study. The variables and their reference number are given in table 3 along with the corresponding abbreviation to be used in this chapter. Appendix E displays a list of all the categories used for each of the predictor variables listed in table 3.

TABLE 3

VARIABLES FOR WHICH DATA WERE COLLECTED

Variable No.	Variable	Abbreviation
1	Amount of teaching experience	EXPER
2	Level of science background	SCIHRS
3	Level of mathematics background	MATHRS
4	Secondary school classification	SCHOOL
5	Pre-test BASIC language score	EXAM1
6	Pre-test computer system score	EXAM2
7	Pre-test attitude score	AT-PRE
8	Post-test BASIC language score	EXAM1'
9	Post-test computer system score	EXAM2'
10	Post-test attitude score	AT-POS
11	Amount of terminal time	TIME
12	Access to a terminal	ACCESS
13	Number of terminals available	#-TERM
14	Number of computer programs used	#-PROG
15	Number of computer programs run	#-RUNS
16	Percentage of own computer programs used	OWNUSE
17	Science subject classification	COURSE

The Wayne State University Computing and Data Processing Center was the source of all computer hardware and software utilized in the analyses of data. An IBM 360/67 dual-processor was the central processor/supervisor which controlled all of the computer programs and facilities used. Command interpretation, execution control, file handling, and accounting maintenance were accomplished through the Michigan Terminal System.[1] The Michigan Terminal System was designed for both batch and terminal modes of access. All computer work for this study was done using remote terminal access. The following types of computer terminals were used at various times: UCC DATEL - Model 31, DIGI-LOG - Model 33, and DATA PRODUCTS - Model PORT-A-COM.

The statistical computing program CONSTAT was used for all data analyses in the hypotheses testing component of this study.[2] CONSTAT is a console-oriented statistical computing program which sets up a data

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[1] The Michigan Terminal System Volume I: The System, Wayne State University, (Detroit: Computing and Data Processing Center, 1971).

[2] CONSTAT, Wayne State University, (Detroit: Computing and Data Processing Center, 1971). (Mimeographed.)

structure common to many statistical problems. It incorporates many subroutines to manipulate data within this structure and performs statistical analyses on the data.[1] Data to be analyzed were entered into and saved in a file that was accessed through CONSTAT on many occasions. A computer printout of that file has been appended to this study as appendix F.

Analyses of Data per Hypothesis

The procedure to be used in testing the null hypotheses listed in chapter 3 will follow a similar format throughout this chapter. The experimental question will be stated followed by a section which will discuss related information. The corresponding research hypothesis will be stated. Abbreviated calculations showing how the test statistic was obtained will be displayed. Finally, conclusions of the statistical and experimental results will be discussed.

Many of the hypotheses are concerned with the effect that a variable has on the amount of computer usage by selected secondary science teachers. Computer usage was measured by recording the number of times

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[1] Ibid.

computer programs were run during the nine week implementation period (September - November, 1973) that corresponded with the fall component of the in-service program. Appendix G to this study is a histogram showing the frequency distribution for the number of program runs during the implementation period. Data concerning computer usage (#-PROG) and (#-RUNS) were recorded each day by each teacher. However, the number of computer programs (#-PROG) used during the implementation period was obtained, but not used in the study. The reason for this decision was that it was impossible to ascertain if the same program was being counted as used on more than one day.

Hypothesis 1: Programming Knowledge Versus Computer Usage

Experimental Question 1

> Does the level of knowledge of a programming language influence the extent to which a science teacher uses the computer as an instructional tool?

Related Information

The score obtained on the BASIC language examination at the end of the summer institute was used as the criterion variable for grouping the teachers in an attempt to answer the above question. The range of scores on the post-administration of the BASIC language examination (EXAM1') varied from a high of 47 to a low of 22 out of a possible 50 points. The mean score was 35.84. Descriptive statistics (mean, variance, standard deviation, and minimum and maximum scores) for this variable, along with those for all other variables, are displayed in table 4.

Those teachers who scored above the mean score on EXAM1' were placed in group two and those below the mean score were contained in group one. A histogram showing the spread of scores for EXAM1' has been included as figure 1.

Research Hypothesis 1

> Those teachers who scored above the mean score on the BASIC language examination administered at the end of the summer institute ran more computer programs during the implementation period than the teachers who scored below the mean score.

TABLE 4

DESCRIPTIVE STATISTICS FOR SELECTED VARIABLES*

VARIABLE**	MEAN	VARIANCE***	STD DEV	MINIMUM	MAXIMUM
EXPER	6.973	19.75	4.444	Ø.Ø	18.ØØ
SCIHRS	66.7Ø	585.Ø	24.19	22.ØØ	143.Ø
MATHRS	12.46	87.64	9.362	Ø.Ø	35.ØØ
EXAM1	5.486	83.7Ø	9.149	Ø.Ø	33.ØØ
EXAM2	5.595	18.86	4.343	Ø.Ø	18.ØØ
AT-PRE	4.557	Ø.5Ø47	Ø.71Ø5	3.4ØØ	6.1ØØ
EXAM1'	35.84	39.97	6.322	22.ØØ	47.ØØ
EXAM2'	4Ø.73	19.59	4.426	32.ØØ	48.ØØ
AT-POS	4.811	Ø.4771	Ø.69Ø7	3.2ØØ	5.9ØØ
TIME	2491.	Ø.7715EØ6	878.4	1133.	4988.
#-TERM	3.838	6.529	2.555	1.ØØØ	12.ØØ
#-PROG	2Ø.89	59Ø.Ø	24.29	1.ØØØ	115.Ø
#-RUNS	21Ø.6	Ø.5332EØ5	23Ø.9	1.ØØØ	871.Ø
OWNUSE	27.89	886.4	29.77	Ø.Ø	1ØØ.Ø

*Variables for which dichotomous data were obtained have been excluded from this table. All calculations based on 37 measurements.

**For explanation of abbreviations see table 3.

***Variances with E notation mean raised to that power of ten.

```
                  No. of Measurements = 37
                  I ---------+---------+
22.Ø             +
             2 I **
24.5             +
             1 I *
27.Ø             +
             2 I **
29.5             +
             5 I *****
32.Ø             +
             6 I ******
34.5             +
             5 I *****
37.Ø             +
             5 I *****
39.5             +
             3 I ***
42.Ø             +
             4 I ****
44.5             +
             4 I ****
47.Ø             +
                  I ---------+---------+
                  Ø         1Ø        2Ø
```

Figure 1. Histogram showing the frequency distribution of the scores obtained on the post-test of the BASIC language examination (EXAM1').

<u>Calculations</u>

The test statistic used to evaluate the corresponding null hypothesis was the t-statistic. Table 5 is the result of these calculations. Group one was those teachers who scored above the mean, while group two was those teachers who scored below the mean score on EXAM1'.

TABLE 5

SUMMARY OF t-TEST FOR H_1
PROGRAMMING KNOWLEDGE VERSUS COMPUTER USAGE

	1st Group	2nd Group
Means	2ØØ.444	22Ø.315
Variance	62468.Ø	47437.8

F Statistic = 1.3168 D.F. (17, 18)
Attained Significance Level = Ø.2837

t Statistic = -Ø.2582 D.F. = 35
Attained Significance Level = Ø.7977

Approx. t Statistic = -Ø.2572 Approx. D.F. = 35.657
Attained Significance Level = Ø.7984

Conclusions

The means for the variable, the number of computer programs run, did not differ significantly as determined by comparing the t-statistic obtained with the appropriate degrees of freedom at the .05 level of significance. Thus, the corresponding null hypothesis could not be rejected. Knowledge of a programming language may be necessary, but the level of knowledge was not a factor in the amount of computer usage by secondary science teachers involved in this study.

Hypothesis 2: Knowledge of Computer System Versus Computer Usage

Experimental Question 2

> Does the level of knowledge of computer hardware and the computer system being used influence the extent to which a science teacher uses the computer as an instructional tool?

Related Information

The score obtained on the computer systems examination at the end of the summer institute was used as the criterion variable for grouping the teachers in order to seek an answer to the above question. The variation of scores is shown on the histogram in figure 2 for this variable. The mean score on the computer systems' examination (EXAM2') at the end of the summer institute was 40.73. The grouping for the analysis of this hypothesis was done by placing those teachers who scored above the mean on EXAM2' in group two and the remainder in group one.

Research Hypothesis 2

> Those teachers who scored above the mean score on the computer systems examination administered at the end of the summer institute ran more computer programs during the implementation period than the teachers who scored below the mean.

```
                 No. of Measurements = 37
               I ---------+---------+
32.Ø           +
             3 I ***
33.6           +
             2 I **
35.2           +
             2 I **
36.8           +
             3 I ***
38.4           +
             6 I ******
4Ø.Ø           +
             5 I *****
41.6           +
             5 I *****
43.2           +
             4 I ****
44.8           +
             3 I ***
46.4           +
             4 I ****
48.Ø           +
               I ---------+---------+
               Ø         1Ø        2Ø
```

Figure 2. Histogram showing the frequency distribution of the scores obtained on the post-test of the computer systems' examination (EXAM2').

Calculations

The test statistic used to evaluate the corresponding null hypothesis was the t-statistic. Table 6 is the result of these calculations. Group one was composed of teachers who scored above the mean, while group two was made up of those teachers who scored below the mean score on EXAM2'.

TABLE 6

SUMMARY OF t-TEST FOR H_2
KNOWLEDGE OF COMPUTER SYSTEMS VERSUS COMPUTER USAGE

	1st Group	2nd Group
Means	215.722	2Ø5.842
Variance	55857.6	53833.6

F Statistic = 1.Ø375 D.F. (17, 18)
Attained Significance Level = Ø.4678

t Statistic = Ø.1282 D.F. = 35
Attained Significance Level = Ø.8986

Approx. t Statistic = Ø.1282 Approx. D.F. = 36.8Ø4
Attained Significance Level = Ø.8986

Conclusions

The means for the variable, the number of computer programs run, did not differ significantly as determined by comparing the t-statistic obtained with the appropriate degrees of freedom at the .05 level of significance. Thus, the corresponding null hypothesis could not be rejected. A basic understanding of the computer system being used would seem to be essential for a science teacher to use the computer in the classroom. However, the level of such understanding did not influence the amount of computer usage by the secondary science teachers involved in the study.

Hypothesis 3: Attitude Versus Computer Usage

Experimental Question 3

> Does the attitude of a science teacher toward computer usage influence the extent to which he uses the computer as an instructional tool?

Related Information

In order to determine if teachers' attitude toward CAI affects the extent of their computer usage, teachers who scored higher than the mean score on the post-institute administration of the attitude questionnaire were placed in group two, while the remainder comprised group one. The mean score on that questionnaire (AT-POS) was 4.811 on a scale from 1 - 7. The distribution of scores is shown in figure 3, a histogram of the scores obtained on the AT-POS.

Research Hypothesis 3

> Those teachers who scored above the mean score on the attitude questionnaire administered at the end of the summer institute ran more computer programs during the implementation period than teachers who scored below the mean.

```
                    No. of Measurements = 37
                  I ---------+---------+
3.2Ø              +
               2  I **
3.5Ø              +
               4  I ****
3.8Ø              +
               2  I **
4.1Ø              +
               Ø  I
4.4Ø              +
               2  I **
4.7Ø              +
               8  I ********
5.ØØ              +
              11  I ***********
5.3Ø              +
               5  I *****
5.6Ø              +
               3  I ***
5.9Ø              +
                  I ---------+---------+
                  Ø         1Ø        2Ø
```

Figure 3. Histogram showing the frequency distribution of the scores obtained on the post-test of the attitude survey (AT-POS).

Calculations

The test statistic used to evaluate the corresponding null hypothesis was the t-statistic. Table 7 is the result of the calculations. Group one was the teachers whose attitude score was above the mean, while group two was the teachers whose attitude score was below the mean score obtained on AT-POS.

TABLE 7

SUMMARY OF t-TEST FOR H_3
ATTITUDE TOWARD COMPUTER USAGE VERSUS COMPUTER USAGE

	1st Group	2nd Group
Means	158.9Ø4	278.562
Variance	22516.6	89275.4

F Statistic = 3.9648 D.F. (2Ø, 15)
Attained Significance Level = Ø.ØØ24

t Statistic = -1.5947 D.F. = 35
Attained Significance Level = Ø.1197

Approx. t Statistic = -1.4571 Approx. D.F. = 21.491
Attained Significance Level = Ø.1571

Conclusions

The t-statistic obtained was not significant when compared at the .05 level of significance and the appropriate degrees of freedom. Thus, the corresponding null hypothesis could not be rejected. The analysis results showed that a science teacher's attitude toward CAI did not influence his amount of computer usage. It is interesting to note that the group who scored below the mean score on the attitude questionnaire ran more programs than did the group who scored above the mean score.

Hypothesis 4: Teaching Experience Versus Computer Usage

Experimental Question 4

> Does the amount of previous science teaching experience influence the extent to which a science teacher uses the computer as an instructional tool?

Related Information

Additional consideration was given to those teachers who had four - seven years teaching experience in the selection of participants for the combined institutes. Figure 4 shows the spread of the years of teaching experience in a histogram.

```
                     No. of Measurements = 37
                   I ---------+---------+
  Ø.Ø              +
                 6 I ******
  3.Ø              +
                 9 I *********
  6.Ø              +
                1Ø I **********
  9.Ø              +
                 6 I ******
 12.Ø              +
                 3 I ***
 15.Ø              +
                 3 I ***
 18.Ø              +
                   I ---------+---------+
                   Ø         1Ø        2Ø
```

Figure 4. Histogram showing the frequency distribution of the amount of teaching experience (EXPER) for the group as measured in years.

It is interesting to note some of the correlations between teaching experience (EXPER) and the other variables. Appendix F contains the correlations between all variables studied. Negative correlations resulted between teaching experience and all examinations and questionnaires administered. However, the correlations of the two administrations of the attitude questionnaire versus teaching experience did get higher between the beginning and the end of the summer institute. The change was from a -0.2942 to a -0.0071. A section of appendix H has been included as table 8, and shows the correlations between teaching experience (EXPER) and all of the examinations used in the study.

In order to determine if length of teaching experience was a factor in the amount of computer use by the teachers involved in the study, the teachers were grouped based on the number of years that each had taught. Teachers with zero - three (inclusive) years experience comprised group one, four - six years, group two, seven - nine years, group three, and group four included all teachers with ten or more years experience.

Research Hypothesis 4

As the number of years of teaching experience

TABLE 8

CORRELATION COEFFICIENTS FOR TEACHING EXPERIENCE
VERSUS SELECTED VARIABLES*

VARIABLE	EXPER	PRE-TEST			POST-TEST		
		EXAM1	EXAM2	AT-PRE	EXAM1'	EXAM2'	AT-POS
EXPER**	1.0000						
EXAM1	-0.2832	1.0000					
EXAM2	-0.2222	0.6623	1.0000				
AT-PRE	-0.2942	0.1456	-0.1265	1.0000			
EXAM1'	-0.2879	0.2929	0.2181	0.2111	1.0000		
EXAM2'	-0.4438	0.3230	0.3858	0.1154	0.3091	1.0000	
AT-POS	-0.0071	-0.0628	-0.1569	0.5467	-0.1383	-0.0335	1.0000

*Based on 37 observations.

**Explanation of abbreviations given in table 3.

increased for science teachers, so did the amount of computer usage (runs) during the implementation period.

Calculations

A one way analysis of variance test was used to obtain a F statistic, permitting the corresponding null hypothesis to be evaluated. Table 9 gives these calculations.

TABLE 9

SUMMARY OF ANALYSIS OF VARIANCE TEST FOR H_4
TEACHING EXPERIENCE VERSUS COMPUTER USAGE (FIRST SET)

Group	Mean	Variance	Sample Size
1st	168.2	62890.4	9
2nd	129.8	8477.6	9
3rd	295.0	52511.1	10
4th	240.1	90260.1	9
Grand	210.6		

Anova Table for (#-RUNS)

Source	Sum of Sq.	D.F.	Mean Sq.	F
Between Groups	153863.10	3	51287.700	0.95858054
Within Groups	1765625.3	33	53503.798	
Total	1919488.4	36		

Attained Level of Significance = 0.4237

Bartlett's Test Statistic = 8.9758
Degrees of Freedom = 3
Attained Level of Significance = 0.0296

In view of the results obtained in the above analysis, it was decided to re-group the teachers by forming two groups, those with more than the mean (6.973 years) number of years experience were placed into group two, and the others into group one. A second one-way analysis of variance resulted in the calculations given in table 10.

TABLE 10

SUMMARY OF ANALYSIS OF VARIANCE TEST FOR H_4
TEACHING EXPERIENCE VERSUS COMPUTER USAGE (SECOND SET)

Group	Mean	Variance	Sample Size
1st	149.Ø	33973.9	18
2nd	269.Ø	67164.Ø	19
Grand	21Ø.6		

Anova Table for (#-RUNS)

Source	Sum of So.	D.F.	Mean So.	F
Between Groups	132979.49	1	132979.49	2.6052386
Within Groups	17865Ø6.9	35	51Ø43.113	
Total	1919488.4	36		

Attained Level of Significance = Ø.1154

Bartlett's Test Statistic = 1.9248
Degrees of Freedom = 1
Attained Level of Significance = Ø.1653

Conclusions

The second analysis yielded a F-value nearly large enough to be significant; nevertheless, the null hypothesis was not rejected at the .05 level of significance. Since the correlation between teaching experience and computer usage (#-RUNS) was +0.2157 (see appendix H), it could be reported that teaching experience was proportional to computer usage by the science teachers involved in this study.

Hypothesis 5: Science Background Versus Computer Usage

Experimental Question 5

> Does the level of science background of a science teacher influence the extent to which he uses the computer as an instructional tool?

Related Information

The level of science background as measured by the number of semester hours of science coursework completed at the collegiate level was used as the criterion variable for grouping the teachers in order to seek an answer to the above question. The distribution of scores is shown in figure 5, a histogram for the number of science hours (SCIHRS).

```
                         No. of Measurements = 37
                        I ---------+---------+
  22.ØØ                 +
                     3  I ***
  34.1Ø                 +
                     4  I ****
  46.2Ø                 +
                     4  I ****
  58.3Ø                 +
                    13  I *************
  7Ø.4Ø                 +
                     5  I *****
  82.5Ø                 +
                     3  I ***
  94.6Ø                 +
                     3  I ***
 1Ø6.7Ø                 +
                     1  I *
 118.8Ø                 +
                     Ø  I
 13Ø.9Ø                 +
                     1  I *
 143.ØØ                 +
                        I ---------+---------+
                        Ø         1Ø        2Ø
```

Figure 5. Histogram showing the frequency distribution of the amount of college science coursework (SCIHRS) for the group as measured in semester hours.

The science background for the total group was quite high, the mean being 66.7 semester hours of college science credit.

Three groups were formed for the analysis procedures. The cut-off points used to form the three groups were forty-five and ninety semester hours of college science credit. This grouping did not yield sample sizes that were close to being equal, but after unsuccessfully attempting several other possible groupings, it was decided to use the one described above.

Research Hypothesis

> As the amount of college science coursework increased for science teachers, so did the amount of computer usage (runs) during the implementation period.

Calculations

A one-way analysis of variance test was used to obtain a F-statistic, permitting the corresponding null hypothesis to be evaluated. Table 11 gives these calculations.

Conclusions

The calculated F-value was not significant at the .05 level for the appropriate degrees of freedom, and the corresponding null hypothesis was not rejected. The level of science background did not influence the amount of computer usage by the secondary science teachers participating in this study.

TABLE 11

SUMMARY OF ANALYSIS OF VARIANCE TEST FOR H_5
SCIENCE BACKGROUND VERSUS COMPUTER USAGE

Group	Mean	Variance	Sample Size
1st	115.Ø	1494Ø.4	6
2nd	228.1	72831.7	25
3rd	233.5	6233.5	6
Grand	21Ø.6		

Anova Table for (#-RUNS)

Source	Sum of Sq.	D.F.	Mean Sq.	F
Between Groups	65656.292	2	32828.146	Ø.6Ø3Ø8Ø93
Within Groups	1853832.1	34	54524.475	
Total	1919488.4	36		

Attained Level of Significance = Ø.553

Bartlett's Test Statistic = 9.7Ø17
Degrees of Freedom = 2
Attained Level of Significance = Ø.ØØ78

Hypothesis 6: Mathematics Background
Versus Computer Usage

Experimental Question 6

Does the level of mathematics background of a science teacher influence the extent to which he uses the computer as an instructional tool?

Related Information

The level of mathematics background as measured by the number of semester hours of mathematics coursework completed at the collegiate level was used as the criterion variable for grouping the teachers in order to seek an answer to the above question. The distribution of scores is shown in figure 6, a histogram for the number of mathematics hours (MATHRS).

```
               No. of Measurements = 37
              I ---------+---------+
  Ø.Ø         +
            6 I ******
  5.Ø         +
           15 I ***************
 1Ø.Ø         +
            4 I ****
 15.Ø         +
            4 I ****
 2Ø.Ø         +
            2 I **
 25.Ø         +
            4 I ****
 3Ø.Ø         +
            2 I **
 35.Ø         +
              I ---------+---------+
              Ø         1Ø        2Ø
```

Figure 6. Histogram showing the frequency distribution of the amount of college mathematics coursework (MATHRS) for the group as measured in semester hours.

The mathematics background for the total group was not high, the mean being 12.46 semester hours of college mathematics credit.

Three groups were formed for the analysis procedures. The cut-off points used to form the three groups were 7.5 and fifteen semester hours of college mathematics credit.

Research Hypothesis

> As the amount of college mathematics coursework increased for science teachers, so did the amount of computer usage (runs) during the implementation period.

Calculations

A one way analysis of variance test was used to obtain a F-statistic, permitting the corresponding null hypothesis to be evaluated. Table 12 gives a summary of these calculations.

Conclusions

The calculated F-value was not significant at the .05 level for the appropriate degrees of freedom, and the corresponding null hypothesis was not rejected. The level of mathematics background did not influence the amount of computer usage by the secondary science teachers participating in this study.

TABLE 12

SUMMARY OF ANALYSIS OF VARIANCE TEST FOR H_6
MATHEMATICS BACKGROUND VERSUS COMPUTER USAGE

Group	Mean	Variance	Sample Size
1st	2Ø6.4	61675.6	14
2nd	192.5	4Ø818.6	11
3rd	232.1	63646.1	12
Grand	21Ø.6		

Anova Table for (#-RUNS)

Source	Sum of Sq.	D.F.	Mean Sq.	F
Between Groups	941Ø.6Ø99	2	47Ø5.3Ø5Ø	Ø.Ø837
Within Groups	191ØØ77.8	34	56178.759	
Total	1919488.4	36		

Attained Level of Significance = Ø.9198

Bartlett's Test Statistic = Ø.5844
Degrees of Freedom = 2
Attained Level of Significance = Ø.7466

Hypothesis 7: Teaching Level
Versus Computer Usage

Experimental Question 7

Does a science teacher at the junior high level use the computer to a greater extent than a science teacher at the senior high level?

Related Information

When selecting the original participants for the

National Science Foundation summer institute, little consideration was given to the teaching level of each applicant. The final sample utilized in this study yielded twenty-three high school science teachers and fourteen junior high school science teachers. This may be partially due to the fact that more computer terminal facilities exist in the high schools than in the junior high schools of Macomb County, Michigan. This variable representing secondary teaching (SCHOOL) was coded either sero or one, zero for senior high school teachers and one for junior high school teachers.

Research Hypothesis

> Junior high school science teachers ran more computer programs during the implementation period than senior high school science teachers.

Calculations

The test statistic used to evaluate the corresponding null hypothesis was the t-statistic. Table 13 is the result of these calculations. Group one was the senior high teachers and group two was the junior high teachers.

TABLE 13

SUMMARY OF t-TEST FOR H_7
TEACHING LEVEL VERSUS COMPUTER USAGE

	1st Group	2nd Group
Means	211.Ø43	21Ø.ØØØ
Variance	644Ø5.6	38658.Ø

F Statistic = 1.666Ø D.F. (22, 13)
Attained Significance Level = Ø.1716

t Statistic = Ø.Ø131 D.F. = 35
Attained Significance Level = Ø.9895

Approx. t Statistic = Ø.Ø139 Approx. D.F. = 35.Ø41
Attained Significance Level = Ø.9889

Conclusions

The t-statistic calculated to compare the means (computer usage) of the two groups was not significant at the .05 level with the corresponding degrees of freedom. Thus, the corresponding null hypothesis could not be rejected. The amount of computer usage as measured by the number of program runs was nearly identical for the two groups. The teaching level (junior high or senior high) was not a factor that influenced the extent of classroom computer usage in secondary science instruction.

Hypotheses 8 and 9: Terminal Availability Versus Computer Usage

Experimental Question 8

> Does the availability of computer terminals to a particular science teacher influence the extent to which he uses the computer as an instructional tool?

Related Information

It was decided to consider this question by using two different measurements for terminal availability. The first was the number of computer terminals available in the school for instructional use by that teacher. Figure 7 shows the frequency distribution for the number of terminals available to each science teacher (#-TERM). The second measurement for terminal availability was obtained by asking each teacher if he had terminal capability in the classroom where he taught. This variable representing terminal capability (ACCESS) was coded either zero or one in the data file, zero for those who did not have access and one for those who did have access to a computer system through facilities in their classroom. Twenty-two teachers reported having terminal capability in their classrooms.

```
                 No. of Measurements = 37
               I ---------+---------+
 1.Ø           +
             8 I ********
 2.Ø           +
             2 I **
 3.Ø           +
             6 I ******
 4.Ø           +
            11 I ***********
 5.Ø           +
             5 I *****
 6.Ø           +
             2 I **
 7.Ø           +
             1 I *
 8.Ø           +
             Ø I
 9.Ø           +
             Ø I
1Ø.Ø           +
             Ø I
11.Ø           +
             2 I **
12.Ø           +
               I ---------+---------+
               Ø         1Ø        2Ø
```

Figure 7. Histogram showing the frequency distribution of the number of terminals available to teachers (#-TERM) for instructional purposes.

Research Hypothesis 8

> As the number of terminals available for instructional use by science teachers increased, so did the amount of computer usage (runs) during the implementation period.

Calculations

The grouping for this test was done using the number of terminals available for instructional use as the criterion variable. Teachers who had one terminal available were assigned to group one, two or three terminals, group two, four terminals, group three, and any teacher having access to more than four terminals was placed in group four.

A one way analysis of variance test was used to obtain a F-statistic, permitting the corresponding null hypothesis to be evaluated. Table 14 shows the resulting calculations.

Research Hypothesis 9

> Those teachers who could operate a computer in their classroom ran more computer programs during the implementation period than the teachers who did not have terminal capability in their classrooms.

Calculations

The test statistic used to evaluate the corresponding null hypothesis was the t-statistic. Table 15 is the result of the calculations. Group one was the teachers who did have access, while group two was the

TABLE 14

SUMMARY OF ANALYSIS OF VARIANCE TEST FOR H_8
NUMBER OF TERMINALS AVAILABLE VERSUS COMPUTER USAGE

Group	Mean	Variance	Sample Size
1st	158.8	33517.2	8
2nd	185.1	2Ø8Ø1.2	8
3rd	181.6	61545.Ø	11
4th	3Ø4.4	88888.9	1Ø
Grand	21Ø.6		

Anova Table for (#-RUNS)

Source	Sum of So.	D.F.	Mean So.	F
Between Groups	1238Ø7.74	3	41269.246	Ø.75842276
Within Groups	179568Ø.7	33	54414.567	
Total	1919488.4	36		

Attained Level of Significance = Ø.5254

Bartlett's Test Statistic = 4.2546
Degrees of Freedom = 3
Attained Level of Significance = Ø.2352

teachers who did not have access to terminals in their classrooms.

Conclusions

Neither the test statistic for hypothesis 8, nor that for hypothesis 9 was large enough to be significant at the .05 level with the corresponding degrees of freedom.

TABLE 15

SUMMARY OF t-TEST FOR H_9
CLASSROOM ACCESS FOR TERMINAL VERSUS COMPUTER USAGE

	1st Group	2nd Group
Means	212.590	2Ø7.8ØØ
Variance	48456.1	644Ø7.4

F Statistic = 1.3291 D.F. (21, 14)
Attained Significance Level = Ø.27Ø2

t Statistic = Ø.Ø61Ø D.F. = 35
Attained Significance Level = Ø.9516

Approx. t Statistic = Ø.Ø594 Approx. D.F. = 28.958
Attained Significance Level = Ø.953Ø

Both null hypotheses were not rejected. Terminals must be available for science teachers if they are to be used as instructional tools, but the type of availability needed by each teacher is unique to his situation. The number of terminals available in a school for instructional purposes and whether or not a teacher has computer terminal capability in his classroom did not influence the amount of computer usage by the science teachers involved in the study.

Hypothesis 10: Knowledge of the BASIC Programming Language

Experimental Question 10

> Did the Macomb In-Service Program produce a significant increase in the participants' knowledge of the BASIC programming language?

Related Information

The mean score for the group on the pre-institute administration of the BASIC language examination was 5.486 out of a possible fifty points. This low over-all score was probably due to the fact that the original selection of participants was based on their having little or no previous computer training. The mean score for the group on the post-test of the same examination at the conclusion of the summer institute was 35.84. A copy of the instrument used for this examination has been included as appendix A to this study. This examination concentrated on elementary BASIC programming and did not cover advanced BASIC programming concepts.

Research Hypothesis 10

> The Macomb In-Service Program did produce a significant increase in the participants' knowledge of the BASIC programming language.

Calculations

A t-test was done to compare the pre-test and the post-test scores of the BASIC language examination. The results of that test are included as table 16.

TABLE 16

SUMMARY OF t-TEST FOR H_{10}
INCREASE IN BASIC PROGRAMMING KNOWLEDGE

t-test for the hypothesis that the
mean of (EXAM1') - (EXAM1) = Ø

No. of Obs. = 37
Mean = 3Ø.3513
Std. Dev. = 9.4757
t Statistic = 19.4834
Attained Significance Level = Ø.ØØØØ

Conclusions

The calculated value of the t-statistic was significant beyond the .01 level with thirty-six degrees of freedom. The corresponding null hypothesis was rejected and the research hypothesis was accepted. The Macomb In-Service Program (National Science Foundation Summer Institute) did produce a significant increase in the participants' knowledge of the BASIC programming language.

Hypothesis 11: Knowledge of the Computer System

Experimental Question 11

> Did the Macomb In-Service Program produce a significant increase in the participants' knowledge of computers, computing, and the computer system being used?

Related Information

The teachers knew very little about the Macomb Intermediate School District's computer system at the beginning of the summer institute. The mean score on the pre-test of the computer system examination was 5.595, as compared to the post-test mean score of 40.73. Fifty points were possible on the examination. A copy of the instrument used for this examination has been included as appendix B to this study. This examination was concerned with elementary system commands and teletype-terminal operations sufficient to use the computer as an instructional tool in the science classroom.

Research Hypothesis 11

> The Macomb In-Service Program did produce a significant increase in the participants' knowledge of the computer system being used.

Calculations

A t-test was done to compare the pre-test and the post-test scores on the computer system examination. The results of that test are given in table 17.

TABLE 17

SUMMARY OF t-TEST FOR H_{11}
INCREASE IN KNOWLEDGE OF THE MACOMB COMPUTER SYSTEM

t-test for the hypothesis that the
mean of (EXAM2') - (EXAM2) = Ø

No. of Obs. = 37
Mean = 35.1351
Std. Dev. = 4.86ØØ
t Statistic = 43.9745
Attained Significance Level = Ø.ØØØØ

Conclusions

The calculated value of the t-statistic was significant beyond the .01 level with thirty-six degrees of freedom. The corresponding null hypothesis was rejected and the research hypothesis was accepted. The Macomb In-Service Program (National Science Foundation Summer In-Stitute) did produce a significant increase in the participants' knowledge of the computer system being used.

Hypothesis 12: Teachers' Attitude Toward CAI

Experimental Question 12

> Did the Macomb In-Service Program produce a significant favorable change in the participants' attitude toward the use of the computer as an instructional tool?

Related Information

The attitude questionnaire was administered on the first and the final days of the institute. The instrument, a semantic differential evaluation form, consisted of three pages. Each page dealt with a related aspect of computer usage: in society, in education, and in the classroom. While responding to the bi-polar adjective pair concerning each aspect, the teachers were demonstrating how they viewed the evaluation, the activity and the potency of each aspect. Table 18 contains the mean scores obtained for each element in the aspect versus attitude component grid (pre-test and post-test), in addition to showing the overall mean scores obtained on various aspects and attitude components.

The largest increase (between the pre-test and the post-test) in the mean score obtained per aspect (page) occurred for the aspect concerning computer usage

TABLE 18

ATTITUDE MEAN SCORE COMPARISONS*

Aspect of Computer Usage (Page Number)	Test Administration	Attitude Component			Row Totals
		Evaluation	Potency	Activity	
Computer Usage in Our Society (Page 1)	Pre	5.8	5.1	5.0	5.3
	Post	5.8	5.2	4.9	5.3
Computer Usage in Education (Page 2)	Pre	5.3	3.5	4.3	4.3
	Post	5.5	3.5	4.4	4.5
Computer Usage in Your Classroom (Page 3)	Pre	4.6	3.3	4.2	4.0
	Post	5.2	4.3	4.5	4.5
Column Totals	Pre	5.2	4.0	4.5	4.5
	Post	5.5	4.3	4.6	4.8

*Based on the entire population studied.

in the classroom. In fact, each attitude component yielded its largest increase on the page dealing with computer usage in the classroom. The page concerning computer usage in our society showed no change in the mean score obtained between the pre-test and the post-test, while the page dealing with computer usage in education showed a slight increase.

Research Hypothesis 12

> The Macomb In-Service Program did produce a significant favorable change in the participants' attitude toward the use of the computer as an instructional tool.

Calculations

A t-test was done to compare the overall mean scores obtained on the pre-administration and the post-administration of the attitude survey. The results of that test are given in table 19.

Conclusions

The calculated value of the t-statistic was significant at the .05 level with thirty-six degrees of freedom. The corresponding null hypothesis was rejected and the research hypothesis was accepted. The Macomb In-Service

TABLE 19

SUMMARY OF t-TEST FOR H_{12}
FAVORABLE CHANGE IN ATTITUDE TOWARD COMPUTER USAGE

t-test for the hypothesis that the
mean of (AT-POS) - (AT-PRE) = Ø

No. of Obs. = 37
Mean = Ø.254Ø
Std. Dev. = Ø.6673
t Statistic = 2.3157
Attained Significance Level = Ø.Ø263

Program (National Science Foundation Summer Institute) did produce a significant favorable change in the participants' attitude toward computer usage in science classrooms.

Hypothesis 13: Terminal Time Versus Computer Usage

Experimental Question 13

> Does the amount of computer time spent at a computer terminal during in-service instruction influence the extent to which a science teacher uses the computer as an instructional tool?

Related Information

The daily schedule of activities during the National Science Foundation Summer Institute allowed each teacher ample opportunity to use the computer terminals located at the institute. Many teachers had also made arrangements with their school administrations to use their school terminals for the duration of the institute. The mean amount of terminal time used during the six-week institute was 2,491 minutes. In order to determine if the amount of terminal time influenced the extent of the computer usage, teachers who used more than 2,491 minutes of computer time during the institute were placed in group one, while those who used less than 2,491 were placed in group two. Figure 8 shows the variation in the amount of terminal time used during the institute.

Research Hypothesis 13

> Those teachers who spent more time on the computer system during the Macomb In-Service Program ran more computer programs during the implementation period.

Calculations

The test statistic used to evaluate the corresponding null hypothesis was the t-statistic. Table 20 is a result of the calculations.

```
                    No. of Measurements = 37
                   I ---------+---------+
1133.Ø             +
                6  I ******
1518.5             +
                5  I *****
19Ø4.Ø             +
                6  I ******
2289.5             +
                4  I ****
2675.Ø             +
                8  I ********
3Ø6Ø.5             +
                4  I ****
3446.Ø             +
                1  I *
3831.5             +
                2  I **
4217.Ø             +
                Ø  I
46Ø2.5             +
                1  I *
4988.Ø             +
                   I ---------+---------+
                   Ø          1Ø        2Ø
```

Figure 8. Histogram showing the frequency distribution of the amount of terminal time (TIME) used during the six-week National Science Foundation Summer Institute.

Conclusions

The t-statistic obtained was not significant when compared at the .05 level of significance and the appropriate degrees of freedom. Thus, the corresponding null hypothesis could not be rejected. Terminal time experience would seem to be necessary to promote computer usage by

TABLE 20

SUMMARY OF t-TEST FOR H_{13}
TERMINAL EXPERIENCE DURING INSTITUTE
VERSUS COMPUTER USAGE

	1st Group	2nd Group
Means	218.35Ø	2Ø1.588
Variance	58Ø3Ø.8	5Ø895.Ø

F Statistic = 1.14Ø2 D.F. (19, 16)
Attained Significance Level = Ø.3993

t Statistic = Ø.2171 D.F. = 35
Attained Significance Level = Ø.8293

Approx. t Statistic = Ø.2183 Approx. D.F. = 36.667
Attained Significance Level = Ø.8284

teachers, but the amount of time spent on the computer system during the institute did not influence the extent of classroom computer usage by the secondary science teachers involved with the institute.

Additional Analyses

Two questions were studied from a descriptive point of view because valid statistical tests were not possible. The first question, which was listed in chapter 1, dealt with the science teaching area and whether or not it was a factor in the amount of computer usage. The second question, added to the study during the analyses, dealt with whether or not science teachers use their own computer programs or those written by others and kept stored in the computer's central library of public programs.

Question 14

> Does the particular science area taught (biology, chemistry, physics, earth science, or science) influence the extent to which a science teacher uses the computer as an instructional tool?

Comments

Because of sample size restrictions this question was not answered via statistical analyses. The final sample yielded only two physics and two earth science teachers. Thus, it was decided to present a graph showing the number of programs run during the implementation period versus the science teaching area. Figure 9 is the graph that shows that biology teachers ran 187 programs, chemistry teachers ran 248 programs, earth science teachers ran 155 programs, physics teachers ran 203 programs, and science teachers ran 217 programs. No statistical inferences were made from these results.

```
Science Area
   Taught
                    |---------+---------+---------+---------+
                    +
Biology    187      |*************************
                    +
Chemistry  248      |*********************************
                    +
Earth
Science    155      |*********************
                    +
Physics    203      |***************************
                    +
Science    217      |*****************************
                    +
                    |---------+---------+---------+---------+
                    0         75        150       225       300
                         Number of program runs (#-RUNS)
                          during implementation period
```

Figure 9. Graph - Science Teaching Area (COURSE) versus Number of Programs Run (#-RUNS).

Question 15

Do science teachers use computer programs that they have developed more than programs developed by others and retained in the computer's central library for public use?

Comments

Every teacher included in the study developed at least one science-oriented instructional computer program. However, many of these were placed into the central library for public access during the implementation period, making it difficult for a teacher to count such programs as either central library programs or their own. The results that were obtained by asking the teachers to state the percentage of their computer usage that was involved with using programs that they had developed is shown in figure 10, a histogram of the percentage of use of their own programs. Although the numbers are only estimates, it seems as if the majority of use involved central library programs.

```
                 No. of Measurements = 37
                 |---------+---------+
    Ø.Ø          +
              15 |***************
   1Ø.Ø          +
               3 |***
   2Ø.Ø          +
               6 |******
   3Ø.Ø          +
               3 |***
   4Ø.Ø          +
               2 |**
   5Ø.Ø          +
               1 |*
   6Ø.Ø          +
               3 |***
   7Ø.Ø          +
               1 |*
   8Ø.Ø          +
               1 |*
   9Ø.Ø          +
               2 |**
  1ØØ.Ø          +
                 |---------+---------+
                 Ø        1Ø        2Ø
```

Figure 10. Histogram showing the frequency distribution of the percentage of use (OWNUSE) of the teachers' own computer programs.

Summary

In summary, the statistical analyses resulted in three research hypotheses being accepted. All three dealt with the effectiveness of the summer institute in changing the participant's knowledge of programming, knowledge of computers, and attitude toward computer usage in secondary science instruction. Table 21 shows a summary of the statistical analyses for this chapter. In it, the criterion and dependent variables are given for each hypothesis along with the test statistic used and the level of significance obtained.

TABLE 21

STATISTICAL ANALYSES SUMMARY BY HYPOTHESIS

Hypothesis Number	Criterion Variable	Dependent Variable	Test Statistic	Significance Level
1	BASIC programming knowledge	Computer usage	t	N.S.
2	Computer system knowledge	Computer usage	t	N.S.
3	Attitude toward computer usage	Computer usage	t	N.S.
4	Teaching experience	Computer usage	F	N.S.
5	Science background	Computer usage	F	N.S.
6	Mathematics background	Computer usage	F	N.S.
7	Secondary school classification	Computer usage	t	N.S.
8	Number of terminals available	Computer usage	F	N.S.

TABLE 21--Continued

Hypothesis Number	Criterion Variable	Dependent Variable	Test Statistic	Significance Level
9	Terminal access in classroom	Computer usage	t	N.S.
10	Summer in-service program	BASIC programming knowledge	t	.01
11	Summer in-service program	Computer system knowledge	t	.01
12	Summer in-service program	Attitude toward computer usage	t	.05
13	Terminal time during institute	Computer usage	t	N.S.

N.S. = Not Significant

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Introduction

The understanding and meaning assigned to natural occurrences is one of the main goals associated with science teaching. Secondary school science teachers need to arouse the curiosity and interest of students in science so that the student takes an active part in the investigation of scientific concepts. Many of the newer process-oriented secondary school science curricula include numerous activities that enable students to better experience the meaning associated with natural occurrences by allowing them to manipulate the events themselves. However, for a variety of reasons, many situations can not be simulated by normal laboratory activities conducted in a classroom setting. It is here that Computer Assisted Instruction can play a necessary role by enabling science teachers to simulate situations or analyze data that otherwise could not be accomplished within the framework of today's normal classroom. Computer usage in secondary school science instruction has been reviewed in this study, which dealt with the identification of factors that affect the extent of CAI in secondary school science.

Research Design

During 1973 thirty-seven secondary school science teachers from Macomb County, Michigan, attended a combined summer and in-service institute conducted by Wayne State University and funded by the National Science Foundation. The purpose of the in-service instruction was to familiarize science teachers with computers and computer applications in teaching. Data and information concerning each teacher were gathered at various times using instrumentation developed for that purpose. Four instruments were used at the beginning of the summer institute and at the end of the summer institute or the in-service component to obtain data for each of the seventeen variables involved in the study.

Inferential statistics were used to evaluate thirteen null hypotheses concerning factors that might influence the extent of use of computer assisted instruction in secondary school science. Two experimental designs were incorporated into the study. The hypotheses concerning the effectiveness of the summer institute in improving programming knowledge, knowledge of the computer system being used, and attitude toward computer assisted instruction were evaluated using a pre-test - post-test pre-experimental design. The remainder of the hypotheses were evaluated using a pre-experimental design. No control groups were utilized in this study. All data were analyzed via computer calculations using "packaged" statistical programs.

All teachers involved in this study had a knowledge of computers and computer applications for science teachers and had access to computer facilities for computer assisted instruction in their schools. These teachers had received instruction during the institutes concerning the quantity and quality of computer programs that were available for their use, and as to how to develop their own programs for classroom instruction in the area of science. Those teachers who did not have computer facilities available for classroom use in their schools during the 1973-1974 school year were eliminated from the study.

Conclusions

In this section a summary of the conclusions corresponding to the analyses presented in chapter 4 will be stated. Before reviewing the conclusions, several comments are in order related to the type of science teacher involved in the study. The quality and quantity of teacher participation in the National Science Foundation institute, as judged by the institute staff, was very high. The evaluation forms completed by the participants at the end of the summer institute showed that most teachers were very satisfied with the instructional program during the six-week summer component. During the summer institute the teachers had ample opportunity to use the computer system and to become familiar with it through the use of remote terminals. Table 4 shows that the average amount of computer terminal time per teacher during the summer institute was 2,491 minutes.

The in-service program, including both the summer and fall institutes, was successful in promoting computer usage by the science teachers who participated. The total in-service program did have a pronounced effect on the extent of computer usage by participating teachers.

The amount of computer usage, measured by the number of times each participating teacher ran computer programs, was relatively high. On the average each teacher ran 211 computer programs to complement his science instruction during the nine week fall implementation period. Assuming that a typical run of a computer program would require from two to five minutes to complete, approximately 400 - 1000 minutes were utilized by each teacher for CAI in science instruction. This was a considerable amount in view of the fact that nearly every teacher in the in-service program had never used the computer as a teaching aide prior to the summer institute.

The conclusions reached as a result of studying the hypotheses presented in chapter 3 and chapter 4 are as follows.

1. The programming language studied during the six-week summer institute was BASIC (Beginners All-Purpose Symbolic Instruction Code). A major part of the institute's instructional program dealt with improving the participants' knowledge of BASIC. Pre-test and post-test comparisons yielded results which showed a significant improvement in the participants' knowledge of BASIC.

However, when the post-test score for each teacher was used as a predictor variable to determine if that score influenced the extent to which a teacher used the computer as an instructional tool during the implementation period, no significant differences were obtained. The level of knowledge of a programming language did not seem to influence the amount of computer usage by those teachers who participated in the study. It should be remembered that the increase in programming knowledge during the institute was considerable for the group as a whole. Perhaps therein lies an explanation for why the level of knowledge of a programming language did not influence the amount of computer usage. A critical amount of programming knowledge may be essential to encourage computer usage and sufficient instruction was given to the group during the summer institute, thus possibly explaining why no significant differences resulted when comparing the groups. This fact could also be used to support the assumption made in chapter 1, that the teachers involved in the study did indeed have sufficient knowledge of the BASIC programming language necessary to implement CAI in their science instruction.

2. The level of knowledge of the computer system being used does not influence the extent of a science teacher's use of computers in instruction. The same comments would apply here as were stated in the previous conclusion. Two additional statements may help to explain this conclusion. The first is that the individual scores obtained on EXAM2', the predictor variable in this case, were distributed over a small range. The second explanation may lie in the fact that the various ways that one can use computer commands are more limited than the ways to use programming statements, thus there probably does exist a critical amount of knowledge concerning the computer system and its command necessary for a teacher to use the computer system successfully. Because of the relatively high scores obtained on EXAM2', it could be reported that the participants in the summer institute had more than the critical knowledge necessary to use the Macomb Intermediate School District's computer system.

3. A positive change did occur with respect to the participants' attitude toward computer usage during the summer institute. This was particularly true in regards to their attitude toward computer usage in their

classrooms. However, when their post-test attitude scores were used as predictors in determining if attitude toward computer usage influences the extent of computer usage by a science teacher, no comparisons were drawn. A reason for this might be that nearly every teacher scored higher on the post-administration of the attitude questionnaire than they did on the pre-test at the beginning of the institute. Attitude toward computer usage may not have to be high to encourage computer usage; perhaps a positive change in attitude is all that is necessary to encourage computer usage. If teachers receive in-service instruction dealing with instructional usage of computers, then their attitude toward CAI should increase in order to promote CAI by that group.

4. It can be concluded that the amount of teaching experience is not a factor influencing the extent of computer usage in secondary school science instruction. The more experienced science teachers used the computer more often than those teachers having less experience, but the difference was not significant. However, a positive correlation (+0.2157) did exist between teaching experience and the number of computer programs run during the imple-

mentation period.

Interviews with all the institute participants during the fall implementation periods seemed to imply that the more experienced teachers knew more ways to obtain computer facilities and time for their classes. It was also interesting to note the correlations between teaching experience and all the examinations given during the institute. In every case a negative correlation results, showing that the more experienced teachers consistently scored lower in every testing situation.

5. Neither the level of mathematics background nor the level of science background is a factor influencing the extent of computer usage by secondary science teachers. All mathematics or science courses at the collegiate level were included regardless of area. The mathematics background for the group as a whole was quite low (12.5 semester hours), while the science background was rather high (66.7 semester hours). Teachers who had limited backgrounds in either or both areas tended to use computer programs that corresponded to their level of sophistication, but did use computer programs to complement their instruction.

6. There is no difference when the amount of computer usage in secondary science instruction by junior high school teachers involved in the study is compared with that of senior high school teachers from the same population. It seems that many of the existing computer programs for instructional purposes in science are geared to generalized levels or instruction more appropriate for junior high schools, but the high schools are generally the first to obtain computer facilities and usually have more facilities than junior high schools. These two contrasting explanations tend to equalize one another and may be the reason for the null result that was obtained in this study.

7. If a science teacher is going to use the computer as an instructional tool in teaching he must have computer facilities available for his use. The extent and type of computer terminal availability are difficult variables to measure because most schools have different methods for regulating the use of existing facilities. Two methods for measuring computer terminal availability were used: the number of terminals in the school for instructional purposes and whether or not the teacher's

classroom had terminal capability. Terminal capability means that the teacher could bring a computer terminal into the classroom and use it there.

Neither teachers from the population who had many terminals in their school nor teachers who had terminal capability in their classroom used the computer more than did the teachers who did not have the above characteristics. This paradox is difficult to explain. It seems that the number of computer terminals theoretically available for instructional use to a teacher and classroom capability should be important in determining the extent of CAI by a science teacher. Perhaps teachers did not have access to facilities even though they were present in the school. Many schools have their computer terminals housed in a single location and they are generally controlled by the mathematics department, which probably was instrumental in obtaining the facilities originally. It is difficult for several teachers to manipulate classes and schedules so that other teachers may use computer terminals that are not readily available for their use. The number of terminals available in a school alone is not sufficient to use as a basis for predicting computer usage.

8. If the goal of in-service instruction is to promote an increased understanding of computers and their usage in education, facilities must be available for students to use a computer to practice writing computer programs and to evaluate existing programs. During the summer institute, each teacher had ample opportunity to practice daily on the computer system. During the six-week institute each member of the group used an average of 2491 minutes of terminal time on the computer system. Using this amount of terminal time as a possible predictor for the extent of computer usage by the selected science teachers during the implementation period did not prove to be a significant factor.

9. The area of science being taught does not influence the extent of computer usage in secondary science instruction. Although a statistical test was not conducted to support this statement, the average number of computer program runs for each of the disciplines was rather close to the overall average.

10. Secondary school science teachers tend to use computer programs available to them through some public source rather than use programs written by them-

selves. A statistical test was not done to support this statement, but most of the teachers reported using a majority of computer programs that were available for their use via the computer's central library of stored programs.

Recommendations

Implications drawn from the conclusions of this study allow the following recommendations to be made in order that theories might be revised, practices modified, or additional research be conducted.

1. When in-service workshops, courses, or institutes are planned for the purpose of promoting an increased awareness and usage of CAI in secondary school science instruction, several points should be considered.

a. The major science teaching area (subject) is not a crucial factor to consider in the acceptance of teachers for instruction, although the instruction is facilitated if all members represent a single science area such as chemistry or biology.

b. Teaching experience, science background, and mathematics background need not be considered as criteria for acceptance of teachers into programs that are aimed at promoting increased computer usage by teachers.

c. Computer facilities must be available for teachers to obtain "hands-on" experience during the instructional program. Additional research is needed as to exactly how much experience is necessary.

2. Secondary schools that have more than several computer terminals should have telephone capability in each science room and at least one of the computer terminals should be available on a reserve basis, much like film projectors and overhead projectors, to any teacher who needs it. Computer terminals are portable and should be moved when necessary. No class, including a computer science class, needs to use terminals every day. This recommendation is made because some schools that have many terminals are not using them as often as schools that have few terminals simply because no flexibility of use exists.

3. Although the Macomb County schools have an elaborate instructional computer system and personnel whose responsibilities are to facilitate the use of existing technology, many teachers who were involved in this study came to the in-service program with little

knowledge of what could be done using CAI in secondary science. State educational agencies, intermediate school districts, and local school districts need to inform the classroom science teacher through the use of media and personnel of both the quantity and quality of computer programs available for public use in the various disciplines. Teachers must know what computer software and hardware are available for their use and have an opportunity to gain "hands-on" experience using such before they can be expected to implement CAI into their classroom.

4. Since the in-service program was successful in promoting increased computer usage by the participating teachers, it could be stated that additional programs should be established not only to promote implementation, but also to encourage better ways to use computers in science instruction. Such programs need to be a regular part of the educational process, not just chance offerings that are created as a result of research or experimental projects. Colleges and universities should include a conventional course offering concerning instructional uses of computers as a part of their regular program in

the preparation and training of science teachers both at the undergraduate and the graduate level. These courses should be taught by staff members who are familiar with using the computer as an instructional aide, not only those knowledgeable in the area of computer science.

5. Replication studies and/or additional research are needed to verify the results obtained in this study concerning the effect, if any, that programming knowledge and secondary school classification have on the extent of computer usage by a science teacher. All teachers involved in this study had six weeks of BASIC programming language instruction. New research is needed where the amount of instruction would be varied in order to determine if a critical amount of programming knowledge does exist in order to successfully use CAI in secondary school science. Science teachers from junior and senior high schools with comparable equipment and terminal availability should be compared in order that the results obtained in this study could be contrasted.

6. Two very important research questions need to be answered in the near future. The questions are: "What constitutes instructional use of computers in

secondary school science?" and "How effective is computer usage in secondary science instruction in assisting students to obtain the pre- defined objectives assigned to that course?" Another way to state these questions is: "What types of computer programs are the teachers using?" and "What effect do they have on the students in their classes?"

Final Remarks

The number of school administrators, teachers, and students who have an opportunity to use computers in their daily routines is increasing at an accelerating rate. The future potential of Computer Assisted Instruction is difficult to predict. Educators need to study the entire area of CAI so that desirable and good use of computers in instruction result and not just more usage. Research and training will be key ingredients in the determination of the future of CAI. As a result of this research, which dealt with a CAI training program, additional knowledge has been gained that may promote better CAI in the future.

APPENDIX A

'BASIC' LANGUAGE EXAMINATION

Name ____________________

BASIC Language Examination

General Directions: All questions on both Parts I and II assume the use of BASIC as the programming language. Your score will be obtained using the formula: S = C - 1/3 (I), where C is equal to the number of correct points and I is equal to the number of incorrect points. Your score will not be adversely affected by leaving a question unanswered.

Part I: Time Limit = 25 minutes

Multiple Choice: Please circle the letter corresponding to the correct choice. Each problem has only one correct answer.

1. Of the following, which symbol is used in flowcharting to indicate that a decision will be made?

   a) 

   b) 

   c) 

   d) 

2. Of the following equations (written in BASIC), all contain at least one mistake except:

   a) X = A + BC
   b) X = 4X
   c) X = X + 1
   d) A - B = X
   e) X = 3C

3. Of the following statement types, which one can not be used to assign information to a variable?

   a) INPUT
   b) LET
   c) RESTORE
   d) READ

4. Of the following, which 'PRINT' statement will cause one line to be skipped on the printout before printing the next result?

   a) PRINT "   "
   b) PRINT " 1 "; X
   c) PRINT "   "; X
   d) PRINT " 1 "; X

5. If X is dimensioned using the statement DIM X (5, 10):

   a) X may retain only 15 simultaneous values.
   b) An array having 10 columns and 5 rows could result.
   c) An array having 5 columns and 10 rows could result.
   d) X can accept only values such that $5 \leq X \leq 10$.

6. Assuming A = 1, B = 2, and C = 4; if a BASIC statement reads 'X = C ↑ (A/B)', what is the correct value of X?

   a) 1
   b) 2
   c) 1/2
   d) 4

7. Of the following statement types, which one can not be used to accomplish looping?

   a) GOTO
   b) IF - THEN
   c) GOSUB
   d) FOR
   e) START

8. Of the following statements, which one would be used to generate a random integer (Y), such that $1 \leq Y \leq 10$?

   a) Y = INT (10 * RND(1)) + 1
   b) Y = INT (RND(10))
   c) Y = INT (RND(1) + 10)
   d) Y = (10 * RND(1)) + 1

9. Of the following statement types, which one must be used following the use of a 'FOR' statement?

   a) RETURN
   b) GOTO
   c) RESTORE
   d) NEXT
   e) INCLUDE

10. Of the following statement types, which one would be used by programmers to insert comments to the 'user'?

   a) REMARK
   b) IMAGE
   c) PRINT
   d) READ

True - False: Please circle either T or F; circle T if the statement is entirely true, circle F if any part of the statement is false.

T F 1. Only string variables can accept alphanumerical data.

T F 2. INPUT statements are used when the data is known at the time the program is written.

T F 3. For every 'READ' statement in a program there must be a corresponding 'DATA' statement.

T F 4. All BASIC statements require a line number assigned to them.

T F 5. Each line of a program is called a 'program command'.

T F 6. System commands are the same as programming statements.

T F 7. A variable must be dimensioned if it is going to be assigned multiple values.

T F 8. User-defined functions are used to replace built-in functions.

T F 9. All numerical constants must be integers.

T F 10. Arguments for built-in trigonometric functions must be expressed in radians.

Place a check beside each of the invalid BASIC variable names.
Place a zero beside each of the valid BASIC variable names.

C$ ____	SCORE ____	S12 ____
H2 ____	E(I) ____	SD ____
$X ____	P$(9) ____	AA ____

Place the symbol in the space provided that corresponds to the mathematical operation given.

Subtraction ____	Division ____
Multiplication ____	Exponential ____

What is the numerical values of each of the following expressions?

3/(5/3/5) ____________________

3/5/(3/5) ____________________

(3/5/3)/5 ____________________

The following program was intended to accept 25 numbers from the user and print the square of that number. Check whether the statement is necessary or not, and check whether the statement is correctly written or not. (Note: A statement may be unnecessary to the program but still correct in format.)

#	Statement	Necessary		Correct	
		(yes)	(no)	(yes)	(no)
5	DIM X(25)	____	____	____	____
8	FOR X = 0 TO 25	____	____	____	____
11	INPUT N	____	____	____	____
14	PRINT N*N	____	____	____	____
17	REM THIS PROGRAM FINDS SQUARES	____	____	____	____
20	NEXT N	____	____	____	____
88	END	____	____	____	____

<u>End of Part I</u> - Return examination to proctor and pick up Part II

Name ______________________

Part II. Time Limit = 35 minutes

1. Given the following BASIC program 'PROG1', show the computer output on the lines that follow the program.

```
PROG1

10 FOR R = 1 TO 4
20 FOR C = 1 TO R
30 PRINT C;
40 NEXT C
50 PRINT
60 NEXT R
70 END
RUN
PROG1
```

____

____

____

____

____

____

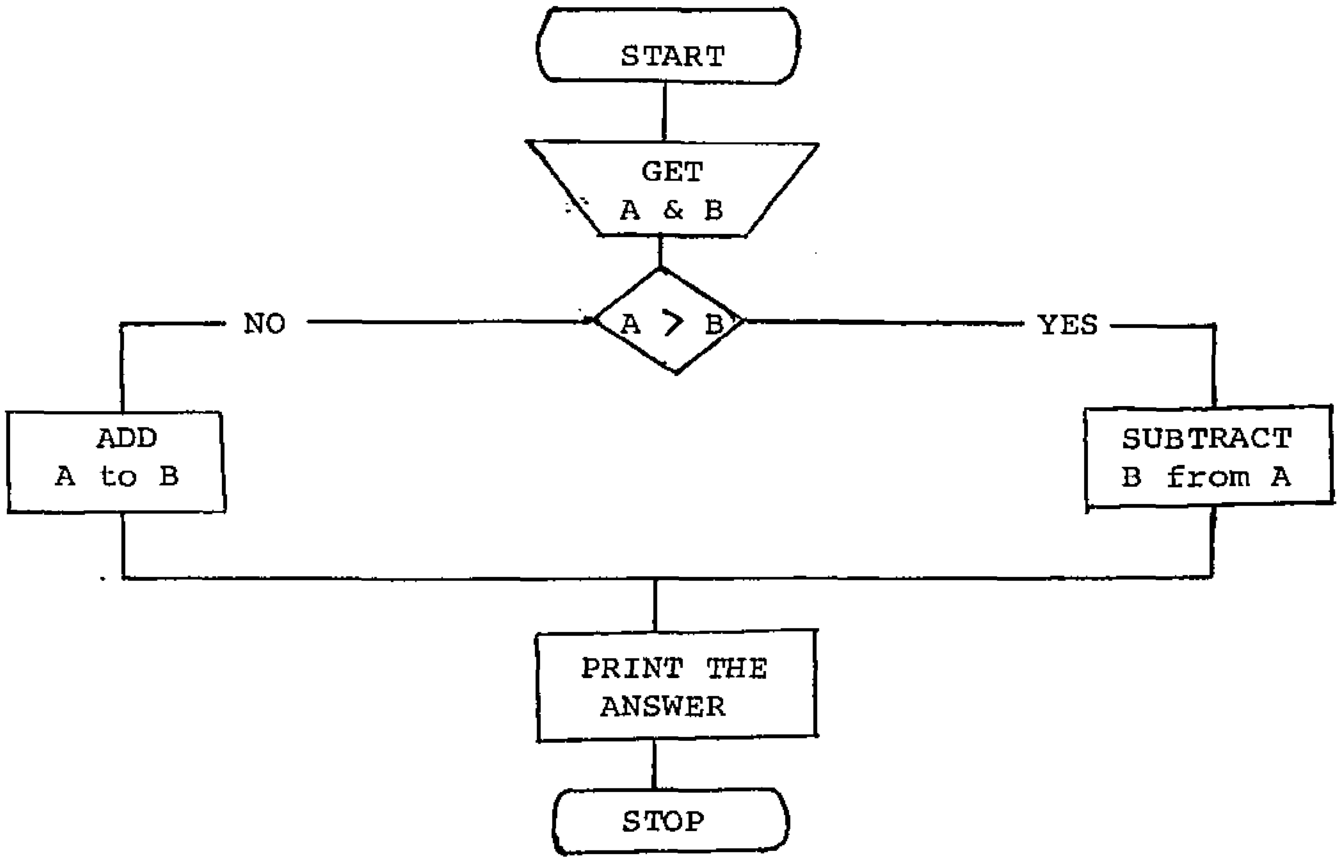
2. 'Play' computer with the following program; i.e., every time a variable changes value, show that change by crossing out the previous value and writing in the new value. Use the spaces provided following the program listing.

```
 10   DIM X(5)
 20   FOR I = 1 TO 5
 30   READ X(I)
 40   NEXT I
 50   LET N = 2
 60   LET A = X(1) * X(2)
 70   IF A > 100 THEN 110
 80   LET A = X(N+1) * A
 90   LET N = N + 1
100   GOTO 70
110   LET N = X(X(1)+1)
120   DATA 2,3,4,5,6
130   END
```

X(1)	
X(2)	
X(3)	
X(4)	
X(5)	

I	
A	
N	

3. Given the following flowchart, write a BASIC program that will solve that problem.



____

____

____

____

____

____

____

____

APPENDIX B

COMPUTER SYSTEMS' EXAMINATION

NAME ____________________

MACOMB INTERMEDIATE SCHOOL DISTRICT
COMPUTER SYSTEMS' COMMAND INVENTORY

General Directions: The purpose of this instrument is to determine the extent of your familiarity with the computer system commands necessary for operation of the Macomb Intermediate School District computer. All questions on this instrument are based on the assumption that one is using the Hewlett-Packard time-sharing system presently in use at the Macomb Intermediate School District.

Matching:

Part A: Certain keys or combination of keys are used to perform specific functions when struck during the normal use of a teletype-terminal. Determine which key(s) given in column II will accomplish the function given in column I and then place the letter corresponding to the correct answer in the space provided before the question number of the function under consideration. Each choice may be used once, more than once, or not at all.

I	II
____1. deletes current line	A. 'control' plus 'X' key
____2. deletes previous character	B. 'control' plus 'C' key
____3. used to conceal "password"	C. 'control' plus 'S' key
____4. acknowledges end of line	D. 'control' key
____5. sends "end of program" message	E. ' ← ' key
____6. suppresses printing	F. 'ESC' key
	G. 'HERE IS' key
	H. 'RETURN' key

Part B: Certain commands enable the computer to perform specific operations with programs. Column I contains a list of operations that the computer may do if given one of the commands listed in column II. Determine which command given in column II will accomplish the function given in column I and then place the letter corresponding to the correct answer in the space provided before the question number of the operation under consideration. Each choice may be used once, more than once, or not at all.

I

____1. saves current program
____2. destroys current program
____3. recalls another program which then becomes the active program
____4. removes program from user's private file
____5. recalls another program which then is added to the current program
____6. lists all user's private files
____7. assigns a name to a program
____8. lists all central program files
____9. executes program

II

A. RETAIN
B. APPEND
C. SCRATCH
D. LIST
E. GET
F. CATALOG
G. RENUMBER
H. KILL
I. GIVE
J. LIBRARY
K. TAPE
L. RUN
M. NONE OF THE ABOVE

Short Answer:

Part C: In the following questions please write your answer in the space provided.

1. What two things happen when the command 'BYE' is typed?

____

____

2. What is one of the factors that affects the amount of time that a potential user is given to 'log-on'?

____

3. What is the computer systems' immediate response when it is given a command by a user?

____

____

4. What is the minimum number of letters needed when abbreviating a command?

____

5. Assume that a program is being entered at a terminal, what command must be given before this program is able to be saved?

____

____

6. What distinguishes a private file name from a public file name?

____

____

7. Given the following program and assuming that the command 'RENUMBER-1, 10' has been given, show the new program listing by writing it in the space provided to the right of the given program.

'Old'	'New'
6 LET H = 16	________________
8 PRINT H	________________
13 INPUT X,Y	________________
16 PRINT X+Y*H	________________
17 IF Y > 15 THEN 13	________________
18 END	________________

8. What are two rules that must be followed when naming a program?

(1) ____

(2) ____

9. Assuming you have just made an error while writing a program at a terminal and the computer responded by typing 'ERROR'; how can you determine the type of mistake you made?

____

____

10. Assuming you have been prompted with the message "PLEASE LOG-ON", what should you type on the following line?

____

____

APPENDIX C

ATTITUDE SURVEY QUESTIONNAIRE

ATTITUDE SURVEY ON COMPUTER USAGE

Instructions:[1] The purpose of this study is to measure the meanings of certain things to various people by having them judge them against a series of descriptive scales. In taking this test, please make your judgments on the basis of what these things mean to you. On each page of this booklet you will find a different concept to be judged and beneath it a set of scales. You are to rate the concept on each of these scales in order.

Here is how you are to use these scales:

If you feel that the concept at the top of the page is very closely related to one end of the scale, you should place your check-mark as follows:

fair __X__:______:______:______:______:______:______unfair

OR

fair______:______:______:______:______:______:__X__ unfair

If you feel that the concept is quite closely related to one or the other end of the scale (but not extremely), you should place your check-mark as follows:

strong______:__X__:______:______:______:______:______weak

OR

strong______:______:______:______:______:__X__:______weak

---

[1] Charles Osgood, George Suci and Roy Tannenbaum, The Measurement of Meaning, (Urbana: University of Illinois Press, 1964), pp. 82-84.

If the concept seems only slightly related to one side as opposed to the other side (but is not really neutral), then you should check as follows:

active______:______:__X__:______:______:______:______passive

OR

active______:______:______:______:__X__:______:______passive

The direction toward which you check, of course, depends upon which of the two ends of the scale seem most characteristic of the thing you're judging.

If you consider the concept to be neutral on the scale, both sides of the scale equally associated with the concept, or if the scale is completely irrelevant, unrelated to the concept, then you should place your check-mark in the middle space:

safe______:______:______:__X__:______:______:______dangerous

IMPORTANT: (1) Place your check-marks in the middle of spaces, not on the boundaries:

THIS   NOT THIS

______:______:______:__X__:______X______:______

(2) Be sure you check every scale for every concept--do not omit any.

(3) Never put more than one check-mark on a single scale.

Sometimes you may feel as though you've had the same item before on the test. This will not be the case, so do not look back and forth through the items. Do not try to remember how you checked similar items earlier in the test. Make each item a separate and independent judgment. Work at fairly high speed through this test. Do not worry or puzzle over individual items. It is your first impressions, the immediate "feelings" about the items, that we want. On the other hand, please do not be careless, because we want your true impressions.

A. COMPUTER USAGE IN OUR SOCIETY

1. Good______:______:______:______:______:______:______Bad

2. Free______:______:______:______:______:______:______Constrained

3. Unintentional______:______:______:______:______:______:______Intentional

4. Unsuccessful______:______:______:______:______:______:______Successful

5. Strong______:______:______:______:______:______:______Weak

6. Active______:______:______:______:______:______:______Passive

7. Wise______:______:______:______:______:______:______Foolish

8. Small______:______:______:______:______:______:______Large

9. Effortless______:______:______:______:______:______:______Laborious

B. COMPUTER USAGE IN EDUCATION

1. Good______:______:______:______:______:______:______Bad

2. Free______:______:______:______:______:______:______Constrained

3. Unintentional______:______:______:______:______:______:______Intentional

4. Unsuccessful______:______:______:______:______:______:______Successful

5. Strong______:______:______:______:______:______:______Weak

6. Active______:______:______:______:______:______:______Passive

7. Wise______:______:______:______:______:______:______Foolish

8. Small______:______:______:______:______:______:______Large

9. Effortless______:______:______:______:______:______:______Laborious

C. COMPUTER USAGE IN YOUR CLASSROOM

1. Good______:______:______:______:______:______:______Bad

2. Free______:______:______:______:______:______:______Constrained

3. Unintentional______:______:______:______:______:______:______Intentional

4. Unsuccessful______:______:______:______:______:______:______Successful

5. Strong______:______:______:______:______:______:______Weak

6. Active______:______:______:______:______:______:______Passive

7. Wise______:______:______:______:______:______:______Foolish

8. Small______:______:______:______:______:______:______Large

9. Effortless______:______:______:______:______:______:______Laborious

APPENDIX D

DAILY LOG OF COMPUTER USAGE

DAILY LOG OF COMPUTER USAGE

Name ______________________ School ______________________

Number of teletypes/terminals in your school available to you and/or your students: __________

Do you have access to a teletype/terminal in your classroom? (yes - no) __________

Day	Week	# of programs used	# of times programs were used	Week	# of programs used	# of times programs were used
1		______	______		______	______
2		______	______		______	______
3	1	______	______	2	______	______
4		______	______		______	______
5		______	______		______	______

Day	Week	# of programs used	# of times programs were used	Week	# of programs used	# of times programs were used
1		______	______		______	______
2		______	______		______	______
3	3	______	______	4	______	______
4		______	______		______	______
5		______	______		______	______
1		______	______		______	______
2		______	______		______	______
3	5	______	______	6	______	______
4		______	______		______	______
5		______	______		______	______

Day	Week	# of programs used	# of times programs were used	Week	# of programs used	# of times programs were used
1		______	______		______	______
2		______	______		______	______
3	7	______	______	8	______	______
4		______	______		______	______
5		______	______		______	______
1		______	______			
2		______	______			
3	9	______	______	Total	______	______
4		______	______			
5		______	______			

APPENDIX E

PREDICTOR VARIABLES AND CATEGORIES

VARIABLE 1	Categories	Years of Teaching Experience
	1	0 - 3
	2	4 - 6
	3	7 - 9
	4	10 or more

VARIABLE 2	Categories	College Science Background in Semester Hours
	1	0 - 45
	2	45 - 90
	3	Over 90

VARIABLE 3	Categories	College Mathematics Background in Semester Hours
	1	0 - 7.5
	2	7.6 - 15.0
	3	15.1 or more

VARIABLE 4	Categories	Secondary School Classification
	0	Senior High School Teacher
	1	Junior High School Teacher

Variable 5, 6, and 7 in the data file were not used as predictor variables.

VARIABLE 8	Categories	Post-test Score on BASIC Language Examination*
	1	Less than 35.84
	2	35.84 or greater

*50 points possible

VARIABLE 9	Categories	Post-test Score on Computer System Examination*
	1	Less than 40.73
	2	40.73 or greater

*50 points possible

VARIABLE 10	Categories	Post-test Score on Attitude Questionnsire*
	1	Less than 4.811
	2	4.811 or greater

*Score possible: $1 \leq x \leq 7$

VARIABLE 11	Categories	Amount of Terminal Time (Minutes) during Summer Institute
	1	Less than 2,491
	2	2,491 or more

VARIABLE 12	Categories	Terminal Access in Classroom
	0	No
	1	Yes

VARIABLE 13	Categories	Number of Computer Terminals Available for CAI
	1	1
	2	2 - 3
	3	4
	4	Over 4

Variables 14, 15, and 16 in the data file were not used as predictor variables.

VARIABLE 17	Categories	Teaching Area (Major Subject)
	1	Biology
	2	Chemistry
	3	Earth Science
	4	Physics
	5	General Science

APPENDIX F

DATA FILE

DATA FILE

CASE	EXPER*	SCIHRS	MATHRS	SCHOOL	EXAM1	EXAM2	AT-PRE	EXAM1'	EXAM2'	AT-POS	TIME	ACCESS	#-TERM	#-PROG	#-RUNS	OWNUSE	COURSE
1	13	22	1Ø	1	5	9	3.4	44	37	3.3	2617	Ø	1	4	1Ø	1ØØ	5
2	7	32	7	1	1	4	3.5	3Ø	39	4.6	1699	1	4	17	253	9	5
3	3	24	4	Ø	2	3	4.4	35	36	5.1	2615	Ø	3	1	1	Ø	1
4	6	47	29	Ø	Ø	2	4.6	34	41	5.Ø	1962	Ø	1	2	4	Ø	2
5	3	68	3	Ø	Ø	1	5.7	33	32	5.1	2845	1	5	4	7	57	2
6	4	39	4	1	7	7	4.5	35	39	5.1	3926	1	4	36	67	9	5
7	2	71	8	Ø	2	5	4.6	4Ø	39	4.8	1324	1	7	6	3Ø	33	1
8	4	63	9	1	1	3	4.9	35	48	4.7	1942	1	3	16	148	13	5
9	2	46	1Ø	Ø	Ø	3	4.1	34	43	5.3	18ØØ	Ø	1	3	4	Ø	1
10	5	48	6	1	1	11	4.Ø	4Ø	39	5.4	2218	Ø	3	18	6Ø	Ø	5
11	9	38	6	Ø	Ø	1	4.1	38	36	3.2	1512	Ø	5	29	77	3Ø	1
12	13	68	6	Ø	1	5	4.Ø	28	33	4.5	1396	1	4	3Ø	871	78	1
13	5	6Ø	25	Ø	33	1Ø	5.9	46	48	5.4	2693	1	6	14	24Ø	5	4
14	7	143	18	Ø	5	11	4.5	45	44	4.9	2951	Ø	2	24	165	66	4
15	3	56	11	1	32	17	3.8	42	43	3.6	32Ø3	1	6	47	676	67	5
16	2	66	12	Ø	5	5	4.2	47	45	3.8	21Ø1	Ø	4	6	14	21	1
17	16	98	27	Ø	3	3	4.3	23	33	5.3	2982	1	12	6	297	7	1
18	1	72	3	Ø	Ø	4	4.6	43	48	5.1	3184	1	4	1	15	Ø	2
19	13	92	24	1	1	3	4.2	32	4Ø	5.9	3Ø61	1	4	1Ø	111	17	5
20	16	59	35	Ø	Ø	3	4.4	36	39	4.9	4988	Ø	5	5	597	2Ø	2
21	7	97	9	Ø	Ø	7	4.9	31	4Ø	5.4	2912	1	1	46	268	9	1
22	9	62	32	Ø	5	5	3.5	34	43	3.7	1234	1	4	9	27	11	3

CASE	EXPER*	SCIHRS	MATHRS	SCHOOL	EXAM1	EXAM2	AT-PRE	EXAM1'	EXAM2'	AT-POS	TIME	ACCESS	#-TERM	#-PROG	#-RUNS	OWNUSE	COURSE
23	1Ø	78	29	Ø	14	8	3.7	39	44	4.8	3688	1	12	1	36	Ø	2
24	18	83	Ø	1	Ø	Ø	4.Ø	3Ø	37	5.Ø	2976	1	3	16	1ØØ	68	5
25	7	73	6	1	2	1	5.5	38	44	5.9	2131	1	3	46	24Ø	23	5
26	9	83	17	Ø	Ø	2	4.6	39	41	3.8	413Ø	Ø	5	18	835	88	2
27	2	68	8	Ø	11	7	5.9	31	44	5.Ø	1785	Ø	3	13	332	24	2
28	1Ø	79	8	1	Ø	4	4.7	36	35	5.3	2625	1	4	44	116	3	5
29	8	111	9	Ø	14	18	4.4	3Ø	48	4.8	187Ø	Ø	1	115	311	23	5
30	6	97	7	Ø	Ø	Ø	4.1	22	38	5.Ø	1713	Ø	5	19	249	6	1
31	6	65	9	1	2	11	4.5	26	46	4.8	31Ø9	1	4	53	2Ø9	Ø	1
32	7	59	7	1	1	5	4.6	29	4Ø	4.1	1235	1	1	4	492	32	5
33	1Ø	69	7	1	Ø	Ø	6.1	41	39	5.7	3Ø1Ø	Ø	1	4	23	22	5
34	4	57	17	Ø	Ø	5	4.3	39	45	4.Ø	1133	1	4	11	33	6	1
35	4	69	18	Ø	6	5	6.Ø	45	43	5.5	2815	1	1	81	159	48	2
36	7	4Ø	21	Ø	18	1Ø	5.4	42	35	5.4	2122	1	4	1Ø	282	96	3
37	Ø	66	Ø	1	31	9	4.7	34	43	4.8	2644	Ø	2	4	435	41	5

* Explanation of abbreviations given in table 3.

APPENDIX G

HISTOGRAM OF #-RUNS

```
                No. of Measurements = 37
                  |---------+---------+---------+
   1.Ø            +
               12 |************
  44.5            +
                3 |***
  88.Ø            +
                3 |***
 131.5            +
                3 |***
 175.Ø            +
                1 |*
 218.5            +
                4 |****
 262.Ø            +
                3 |***
 3Ø5.5            +
                2 |**
 349.Ø            +
                Ø |
 392.5            +
                1 |*
 436.Ø            +
                Ø |
 479.5            +
                1 |*
 523.Ø            +
                Ø |
 566.5            +
                1 |*
 61Ø.Ø            +
                Ø |
 653.5            +
                1 |*
 697.Ø            +
                Ø |
 74Ø.5            +
                Ø |
 784.Ø            +
                Ø |
 827.5            +
                2 |**
 871.Ø            +
                  |---------+---------+---------+
                  Ø        1Ø        2Ø        3Ø
```

Histogram of #-RUNS

APPENDIX H

CORRELATIONS FOR ALL VARIABLES

CORRELATIONS -- 37 Measurements

VARIABLE	EXPER	SCIHRS	MATHRS	SCHOOL	EXAM1	EXAM2
EXPER	1.0000					
SCIHRS	0.2041	1.0000				
MATHRS	0.3542	0.1231	1.0000			
SCHOOL	0.1192	-0.2052	-0.4009	1.0000		
EXAM1	-0.2832	-0.0420	0.1089	0.0444	1.0000	
EXAM2	-0.2222	0.1004	0.0464	0.0738	0.6623	1.0000
AT-PRE	-0.2942	0.1298	-0.0775	-0.1109	0.1456	-0.1265
EXAM1'	-0.2879	-0.1767	0.1393	-0.0869	0.2929	0.2181
EXAM2'	-0.4438	0.1949	0.1224	-0.0155	0.3230	0.3858
AT-POS	-0.0071	0.2754	-0.0012	0.0694	-0.0628	-0.1569
TIME	0.2820	0.1557	0.2340	0.0983	0.1078	0.0440
ACCESS	0.0828	0.0312	0.0530	0.1902	0.0506	-0.0010
#-TERM	0.2222	0.1174	0.3725	-0.2372	0.1639	-0.0361
#-PROG	-0.0047	0.3168	-0.1581	0.0617	0.1342	0.4738
#-RUNS	0.2157	0.1684	0.0506	-0.0022	0.2650	0.2101
OWNUSE	0.2368	0.0224	-0.1065	0.0256	0.1892	0.1565
COURSE	0.1395	-0.0072	-0.1918	0.7757	0.2935	0.2744

CORRELATIONS -- 37 Measurements

VARIABLE	AT-PRE	EXAM1'	EXAM2'	AT-POS	TIME	ACCESS
AT-PRE	1.ØØØØ					
EXAM1'	Ø.2111	1.ØØØØ				
EXAM2'	Ø.1154	Ø.3Ø91	1.ØØØØ			
AT-POS	Ø.5467	-Ø.1383	-Ø.Ø335	1.ØØØØ		
TIME	Ø.Ø927	Ø.1724	-Ø.Ø181	Ø.22Ø5	1.ØØØØ	
ACCESS	Ø.Ø669	-Ø.1Ø97	-Ø.Ø259	Ø.1747	-Ø.Ø354	1.ØØØØ
#-TERM	-Ø.2136	-Ø.Ø962	-Ø.171Ø	-Ø.Ø588	Ø.2443	Ø.34ØØ
#-PROG	Ø.1325	-Ø.Ø819	Ø.2421	Ø.Ø829	Ø.ØØ11	Ø.1111
#-RUNS	-Ø.Ø144	-Ø.2277	-Ø.Ø827	-Ø.1973	Ø.1898	Ø.Ø103
OWNUSE	Ø.Ø228	Ø.2552	-Ø.3213	-Ø.3349	Ø.Ø9Ø7	-Ø.Ø424
COURSE	Ø.Ø112	Ø.1433	Ø.1221	Ø.1173	Ø.Ø971	Ø.Ø958

CORRELATIONS -- 37 Measurements

VARIABLE	#-TERM	#-PROG	#-RUNS	OWNUSE	COURSE
#-TERM	1.ØØØØ				
#-PROG	-Ø.2447	1.ØØØØ			
#-RUNS	Ø.Ø81Ø	Ø.2Ø88	1.ØØØØ		
OWNUSE	-Ø.1375	Ø.Ø438	Ø.4367	1.ØØØØ	
COURSE	-Ø.2985	Ø.1668	Ø.Ø274	Ø.1644	1.ØØØØ

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Humboldt Institute, Minneapolis, Minnesota - 1961 - Airline and Traffic Management Degree

Shippensburg State College, Shippensburg, Pennsylvania (1962 - 1965) Major: Mathematics Minor: Physics Degree: B.S. in Education

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University of Wisconsin, Milwaukee, Wisconsin (1967 - 1968) Major: Teaching of Physics Degree: M.S. in Physics

University of Maryland, College Park, Maryland (1970 - 1971) Major: Science Education

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