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DEVELOPMENT OF A MICROCOMPUTER IMPLEMENTATION MODEL
AN IN-SITU, ADAPTIVE RESEARCH PARADIGM

by

© JOHN TRAVERS

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ABSTRACT

The purpose of this study was to investigate a rather complex, but timely educational innovation. Specifically the focus of the research was to "uncover" the pertinent variables associated with the implementation of a microcomputer into a junior high school setting.

As a result of tremendous reductions in both the size and cost of computer hardware and commensurate improvements in computer speed and reliability, micro-electronic research has produced the microprocessor or "computer on a chip." These developments have re-awakened education's interest in the possible utilization of these devices within the classroom.

Since the microcomputer has not, as yet, appreciably entered the educational milieu, their implementation is a necessary condition. Research on implementation projects in the past has shown that the process of change, especially teacher role change, within the classroom setting is certainly non-trivial. Therefore considerable attention was focused on the implementation plan to be utilized in the change process. Since classroom operation of the microcomputer was considered a major project outcome, an in-situ research model was selected. Finally, since research on previous implementation projects revealed that teachers modify materials to make them operable within their classrooms, a "mutually adaptive" implementation paradigm was selected.

The sample consisted of six teachers and their principal at a junior high school within the Edmonton Public School System. The research was carried out from December 1979 to June 1980. After rather extensive preparation the teachers, with two exceptions, were able to

choose an application, utilize the programs within their classrooms, and assess the efficacy of their application and the microcomputer within the junior high school system.

The research revealed two major impediments to microcomputer implementation. The teachers experienced initial difficulty learning the BASIC language and applying this knowledge to the production of courseware. The other major difficulty the teachers experienced was coping with the one-to-one restrictiveness of the present generation of microcomputers within their classrooms.

On the other hand the microcomputer proved to be reliable and quite easy to operate. The teachers perceived the microcomputer as having considerable potential as an instructional device and became actively involved in the project. Also of significance was the intense interest generated by the students involved with the project.

This research indicates that with adequate support typical teachers are entirely capable of utilizing the microcomputer as an instructional device. The form and extensity of the consultative assistance during the implementation process is though a critical factor to the innovation's success.

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THE PROBLEM

INTRODUCTION

A number of educators in the early 1960's saw possibilities for the utilization of computers in education. Unfortunately very few of these early projects survived beyond three or four years. Hunka (1976) observed a number of reasons for these failures. He states:

> Some educators thought that one could simply plug the computer into a power source, and presto, instant education!...
> Some educators thought that the computer was the ideal method of delivery of programmed instruction.
> The result was that CAI (Computer Assisted Instruction) became sterile page turning.
> Some educators in charge of CAI facilities did not understand even the most elementary concepts of computing....
> Educators and teachers could not, or would not, translate their effective teaching strategies used in the classroom, to the strategies required by the computer....

The feasibility of successful integration of the computer into the educational milieu today could be slightly opportune. Researchers, acquainted with this area, are no longer so naive to assume that the computer will replace the teacher. There is considerable doubt that the computer should; even if it could. There is, though, a rather negative pre-history that researchers and teachers must overcome. One focus of this study is to attempt, as much as possible, to alleviate the fear and suspicion which surrounds this new technology.

The centers which did survive (PLATO at the University of Illinois, TICCIT designed by the MITRE corporation, and DERS at the University of Alberta, to name a few) continued to develop instructional expertise in this medium, but very few of these had an appreciable effect on the public educational system. This situation might have remained the same had it not been for the development of some rather exciting discoveries in the field of micro-electronics.

Heretofore the development of educational computer systems had been rather large ventures requiring fairly large budgets to become operational. Since the finances required were generally beyond the grasp of the individual school, development in this area was limited to large "time-sharing" systems, generally situated around large urban centers.[1] To be viable these systems required, not only large amounts of capital, but a fair degree of interschool cohesion. These factors tended to inhibit, in large part, the development of computing in the public school system.

Beginning in the early 1970's micro-electronics research produced the microprocessor or "computer on a chip." By the mid 1970's these devices were beginning to be marketed as "stand-alone" microcomputers. These machines had the power of their earlier cousins at a fraction of the cost. Licklider (1979) states "the cost-effectiveness of computing increased more than a million times in the interval since World War II." (p. 1). The situation today is that a school system or even an individual school can afford the purchase of these devices. This cost effectiveness notion is now being used as a rationale for the purchase of microcomputers in education. Unfortunately, though cost effectiveness may be a necessary condition for success, it is by no means sufficient.

A computer still requires a program or sequence of instructions to make it at all useful. The microcomputer at its present stage of

[1]The PLATO system has approximately 800 terminals connected to one computer. Chicago has about 900 terminals in its public schools.

development is not a "plug-in-teaching-machine." The program required, and even more fundamentally, the educational situations intended for this device, must be researched. The complexity of the microcomputer may necessitate a greater degree of teacher awareness than is required with the more traditional teaching technologies (books, film, etc.). Is it possible to expect the typical teacher to respond in the necessary ways such that this new technology can be implemented effectively into the classroom? It is the intention of this study to find the answer to this question.

STATEMENT OF THE PROBLEM

"In 1960, the number of high speed electronic computers in existence was not very large, nor was the number of individuals to make use of them. Today, the number of computers in existence has vastly increased, and their use by banks, retail stores, etc. means that they directly affect the life of the average citizen.... In fact, the role of computers in our society is so important that a national committee (The Conference Board of the Mathematical Sciences, Committee on Computer Education) has called for a course on 'computer literacy' to be made a requirement for all secondary school students." (Begle, 1979, p. 17). With the above position statement, the recommendations regarding computers in schools is clear. The cost effectiveness of the microcomputer is such that the financial impediments have been removed. It would seem propitious then to research the potential of this innovation in the school milieu.

The following questions exemplify the areas of concern of this study:

Will the teachers recognize the need for microcomputer utilization within the classroom?

Will the teachers be capable of developing the knowledge, skill, and understanding necessary for the implementation?

Will the teachers be willing to devote the necessary time and energy for project success?

What effect will the implementation model have on the development of classroom utilization.

Will the microcomputer, at its present stage of development, provide adequate potential for educational utilization?

What effect will the social dynamics of the implementation process have on innovative success?

PURPOSE OF THE STUDY

The purpose of this study is to investigate the determinant variables associated with the implementation of a microcomputer into a junior high school.

A basic premise of this study is: that not only are microcomputers a relatively sophisticated innovation, but also that the implementation process itself is complex and interrelated. Sarason (1971) contends, that because implementation is complex, very little is known about it and as a consequence very few implementation proposals become intended outcomes.

To approach this problem in a linear-unidirectional research, development, and dissemination paradigm would not seem to be fruitful. (Guba and Clark, 1975; Stenhouse, 1975). Hunka (1978) states "The crucial factor which is missing in the research sequence is the monitoring and feedback required to correct basic theory, and to refine and tune our procedures and materials at the development stage.... Researchers seem to be most cognizant of the need for monitoring, but the research environment is too restrictive, when compared to the classroom environment, to assume that what works well in one will work well in the other." (p. 14). Elaborating on this theme, Oettinger (1969) asserts "But time and time again in the brief history of computers glowing experimental results have lost their meaning in the translation from pilot scale to useful operating size." (p. 186). What emerges from these references is that a traditional statistically oriented model of research may be inappropriate.

The impact of an innovation is not a simple set of discrete effects, but it is a complicated pattern of events formed by the participants. Therefore, it is not simply sufficient to recognize the need for an "in-situ" feedback research paradigm, but it is also necessary to identify, as clearly as possible, the potential impediments and incentives of the implementation. Wolcott (1977) identifies the teacher and the administrator as the crucial players in the implementation process. Sarason (1971) focuses on the school culture as an important factor. Fullan, Eastabrook, and Biss (1977) and Fullan and Pomfret (1977) in an extensive review cite a number of critical factors which are determinants for innovative success. The implementation research process would then seem to be furthered by "threading" a plausible course through this complex field in order to arrive at an operational model consistent with innovative success.

DEFINITION OF TERMS

Adaptive Implementation refers to an implementation mechanism which is sensitive to environmental conditions and modifies itself in order to accommodate identified needs.

Algorithm refers to a list of instructions specifying a sequence of operations which give the answer to a problem.

BASIC (Beginner's All-purpose Symbolic Instruction Code) refers to a programming language that is one of the easiest computer languages to learn, use, and teach.

BIT refers to the smallest amount of information a computer can hold.

BYTE refers to a basic unit of computer memory (generally eight BITS).

CAI (Computer Assisted Instruction) refers to a method of using a microcomputer to present instructional materials.

CAL (Computer Augmented Learning) refers to a method of using a computer to supplement traditional instruction.

CRT (Cathode ray tube) refers to the screen which computer information is conveyed.

CMI (Computed Managed Instruction) refers to an application of computers as the record keeper, manager, and prescriber of instruction.

Coding refers to the writing of computer instructions in a programming language.

Computer literacy refers to an understanding of the computer's principles of operation, application, programming and social repercussions of the computer.

Courseware refers to the sets of instructions which compose an educational program for the computer.

Debugging refers to the process of eliminating mistakes from a computer program.

Digital computer refers to a machine which processes data. It is capable of accepting information, operating on it in a prescribed way, and supplying the results.

Fidelity Model refers to a traditionally structured approach focusing on the input and output concerns of implementation.

Floppy disks refers to auxiliary storage devices used with computers. It is housed in a cardboard jacket which resembles a 45-rpm record.

Flowchart refers to a pictorial description of a computer solution to a problem which is used as a guideline for writing the program in a computer language.

Hardware refers to the physical equipment of the computer.

High Level Language refers to a computer language more intelligible to humans.

Integrated circuit refers to an electronic circuit in which all the components are fabricated in a tiny area.

Main Frame Computer refers to a large computer installation servicing an extensive application

Microcomputer refers to a small low-cost computer. It contains at least one microprocessor, memory, and other devices to receive and follow instructions.

Microprocessor refers to an integrated circuit which performs the task of executing instructions.

Minicomputer refers to a medium sized computer typically servicing a limited application.

Program refers to an ordered list of statements which direct the computer to perform certain operations in a specified sequence.

Simulation refers to the representation of physical systems and phenomena by computer.

Software refers to programs for use on a computer.

Time-sharing refers to a method of sharing a computer among several users.

Terminal refers to an input/output device coupled to the microcomputer.

ASSUMPTIONS

In the interpretation of this study the following assumptions must be considered:

1. The specific computer projects selected by the teachers will be representative of the computer's potential in these areas.

2. The teachers will be valid assessors of the classroom implications of the microcomputer.

3. The teachers are "typical" of junior high school teachers with respect to computer knowledge and interest.

DELIMITATIONS

In the interpretation of this study the following delimitations will have to be considered:

1. The study is confined to six full-time teacher volunteers (five Mathematics and Science and one Industrial Arts and their principal in one Edmonton Public Junior High School).
2. The classroom experimentation is restricted to those of the teachers involved in the project.
3. The specific computer applications will be chosen by the teachers.
4. Software development will be restricted to small representative program areas either teacher or consultant developed.
5. A number of areas of potential computer usage will not be attempted (CAI or tutorial) as these require considerable pre-programming before the computer can be utilized.

LIMITATIONS

In the interpretation of the data, the following limitations will have to be considered:

1. The school was not randomly chosen. It is thought "typical" of junior high schools in the Edmonton area.
2. The results of the study may be restricted to mathematics and science teachers at the junior high level.
3. The study is of a limited duration (6 months).

IMPORTANCE OF THE STUDY

Spencer (1978) begins his book with the following statement:

> "The computer is now becoming available to a large segment of the population and is beginning to have an impact on our daily life. It is reshaping century-old ways of doing things. This machine, human's most remarkable invention, is invading every nook and cranny of society, opening up vast new possibilities by its extraordinary feats of rapid calculation. It has made possible to multiply by milllions of times the capabilities of the human mind. In short, it is becoming so essential a tool, with so much potential for changing our lives and our world, that it is necessary for everyone to know something about it. (p. 15).

But Licklider (1979) goes on to point out:

> But the field of education is not taking much advantage of the new technology. Education is not only missing a great opportunity; it is failing to discharge a crucial responsibility. The world is rapidly moving into the 'information age.' In order to make the transition wisely and well, the public must understand information science and technology. (p. 1).

For computer technology to have an appreciable positive impact on education, teachers will have to understand and adapt them to their needs. Effective implementation of these devices is by no means simplistic. Teachers may hold scepticisms for innovations and a collection of predisposed feelings about computers in general. Emphasis for implementation must be in the field (Stenhouse, 1975) rather than in specialized curriculum development departments. This study will attempt to evaluate an "in the field" feedback model for microcomputer implementation. If successful the results should:

1. serve as a beginning for further research in microcomputer implementation in the provinces;
2. serve as a "guide" for other schools or districts interested in implementation of the microcomputer;

3. serve as a beginning for teacher developed computer related curricula in this school and the province.

CHAPTER II

REVIEW OF THE LITERATURE

INTRODUCTION

The purpose of this chapter is to explore what at first glance might appear to be three rather divergent fields of inquiry: microcomputer technology, implementation paradigms, and in-situ educational research.

Developments in electronic computational automata are traced from their infancy, scarcely forty years ago, to today's microcomputer technology. As a result of rather dramatic developments in this industry, there has been a call for utilization of these devices within the educational system. This is essentially an implementation problem as the microcomputer has not yet appreciably entered the educational milieu. Two implementation models and determinant factors are discussed which are deemed pertinent to the implementation problem. Finally an in-situ ecological research paradigm considered appropriate for this project is discussed. The following chapters will then attempt to <u>integrate</u> these diverse fields of inquiry into an operational model for microcomputer implementation within the schools.

DEVELOPMENTS IN COMPUTATIONAL AUTOMATA

To be truly honest to an understanding of the recent developments in the domain of computational automata it is necessary to acquire a brief historical perspective of the development of computing technology. Throughout history mankind has devoted considerable energy to the development of ciphering aids. One of the first of these instruments was the abacus, which reduced the drudgery of long repetitive calculations. Much later in the 1600's a Frenchman named Blaise Pascal invented the first real calculating machine composed of a complex collection of gears and wheels. By the eighteenth century, because of increasing interest in surveying, architecture, and navigation, calculating devices were being constructed to compute the required numerical tables. Soon after, the integration of the punched card and the calculating machine enabled Hermin Hollerith and others to automate the American census. Continued development in electro-mechanical technology led to the successful development of the first general purpose computer, the Harvard Mark I in 1944. Between 1943 and 1945 a computer called the ENIAC was developed, composed of 18,000 vacuum tubes as switching devices. Although this computer was the first truly electronic computer, it exhibited a number of imperfections which set the stage for the truly astounding technological developments to come. Specifically, the ENIAC was large and bulky, weighed an impressive 30 tons, generated copious amounts of waste heat, and was frequently inoperable due to the need to replace defective vacuum tubes.

Shortly thereafter, the invention of the transistor in the BELL laboratories was immediately recognized as a successor to the inefficient vacuum tube. The generation of computers composed of this technology were much smaller, more reliable, and far less costly to operate. A penchant for continued miniaturization led to the inclusion of a number of transistors on a silicon chip, called the integrated circuit (IC). This development continued the trend towards computers which were smaller, cheaper, and more reliable.

In 1971 the INTEL Corporation developed the first programmable, single chip microprocessor (INTEL 4004) for use in a computer terminal. Although its operation was too slow for a terminal, INTEL's success inspired the company to develop the INTEL 8008 and later the INTEL 8080. The capabilities of the INTEL 8080 microprocessor was quickly recognized as a candidate for the central processing unit of a computer. By the mid 1970's these microprocessors were being linked to memory and input-output devices to create the microcomputer (Vacroux, 1975).

In early 1975 the Altair 8800 microcomputer was marketed in kit form requiring the user to have previous electronic or computing experience. Sold in this form the microcomputer did not attract much attention from most educators, but in mid 1977 the Commodore company announced the PET 2001, a fully functional microcomputer ready for immediate operation. This system was very quickly recognized as having considerable potential for public education. This market and others were identified as offering considerable financial return for investment and very quickly a number of companies were producing microcomputers. A number of these were: the APPLE, the TRS-80, the IMSAI, the COMPUCOLOR, the HORIZON, and a host of others. A few of these units were so popular that "total sales by the end of 1979 included more than 100,000 TRS-80s, 80,000 APPLEs, 30,000 PETs, and 10,000 COMPUCOLORs" (Hallworth and Brebner, 1980, p. 112).

Before considering the potential the microcomputer has for education, it would seem propitious to extrapolate a short distance into the future to assess the possible direction of microcomputer hardware development. Using photo-reduction techniques it is now possible to manufacture 8 bit microprocessors capable of accessing about 64,000 memory locations. Utilizing electron-beam techniques more powerful 16 bit microprocessors are becoming available which will make the microcomputer as powerful as many of today's minicomputers. The density of memory chips is also expanding and becoming much cheaper. Today's memory chips can store upwards to 32,000 characters per chip with access times typically less than a microsecond. Peripheral floppy disks now store about 125,000 to 150,000 characters per side, but with the advent of cheaper, more reliable hard disk mediums, microcomputers with disc access to more than 10 million characters will soon be available.

These technological developments clearly indicate that computational hardware is decreasing in both cost and size with ever increasing calculational abilities. In this regard, Hallworth and Brebner (1980) make the following statement:

> Herbert Grooch, Past President of the Association for Computing Machinery, estimates that the computer revolution with known technology is now about two-thirds complete. He has predicted that by the year 2000 it will be possible to get 100 million components on one chip the size of a fingernail, and that machines with the power of the large systems available today, such as the CDC 6600, will by then be the size of a wristwatch and cost something in the range of $10 to $100. (p. 6).

EDUCATIONAL IMPLICATIONS

As a result of the large scale integration of computational hardware, the visibility of these devices has increased markedly in the last decade. Microprocessors are now playing an increasingly ubiquitous role in a number of applications within the post-industrial western cultures. Banking institutions and retail outlets have shown an enormous increase in their reliance on distributed information processing. Computers have also played a role in education, but it has been minimal. There are a number of reasons for this, perhaps the most important being the fairly extensive financial commitment required for entry into the computer market. Either lack of access to funds of sufficient size or the inability to combine resources have, to a large extent, restricted extensive computer usage in the educational scene to research projects within post-secondary institutions. This cost impediment has dramatically disappeared and as a result schools are now actively considering the purchase of microcomputers. A recent survey by Creative Strategies Inc. predicts the number of school purchases of microcomputers will quadruple between 1978 and 1982.

This increase in microcomputer purchases can in part be explained by the reduction of price of this machinery, but not entirely. Hooper (1978) contends that "mainly as a result of automation, industrial countries are now experiencing the decline of manufacturing industry as the major employer of the nation's workforce." (p. 148). As a result of this phenomenon, the major employer in the U.S. is shifting towards the information based industries (Program of Information Resources Policy, 1976, p. 4). Commensurate with this employment shift is a public recognition of the need for further education in order to train a citizen for the emerging society. The role of the computer as a control device in this technological transition is widely accepted. This movement has caused responsible educators to renew their interest in the educational applications of this device.

Possibly a third and convincing reason for the renewed interest in computer assisted instruction is the public perception that the education system is perceived as being unsatisfactory (OECD, 1976; Braun, 1980). There are a number of reasons for this, but perhaps the most visible is the perception of declining academic achievement. The genesis of this decline is quite possibly a reflection of the limitations in the structure of the mass educational system. The restrictions in the lock-step curriculum, standardized materials, and classes in which one teacher attempts to direct the instruction of a large group of students, often assumed to be at the same achievement level, may be a major contributory factor (Hallworth and Brebner, 1980). One way out of this impasse is seen to be the preparation of an individualized curriculum presented via the computer medium. The implicit intention here is to utilize the computer's extensive memory and speed to present the students with instructional materials consistent with their unique achievement level. Two large scale computer projects within education, which have extensively researched this dimension, are the drill and practice programs of Dr. Patrick Suppes at Stanford and the development of tutorial materials using the PLATO system at Urbana, Illinois. Each of these projects represents extensive experimentation with utilization of the computer medium in instruction and deserve further consideration.

During the 1920's and 1930's considerable interest was devoted to studies investigating the rote skills development of students by means of drill (Begle, 1979). This interest was recognized by Dr. Patrick Suppes as having considerable applicability to computer utilization. In 1963 the Institute for Mathematical Studies in the Social Sciences was established, under his direction, to investigate this domain. Considerable effort was expended to create instructional materials in mathematics, reading, and language arts, generally at the elementary school level. Extensive evaluations in different locations in the U.S. have shown consistent results favoring this form of computerized instruction over conventional means, with the most impressive gains shown in those areas with a higher representation of lower ability students (e.g. Los Neitos, California). As a result of the rather impressive success of this project, the Computer Curriculum Corporation was established in 1969 to market these materials. It may be of interest that this corporation continues to market these materials on an international basis and was recently in Edmonton promoting their courseware.

The other computer project of considerable significance was the PLATO project started in 1960 at the University of Illinois. Among the first of the computer projects in education, it has continued to develop and is perhaps the major contributor to tutorial computer instruction. Perhaps, most significant of its differences from the drill materials developed at Stanford, is its encouragement for instructors to develop their own materials utilizing the TUTOR language. The philosophy that teachers should be in control of the development of courseware is deemed central to its success and is reflected in the positive attitudes students have expressed towards the system. Evaluations performed by the Educational Testing Service in 1975-76 and the following year show significant gains over traditional instructional patterns. Hallworth and Brebner (1980) report "students' attitudes towards the PLATO mathematics materials were very positive, and their attitude towards mathematics itself, and towards their own ability to cope with mathematics, clearly improved with experience on PLATO." (p. 21).

The efficacy of computer assisted instruction has been reviewed extensively (Jamison, Suppes, and Wells, 1974; Edwards, Norton, Taylor, Weiss, and Van Dusseldorp, 1975; Thomas, 1979). All of these reviews, with very few exceptions, report achievement gains over traditional methods, retention equal to traditional instruction, favorable attitudes towards the computer and often the subject being taught, and typically these results being achieved in a shorter time period. These findings are consistent with a review recently conducted of thirty-two studies performed by HumRRo for the Office of Technology Assessment. These conclusions lead Hallworth and Brebner (1980) to report, "Certain findings, however, are consistent over the projects. These include two very important considerations, namely that students do learn from CAI materials and they do on the whole enjoy learning in this manner." (p. 79).

Perhaps the most disconcerting aspect of the Hallworth and Brebner (1980) report are the results of an Alberta survey they conducted in the summer of 1979 which showed "there was practically no CAI in the schools and few of the districts were contemplating its introduction in the near future." (p. 100).

This situation will change rapidly with the cost availability of the microcomputers. Two very real impediments, though, remain to the development of efficacious utilization of the microcomputer. These are:

A lack of awareness and training among the teachers on the uses of the microcomputer in education.

The lack of adequate "quality" courseware (Braun, 1980).

Two major focuses of this study will be to assist the teachers in specifying the potential applications for a microcomputer in their school and assistance with the development of courseware for their application.

SUGGESTIONS FOR EDUCATIONAL MICROCOMPUTER APPLICATION

Computer Literacy

The utilization and visibility of microcomputer applications in the every day affairs of industrial societies has increased markedly in the past decade. Many of the nation's employees have their payroll cheques produced by a computer system. Factories are beginning to install automated control processors, banks now offer daily interest calculations and inter-branch banking, hotels allocate rooms via computerized reservations systems, department stores calculate inventories and customer accounts with a new breed of "intelligent" cash terminals, the typewriter is being replaced by the text processor, and the credit card has become international. Educators generally agree that the curriculum should reflect the developments of society, prompting the National Council of Teachers of Mathematics (NCTM) to recommend in An Agenda for Action - Recommendations for School Mathematics of the 1980s that "A computer literacy course, familiarizing the student with the role and impact of the computer, should be a part of the general education of every student." (p. 9). Spencer (1978) makes a similar request:

> ...any educational program which strives to prepare the student for his/her post-high school life is incomplete unless it introduces the student to the capabilities, applications and implications of computers. (p. 18).

Perhaps most emphatically The National Council of Supervisors of Mathematics in their 1977 position paper include computer literacy as one of the basic skill areas. They define computer literacy as follows:

> It is important for all citizens to understand what computers can and cannot do. Students should be aware of the many uses of computers in society, such as their use in teaching/learning, financial transactions, and information storage and retrieval. The 'mystique' surrounding computers is disturbing and can put persons with no understanding of computers at a disadvantage. The increasing use of computers by government, industry and business demands an awareness of computer uses and limitations.

Molnar (1978) also makes an eloquent statement that education recognize what he terms as "The Next Great Crisis in American Education: Computer Literacy." The development of a computer literacy unit or course would then be seen to be both valuable and timely.

Drill and Practice

From the early work done by Dr. Patrick Suppes it is clear that computers can present material including applications such as spelling practice, word recognition, mathematical computational skills, in fact in any area where immediate feedback of response correctness is related to associative recall tasks. Most often the computer presents problems to reinforce materials presented earlier by the teacher. The computer can keep track of right and wrong answers, provide immediate feedback, and in some cases provide remediation for the common types of errors associated with the task at hand. Perhaps most important to the teacher is the support these materials can give in an often laborious teaching duty and the ease with which the programs can be prepared.

Simulations

That the computer has proven to be an invaluable aid to scientific research is beyond question. One rather elegant application in this domain is the area of computer simulation. Oettinger (1969) comments "more subtle qualities, however, make computers capable of profoundly affecting science and education by stretching human reason and intuition, much as telescopes and microscopes extend human vision... The advance of science has been marked by a progressive and rapidly accelerating separation of observable phenomena from both common sensory experience and theoretically supported intuition. It is by restoring the immediacy of sensory experience and by sharpening intuition that computers are reshaping experimental analysis." (p. 200-201). In a similar sense the computer can be programmed to simulate a real world experience or mathematical phenomena which restores ~~an~~ immediate relationship possibly not as evident if expressed in less dynamic media within the classroom environment.

Problem Solving

Begle (1979) reports "It is sometimes asserted that the best way to teach mathematical ideas is to start with interesting problems whose solution requires the use of ideas.... Problems play an essential role in helping students to learn concepts." (p. 72). He also reports "Some introductory ideas, in particular those relating to flowcharting, turn out to be not only perfectly feasible for junior high students but also quite useful pedagogically in developing other mathematical ideas for these students." (p. 17). By eliminating the drudgery of long and laborious calculations, students might be able to use the computer to focus more on the problem at hand. Assignments in this area could involve developing an algorithmic solution, designing a flowchart, writing a program, and executing the program on the computer for problem solution. This approach allows the student to experience the process of problem solving which may involve backtracking and debugging the program in order that the correct solution is ascertained. This is valuable discipline.

Computer Managed Instruction

Computers are capable of storing test items, especially in the form of true/false, multiple choice, and matching tests. The students' responses to specific items can be recorded and analyzed later by the teacher. A second application area is the test banking of item pools for one or more teachers. Specific test items can be selected from the item bank and printed out in a pencil and paper test format. The most sophisticated form of this kind of test administration is the management of students' learning experiences, employing the computer also to select and schedule the presentation of instruction topics and their evaluation. This form of computer managed instruction typically works best for students who are already working in small groups or individually on the instructional materials.

Computer Assisted Instruction

The interest in "programmed instruction" in the 1950's and the development of the digital computer in the 1960's led to the expectation that Computer Assisted Instruction (CAI) would revolutionize education (Licklider, 1979). Unfortunately a number of enthusiasts predicted that teachers would soon be replaced by this new form of instruction. These overexpectations have not borne fruit and this computer application has not appreciably penetrated Canadian public school systems (Hunka, 1976). One major impediment is the current lack of "quality" courseware available. The future of this form of instruction is promising with the continued development of more powerful central processing units and core memories capable of operating larger multi-user microcomputer systems. Unfortunately the inability of most current microcomputer languages to adequately support the wide range of pedagogic requirements remains the major obstacle to efficacious development of this computer application (Hunka, 1980).

IMPEDIMENTS TO EDUCATIONAL MICROCOMPUTER DEVELOPMENT

"The future of computers in education will be shaped by three main factors - technological change, societal change, and changing public attitudes to education." (Hooper, 1978, p. 147). The rapidity of large scale integration of electronic components and the effects these have had on the computer industry have been documented. The effects these developments are having and will have on future society have also been alluded to. All these changes can be associated with a positive effect on education recognizing the need for computer utilization. Simultaneous with these forces is a certain public disillusionment with education's ability to raise the nation's economic and social opportunities (OECD, 1976). Coincident with this dissatisfaction is a decline in student enrollment and the resultant dwindling financial resource base. Within this mosaic the computer can be seen as an expensive toy counteracting the instruction in the basic curriculum (Hooper, 1978). These counteracting forces are contributing to considerable consternation to those entrusted with the responsibility of future educational management. One approach might be to wait and see what happens or "to leave the future to new generations." (McIsaac, 1979, p. 7). This approach is in clear opposition to the recommendations of a host of authors (Hallworth and Brebner, 1980, Braun, 1980; Hooper, 1978; Moursund, 1979; Luehrmann, 1980).

In order to explicate these objectives to a more passive approach to microcomputer utilization, the field has been separated into four dimensions. These are microcomputer hardware, software, courseware, and personnel.

Hardware

"The sheer speed of technological change in a fast growing and profitable world industry will make it difficult for educational institutions to make optimal decisions concerning the purchase of equipment. The advent of cheap microprocessors could lead to an ad hoc collection of incompatible machines in educational institutions under no one's control and subject to no overall policy." (Hooper, 1978, p. 149). There is every indication that technological large scale integration will continue for at least a decade with the resultant profusion of computer manufacturers and computer models. Unfortunately, program materials from one machine will not usually operate on another. Even from the same manufacturer, new models may not run programs written on the older machines. These phenomena can lead to constant production of new programs for new machines or continual translation of programs from one machine to another. The Minnesota Educational Computer Consortium has in part solved the problem of inter-machine incompatibility by bulk buying from one manufacturer for the entire state, but until manufacturers recognize the need for hardware and software standardization the present chaotic condition will persist.

Software

"Meanwhile, although the history of operational digital computers has been relatively short, the history of their use in education has been shorter still. In part this is due to the communications barrier which exists between a computer working in binary code and the human being thinking and communicating in natural language." (Hallworth and Brebner, 1980, p. 4). Numerous CAI languages have been constructed to facilitate the communication problem and the pedagogic needs of the instructor. A number of these are COURSEWRITER, TUTOR, CAN, NATAL - 74, BASIC, APL, PASCAL, PILOT, AND C; each possessing special abilities for the production of courseware. The BASIC language is by far the most widely utilized language in microcomputers. In its extended form it has relatively sophisticated string and file handling capacities, but it lacks sophistication in providing the courseware author with powerful answering routines, student file handling, and multi-branching procedures. Possibly the recent introduction of PASCAL and PILOT for microcomputers will improve the educational software domain, but until there is language standardization, the transferability and distribution of courseware will remain a major problem.

Courseware

"Effective computer-based educational materials are not small simple programs; they are complex because learning, even simple learning matters, is a complex process." (Bork and Franklin, 1979, p. 26). A number of authors (Braun, 1980; Dwyer, 1980; Frenzel, 1980) all identify the lack of available "quality" courseware as a major inhibitor to effective utilization of microcomputers in education. Dwyer (1980) for example states "The potential of microcomputers for education will never be realized unless a massive effort is immediately undertaken to produce educational software and courseware." (p. 74). Production of courseware requires a person who is completely familiar with the subject matter learning theory, programming techniques, and who is capable of adapting the material to the requirements of the hardware and software available. In certain applications (e.g. CAI or simulations) this is a very sophisticated and enormously time consuming task. Computer companies and publishing houses are beginning to make the necessary investments in courseware production, but until there is standardization of software the market for any one microcomputer remains small and thus less profitable.

Personnel

"There is at the present time still an unbelievable lack of knowledge of the new technology, and consequently strong resistance to its use. Old myths of electronic brains and superhuman robots persist, and computers are not seen as tools, but rather as intelligent machines which will take over teachers jobs." (Hallworth and Brebner, 1980, p. 216). Yet these same authors report on a study by Alderman, Appel, and Murphy of their assessment of the PLATO and TICCIT projects that the support of the instructor is a vital factor for implementation success. Moursund (1979) concurs with the view which sees teacher knowledge as the largest impediment to microcomputer implementation. The development of teacher competence in this area can now be seen to be a major portion of this study and is the subject of the next section. Moursund (1979) concludes his excellent report clarifying the problem succinctly:

> We know enough about in-service teacher training to realize that a short workshop or even a one-term evening course is inadequate for most teachers. The educational use of the computer is not simple. It takes substantial training and experience for most teachers to reach a point where they can effectively integrate [my emphasis] teaching using computers and teaching about computers into their classrooms. (p. 38-39).

IMPLEMENTATION RESEARCH

Burnett (1978) reports "one must take cognizance of the fact that most practicing teachers are presently ill-prepared for handling the impact of the emerging technology on their own programs." (p. 27). Although Bukoski and Korotkin (1976) reported that approximately 27% of the secondary schools in the U.S. were using computers in instruction, this figure is illusory in the sense that most of these applications centered around teaching computer programming, and a very low percentage of the total instructional time was devoted to this application. According to Dennis (1977) "using computers in the instructional process, as those teachers actually doing so will attest, is an activity which requires concentrated energy in order to become proficient." (p. 26). If the classroom use of computers is by no means trivial, then what strategies would be most propitious to the effective implementation of this device? McGinley (1973) has advocated the utilization of outside consultants with expertise in instructional systems using computers. Is this sufficient? Fullan and Pomfret (1977) in their extensive review of a vast number of implementation projects of the 1960's, many using experts in the respective fields, report that most of these failed to bring about appreciable changes in practice. This raises a question - Why? Guba and Clark (1975) contend that the structure of the educational Research - Development - Diffusion - Adoption apparatus is central to this failure. Fullan and Pomfret (1977) corroborate this view. "Less than a decade ago, commentary and research on planned school change revolved almost exclusively around specifying the properties of the innovation, assessing the outcomes, and to a lesser extent, planning changes and getting people to agree with them." (p. 336). They continue, "There is a singular lack of curiosity about what happens to an innovation between the time it was designed and various people agree to carry it out, and the time the consequences became evident. Once an innovation was planned and adopted, interest tended to shift toward the monitoring of outcomes." (p. 337). These authors report the problem of effective implementation does not lie with the specification of objectives, developing materials and a plan of dissemination, or getting people to agree with the project, although these steps are necessary, but that there are even more determinants involved in the implementation process. Fullan and Pomfret (1977) and Fullan (1979, 1980) on the basis of extensive review of a number of implementation projects identify five dimensions of implementation which must be recognized. These are:

Materials - Subject Matter

Structure - Organization

Attitude - Value Internalization

Knowledge - Understanding

Role - Behavior

Concern with any one of these dimensions to the exclusion of the others can result in a "false clarity" (Fullan, 1980, p. 3). A case in point was the study conducted by the National Advisory Committee on Mathematical Education (NACOME, 1975) as to whether the adoption of the "new math" program in the schools had in fact changed the teachers' understanding of the new concepts and to whether the teachers had actually modified their teaching behavior consistent with these new concepts. Fullan (1980) reports a number of studies (Robinson, 1978; Leithwood, 1978; Weatherly and Lipsky, 1977) which all reveal a number of implementation projects not considering one or more of the aforementioned dimensions.

Recognition of this multi-dimensionality of implementation has considerable bearing on the strategy or process which the implementor chooses. Fullan and Pomfret (1977) identify two approaches which researchers in the field of implementation ha ttempted to utilize. These are the "fidelity" or relatively structured approach and the "mutually adaptive" or relatively unstructured approach.

The fidelity model, perhaps more consistent with larger implementation projects, concerns itself with the identification of objectives, goals, and plans of action; and the subsequent evaluation of the degree of implementation with respect to how much actual use corresponds to intended use. (Fullan and Pomfret, 1977). Central to this model is the notion of a priority specification of the plan of implementation, which will be seen later as one of its major detractions. Also consistent with this approach is the implicit requirement to identify, as clearly as possible, outcome measures for the degree of implementation. Hall (1974) and Hall and Loucks (1976) have shown that "individual users reflect different levels of use or degrees of implementation vis-a-vis an innovation, and may go through different levels over time as they develop the ability to use the innovation." (Fullan and Pomfret, 1977, p. 355). They have categorized these levels as follows:

Non-Use

Orientation

Preparation

Mechanical Use

Routine Use

Refinement

Integration

Renewal

These have been validated by Loucks and Hall (1979); Heck (1979); Reidy and Hord (1979) in a variety of implementation programs. As Fullan (1980) indicates "The basic approach is the same - defining in advance the criteria or indicators of each of the levels which are in turn assessed for each individual user (teacher) at any given point in time." (p. 6).

Considering that implementation is both multidimensional and multileveled led to their combination by Leithwood and Montgomery (1978). Using an adaptation of Hall's focused interview, these researchers attempted to measure levels of use for each of the dimensions of implementation. As a result of extensive evidence collected by Berman and McLaughlin (1976) revealing teacher adaptation of similar curricular programs, Hall and Loucks (1978) suggest teachers or schools may have "innovation configurations" which are radically different. Perhaps the most important to this research are the notions that implementation is a *process* and as such is *developmental* over time, and that within a set of users there may be *variations* in the levels or degrees of utilization!

As a result of studies of 293 federally sponsored implementation programs, the Rand Change Agent Study also revealed that most users work out their own specific adaptations. As Fullan (1980) states "In referring to certain types of innovations in classroom organization (e.g. open classrooms, new teaching techniques), McLaughlin (1976, p. 340) states that 'innovations of this type cannot be specified or packaged in advance...the very nature of these projects requires that implementation be a mutually adaptive [my emphasis] process between the user and the institutional setting.'" (p. 11). These authors, Berman and McLaughlin (1976) also indicate that the extensity of the mutual adaptation is proportional to the change complexity. Clearly then in complex innovations, the initial specificity of implementation objectives is exceedingly difficult and may also have little validity. Freudenthal (1978) supports this view indicating that operational objectives be "derived a posteriori, where subject matter and method are continuously adapted to experience." (p. 67). Elliot and Adelman (1974) make a case for a collaborative relationship of the implementor and the implementee, working together to develop methods of integration. This model is consistent with the views of Stenhouse (1975), that research in education be "school based or in-situ." Implementation in this perspective can be seen to be a process in which the needs of both the implementor and the implementee are clarified and adapted. Freudenthal (1978) perhaps expresses this model most eloquently:

> Innovation, in order to be a learning process, should be more flexible, as the experiences and judgements which lead to programming only emerge and condense within the learning process; since there are no guides and helmsmen from outside, the learning process must be guided and steered from inside. (p. 66).

If we can assume these implementation strategies, the fidelity and the mutually adaptive approaches represent both extremes of the implementation continuum, then there may exist a middle ground where integration of the attributes of both of these approaches can occur. The structured approach has the advantage of attempting to clarify the intended goals, which should decrease initial teacher confusion, but the adaptive model might be especially effective in dealing with the complex teaching behaviors which might have to be altered as the plan develops. The structural approach recognizes the variance of implementation outcomes while the adaptive approach offers support during the process thus allowing the teachers an opportunity to formulate their own adaptations. In a rather simplistic sense the fidelity model can be associated with a product centered approach while the mutually adaptive model can be likened to a process orientation.

That implementation in education is a complex field is made evident by the fact that recognition of multi-dimensionality, multi-levels of utilization, and broad strategies are not sufficient to characterize the complete domain. Consideration must also be given to implementation methodologies.

Implementation Methodologies

Gross, Giacquinta and Bernstein (1971) in their studies of the "Teacher as a Catalyst" found that the majority of their teachers were unable to specify the critical properties of their innovation. Fullan (1980) reports "confusion, anxiety and lack of change due to problems of general and vague goals have been found in almost every study of major educational change." (p. 23). McLaughlin and Marsh (1978) have identified the need of plans for explicitness in order that conceptual clarity be developed. They contend:

> Conceptual clarity may be fostered - but cannot be assured - by specific goal statements or by the use of packaged materials or by lectures from outside consultants. The conceptual clarity critical to project success and continuation must be achieved during [my emphasis] the process of implementation it cannot be 'given' to staff at the outset. (p. 80).

These same authors also proportionally relate the quality of assistance in successful projects to the utilization of practical skills to develop the underlying philosophy or conceptions of the innovation. The aforementioned research reveals the need for implementation programs of sustained in-service which is ongoing, continuous, and including a "comprehensive plan which addresses the main factors likely to affect the outcomes of the in-service program." (Fullan, 1979b, p. 13). Joyce (1979) reports that successful in-service must contain all five of the following - theory, demonstration, practice, feedback, and coaching. This work corroborates the research of Loucks and Hall (1979) which identifies "stages of concern" ranging from lack of awareness, through informational, to personal, management, outcome, collaboration, and refocusing. That is, at different stages of the implementation process, teachers will exhibit different needs and concerns and the in-service strategies utilized must be consistent with these.

Fullan (1979b) also identifies nine additional factors which have a bearing on the degree of implementation success. These are:

1. pre-history - teachers' positive or negative experiences with other implementation projects
2. distinctions between role and content changes
3. a process for clarity of project goals and the means to these goals
4. in-service training linked to the implementation needs
5. regular meetings
6. local materials availability and adaptation
7. adequate amounts of time for the implementation
8. a plan of action (timeline)

9. administrative support (district and school).

Perhaps the most striking consistency of extensive reviews of implementation projects, is the recognition of the difficulty for teachers to modify their teaching behavior consistent with the innovation. These role changes seem to require an environment within which individuals are "coached and supported." Joyce and Showers (1980) indicate that any role change involves an initial period of inefficiency as the new behavior is integrated into the teacher's total pedagogic style. Fullan (1979b) expresses this requirement most succinctly: "Effective in-service programs do involve an ongoing process in which people learn collaboratively and cumulatively by interacting with peers and other resource personnel, focusing on particular problems and necessary conceptions and skills of those involved in the setting." (p. 19).

Effective implementation programs can be seen to involve organizational features (regular, ongoing, timelined, in-service, etc.) learning theories (theory, demonstration, practice, etc.) and socialization processes (collaboration, coaching, interaction, etc.). All three elements must be present in order that in-service becomes an effective vehicle for change, especially teacher role change.

ECOLOGICAL RESEARCH AND IMPLEMENTATION EVALUATION

"Our researches cannot be restricted to the laboratory; for the most part, they must be carried out in real-life educational settings... the scientific study of sets of relations as they affect learning constitutes the ecology of education....the strategy of choice for investigating person-environment and environment-environment relations is the ecological experiment." (Bronfenbrenner, 1976, p. 5). In this passage, Bronfenbrenner advocates a rather radical departure from the classical scientific research paradigm. The rationale for this assertion is perhaps reflected in the following statements:

> In an attempt to appear scientific, educational researchers have accepted an antiquated vision of simple cause and effect linked to primitive classification and sophisticated statistical techniques. (Higginson, 1977, p. 50).

and

> Given the complexity of educational problems and educational practice, it is no wonder that education has turned to science for guidance. In the early years of doing this, the major emphasis was on measurement and experiment. The payoff from this effort has generally been less than had been hoped for. (Davis and McKnight, 1979, p. 8).

These statements have in fact an epistemic commonplace. In order for educational research to appear "scientific," research in the field has generally focused upon delimiting the independent and dependent variables of the experiment. In some cases this approach has run the risk of experimental distortion. Underlying this approach is the implicit assumption that a summation of these cause and effect parts will equate to a "holistic" view of the educational domain. Bateson (1972, 1979) would argue passionately that the fallacy of this approach lies in the failure of these researchers to recognize the difference between physical and sociopsychological variables. He would contend that human learning, and for that matter all educative experience is constructed out of contexts or sets of contexts. Advocation of simplistic cause and effect relationships in stimulus-response experiments, with a human subject, may eventually prove to be meaningless, due to confusion of levels of context or "logical types" (Bateson, 1972, pp. 279-308). Bronfenbrenner clarifies this issue in the following manner:

> The difference lies not only in the requirement of a real-life setting, but in the nature of the underlying research model. In the classical psychological experiment, antecedent and consequent conditions are couched in terms of variables that are conceived as linear, additive, and distinct from each other." (p. 6).

If the ecological experiment, in order to be meaningful, must preserve the integrity of the setting and also reconcile the fact of a complex interplay of relationships, then what role, if any, can science play in illuminating the determinants of the educational milieu? Davis and McKnight respond to this question in the following manner:

> More recently, a more sophisticated analysis has been made of what 'science' has meant in the cases of physics, astronomy, chemistry, biology, medicine, and other hard sciences. In these areas, the pay-off from science has been very great indeed. What has become clear is that, important though measurement and experiment can be in science, a very large share of the effort - indeed, the larger part of it - must go into description and to the development of appropriate conceptualizations. (p. 9).

Two rather well recognized examples from the history of natural scientific development corroborate this view. In the medieval alchemist's pursuit of a reaction to produce gold, there seemed no end to the variations in color, taste, hardness, etc. of the substances produced. Today their difficulties can be seen as the application of inappropriate descriptors. By the middle of the seventeenth century

Robert Boyle (1627-1691) had observed that some kinds of matter resisted decomposition while other kinds did not. He called the former elements. Subsequently John Dalton (1766-1844) building on this elemental observation, proposed a theoretical explanation for these descriptions called the "Atomic Theory of Matter" which earned him the honor of The Founder of Modern Chemistry.

The development of the kinetic theory and its present power of explanation is another case in point. Observations by Rumford of enormous heat generation, while he was cannon boring, led to the speculation that all substances must contain an apparently unlimited amount of "caloric" or capacity for heat. This "caloric" notion, while useful in a number of ways, did not present much explanational power about a theory of matter. It was not until 1827 that Robert Brown noticed that small particles suspended in a liquid had an irregular motion, that increased when heated. This observation hinted it was motion inside matter, not some indefinable "caloric" which could account for Rumford's observations.

Davis and McKnight (1979) connect these historical anecdotes by stating "No task is more important than the task of conceptualizing aspects of reality. Yet somehow this task has been neglected in education's early attempts to make use of science." (p. 16). From this perspective the role of the ecological experiment can be seen to be one of discovery or identification of the functional relationships within the setting and not hypothesis testing. This discovery process can occur as a result of the magnification of relationships when attempts are made to modify aspects of the environment (Bronfenbrenner, 1976). Sarason (1971) puts the problem in the following context:

> There is a surprising degree of similarity in the thinking of the outsider who wants to change the schools and the insider who has a similar goal: both the insider and the outsider show an amazing degree of ignorance about the culture of the school, and (equally as fateful) both seem to have no theory of the change process. (p. 2).

The focus of this research then is to design an implementation strategy consistent with the at present capabilities of the microcomputer in order to reveal as clearly as possible the forces and systems which are determinant in educational change.

Ecological Research Evaluation

The inadequacy of appropriate descriptors was seen to be one of the major deterrents to the development of the atomic and kinetic theories. A similar deficiency most likely exists in the utilization of descriptions concerning the extensity of the implementation. Traditionally, efforts in curriculum implementation have focused on student outcomes as the dependent variable to the exclusion of other possibly more valuable data. Berman and McLaughlin (1976), also reported in Fullan (1979a), assert:

> Although student outcomes might be the ultimate indicator of the effectiveness of an innovation....projects must go through the complex and uncertain process of implementation before they can affect students, it makes sense to put first things first and to measure the effectiveness of implementation before examining potential student impacts. (p. 350).

The fidelity approach, with its concern for the comparison of intended and actual outcomes with teachers, in combination with Hall's "levels of use" can to some extent illuminate the degree of implementation. Since variations of use also exist for each of the dimensions of implementation, the "stages of concern" (Loucks and Hall, 1979) can indicate the kinds of concern held by different teachers at various stages in the implementation process. Perhaps most importantly, these indicators can assist in revealing the obstacles and effectiveness of the implementation strategy. Within the "mutually adaptive" paradigm there is the recognition that the process may uncover more fundamental relations. Through the use of multiple methodologies (participant observation, interviews, background analysis, questionnaires, and phenomenological - teacher self-assessment), the intention is to "portray, illuminate or otherwise help explain the complexities of what is happening." (Fullan, 1979a, p. 26).

The difficulty of this approach is the "qualitativeness" of the variables in relation to those of the fidelity model, but its advantage is the close connection the data has with the situation. Fullan (1979a) in his analysis of the evaluator role in contemporary implementation reveals the incredible complexity that must exist.

> ...the evaluator should possess the following types of knowledge and skills: a sophisticated understanding of the complexities in the philosophies and purposes of evaluation (House, 1976, and 1977); an ability to conceptualize and understand the process of change - the interrelationships between project development, strategies for change, variations in implementation and student outcomes; skill in designing, carrying out, and interrelating multiple evaluation methodologies simultaneously - ethnography, participant observation, interviewing, documentary analysis, questionnaires, testing; social and interpersonal skill in establishing rapport and maintaining effective interaction on a continuous basis with various groups affected by the program being evaluated - sponsors, administrators, teachers, etc.; political and interpretative skills in feeding back or delivering the results of the evaluation. (pp. 31-32).

This is indeed a formidable task!

CHAPTER III

DESIGN FOR THE STUDY

INTRODUCTION

This chapter will focus on the description of the ~~sample~~, delineation of the project goals, description of the project strategies, plans for implementation and the sessional developments, monitoring instruments and the project evaluation procedures, and finally analysis of the data.

THE SAMPLE

The sample for the project included six full time teacher volunteers, a portion of their students, and the principal from a junior high school within the Edmonton Public School System.

The junior high school was selected in preference to other educational levels for a number of reasons. The major reasons being, that at present absence of extensive utilization of this technology at this level, and the somewhat pressing need for exploring ways of improving the instructional repertoire of these teachers.

The principal of one junior high school was contacted in late 1979 (see Appendix A) with the request to propose the project to his staff. As a result of this meeting six teachers (three Mathematics, two Science and one Industrial Arts) expressed an interest in the project and a decision for a first meeting was finalized.

PROJECT GOALS

The project goals which follow are considered pertinent to the development of microcomputer utilization by the teachers within their classrooms. An implicit assumption underlying this project approach to microcomputer employment, is the need to instil a sense of "confidence" in the teachers concerning the operation of the microcomputer. The vehicle to this goal was assumed to involve the development of a fundamental grasp of the microcomputer's capabilities and limitations. Thus, it was necessary for the teachers to learn, at a minimal level, a programming language (BASIC) and integrate this knowledge with the construction of microcomputer courseware in specific application areas.

The goals of the project can be trichotomized into the following three stages:

<u>Preimplementation or In-service Stage</u>

Teacher recognition of computational developments and education's responsibilities within this domain.

Teacher identification of the application areas in which the microcomputer has shown educational promise.

Teacher acquired knowledge concerning the operation of the microcomputer.

Teacher acquired knowledge concerning programming the microcomputer in the BASIC computer language.

Teacher recognition of the microcomputer's capabilities and limitations.

Teacher integration of the microcomputer's capabilities within educational application area.

Teacher construction of a microcomputer program within this application area.

Implementation Stage

Teacher experimentation in the classroom with the microcomputer application.

Teacher feedback and revision of the program on the basis of experience gained from the initial classroom trials.

Teacher optimization of the microcomputer application and the methods of classroom utilization.

Summative Evaluation Stage

Summative reflection of the application efficacy and suggestions for continued improvement.

Summative assessment of the project and suggestions for improvement.

PROJECT STRATEGIES

In order to maintain contextual validity, all the project in-services and experimentation were planned to take place within the school environment. Since meeting times for the whole group were difficult to find during school hours, the project in-services were tentatively scheduled during the noon hours.

In-service Settings

Recognition that this kind of implementation project be "school-based" may not be entirely sufficient. The creation of an environment in which the teachers could learn and grow was also required. In order to create this environment an "adaptive" model of implementation was utilized. This model presupposes that the teachers were able to select and develop their own areas of interest within the microcomputer domain. A second and perhaps most important aspect of the setting was a recognition of the informational reciprocity necessary between the consultant and the teachers. Mutual interaction and collaboration between the teachers was also encouraged as a recognition of the powerful social dynamics of the group in the change process.

Participant Roles

Recognition of reciprocity of the teacher-consultant relations did not necessarily mean the roles of these two groups were isomorphic. The roles of the teachers and the consultant were conceived as different, but complementary.

The consultant role included acting as an initial program planner in establishing the implementation organizational structure, assisting in the collection and preparation of various resource supports, coaching and guiding the individual teachers in their application areas, offering feedback on the projects development, and developing and administering the final evaluation instruments.

The <u>teacher</u> role included learning the microcomputer's operation and a programming language (BASIC), selecting an area for potential microcomputer application within their classroom, developing the courseware material, planning for classroom experimentation, reporting to the group on the classroom operation, and assisting in the collective identification of developmental difficulties.

<u>Resource Supports</u>

The following resources were utilized at various stages of the project:

1. An "APPLE II plus" microcomputer with 48 K RAM and a "floppy disc" peripheral memory was supplied by the Edmonton Public School Board.
2. Applesoft Tutorial and Programming Manuals for explanation of the microcomputer's operation and programming language.
3. Sample programs from "The Basic Workbook" to assist the teachers in developing programming techniques.
4. Selected readings on the potential areas of microcomputer application within education.

PLANNING FOR THE IMPLEMENTATION

Integrating the project goals and strategies into a coherent structure, consistent with the developmental character of the project, was considered the next phase. The project can thus be conceptualized as proceeding through the following stages.

Orientation, Awareness, and Establishing a Relationship

In the incipient phase of development it was considered necessary to provide the teachers with a number of "advance organizers" with respect to the project. Specifically these were a delineation of the broad aims and objectives of the project focusing on the uniqueness of the microcomputer at this stage of its development, the potential incentives and impediments for the teachers involved in a project of this type, and finally, and perhaps most importantly, consideration of the "uniqueness" of the adaptive, in-situ, teacher-based implementation model in comparison to previous implementation designs.

Microcomputer Applications and Implementation

A more detailed understanding of the potential areas of educational microcomputer application was considered as a next stage in the development of the project. Once establishing a range of potential applications, the next area of concern was how these applications might be developed. The teacher developed courseware model was presented as a plausible solution strategy to the at present scarcity of microcomputer courseware for direct application in the junior high school. Resource supports for this approach, timelines for developing the applications, roles and responsibilities of the consultant and the teachers, and monitoring and evaluation concerns would conclude the introduction to this approach.

Demonstration, Skills Development, and Courseware Construction

This stage involved the development of teacher knowledge and skills in the areas of microcomputer operation and programming. Through the development of microcomputer competency in these areas (application areas of microcomputer utilization within the classroom and microcomputer capabilities), the teachers were to choose application areas for courseware development. Recognition of the heterogeneity of individual capabilities and application complexities at this stage obviated varying degrees of consultative assistance, guidance, and support.

Classroom Implementation, Experimentation, and Feedback

The teacher developed courseware could then be employed within the classroom setting. Of concern at this stage would be the difficulties of operating the microcomputer within the classroom environment, the validity of the instructional assumptions implicit in the courseware construction, and the reactions of the students to the presence of the microcomputer in the classroom. On the basis of observations of the respective applications the teachers and the consultant would begin to reflect on areas requiring improvement.

Courseware Revision and Reapplication

This stage reflects the cyclical nature of this project. On the basis of the classroom observations and reflections, the microcomputer courseware was to be revised and reapplied within the classroom.

Summative Evaluation

Assessment of the various application areas, focusing on the discrepancy between the intended and actual outcomes, was considered appropriate at this stage. Since the teachers would have been intimately involved with the development and implementation stages of the project, their perceptions of the determinant factors influencing the microcomputer's utilization within the classroom were considered to be valid and of great importance.

PROGRAM DESIGN

Table I represents a more explicit delineation of the generic plans for implementation. Session 1 was conceptualized as to occur in December 1979 and the project was to be completed by June 1980. This plan should not be interpreted as a rigid and fixed schedule of future events, but as a tentative outline which could be adapted as the needs of the teachers and the setting begin to assert themselves.

Table I

A PREIMPLEMENTATION SESSIONAL OUTLINE

SESSION I -	An introduction to the microcomputer and establishing a relationship. Concerned with: consultant background and interest historical developments in computing potential areas of educational microcomputer application project incentives and impediments uniqueness of the implementation model

A teacher decision to continue or not to continue their involvement in the project. A decision to continue would carry the expectation to remain with the project until completion.

SESSION II - Project needs and teacher concerns.

Concerned with:

- demonstration of the "APPLE" microcomputer
- explication of the potential microcomputer applications.
- role descriptions of the participants in the teacher-based courseware construction model
- resource supports
- a tentative future sessional outline
- project evaluation instruments
- scheduling of individual microcomputer usage

INDIVIDUAL MICROCOMPUTER USAGE

Each teacher working individually on the microcomputer to learn its operation and BASIC language.

INTERVIEW 1

Each of the teachers would be interviewed individually to determine their:

- concerns and needs at that point
- areas of interest and potential application choices
- additional resource support requirements

SESSION III - Development of a curricular plan.

Concerned with:

- teacher presentation of their individual application decisions organizational requirements (future sessions, microcomputer scheduling, programming assistance)

planning for specific microcomputer applications

INDIVIDUAL ASSISTANCE

Concerned with:

development of specific courseware

planning for classroom application

CLASSROOM EXPERIMENTATION

INTERVIEW 2

Individual interviews focusing on the teachers' perceptions of the classroom experience.

SESSION IV - Group feedback of the teachers' classroom experiences.

Concerned with:

reports to the group of the teachers' and consultant's observations

collective suggestions for improvement of the applications

rescheduling

ADDITIONAL INDIVIDUAL ASSISTANCE FOR REVISION AND CLASSROOM EXPERIMENTATION

SESSION V - Additional feedback, reflection, and evaluation.

Concerned with:

reappraisal of the classroom applications

future revisions and extensions of the project

summative perceptions and conclusions of the teachers

application of the final evaluation instruments

MONITORING INSTRUMENTATION

Audio Tape Recording

During all the in-service sessions and the interviews a cassette audio tape recorder was used to document the participants' conversations. The tapes were transcribed to provide a written record of the verbal communications (see Appendices B and C). Much of the data for Chapter IV was obtained from these sources.

Interviews

Each of the teachers remaining in the project were interviewed on two occasions. The first interview was to determine the potential areas of teacher interest and the problems they encountered in using the microcomputer. The second interview was more concerned with the teachers' perceptions of the employment of the microcomputer within their classrooms (see Appendix C). Both interviews typically lasted approximately from 30 to 45 minutes. In addition, the principal was interviewed at the interview 2 stage to determine his perceptions of the project.

Observation

During the in-service sessions the researcher "attempted" to also observe the reactions of the teachers at the various stages of the project. This proved to be exceedingly difficult as considerable focus and energy is required to co-ordinate and present the sessions. On sessions two and three an independent observer was used to corroborate the researcher's perceptions. Informal observations were made throughout the project during almost weekly visits to the school.

In addition the classroom operation of the microcomputer was observed to cross-validate the perceptions of the teachers.

Post-Project Questionnaire

This instrument involved rather extensive development. The teachers were asked to respond to 93 questions focusing on their background experience, their observations of the efficacy of the microcomputer in their classrooms, their assessment of the project, their assessment of the student perceptions, their ideas for future microcomputer usage, etc. The students involved in the project were also given a 30 item questionnaire to assess their perceptions of the microcomputer. The principal of the school was also asked to respond to an abbreviated form of the teacher questionnaire. See Appendix D for a complete listing of these instruments.

A MEASURE OF PROJECT EXTENSITY

Hall and Loucks (1976) have identified eight "levels of use" (non-use, orientation, preparation, mechanical use, routine use, refinement, integration, and renewal) which have to be used as a measure of the extensity of an implementation program. These same authors in 1979 identified seven "stages of concern" (lack of awareness, informational, personal, management, outcome, collaboration, and refocusing) which teachers exhibit at different stages of the implementation process. Joyce (1979) identifies five stages (awareness, conceptual control, skills development, application, and repertoire) of implementation concern reflecting the developmental character of the process. Joyce and Showers (1980) focus on three stages (awareness, principles, skills, and problem solving activities) necessary for implementation. In order to obtain a more reliable measure reflecting the idiosyncracies of microcomputer implementation, the researcher has integrated and modified these scales into the following.

Phases of Development

1. Informational Awareness

   This phase reflects the goals, aims, and objectives of the project also including recognition of potential areas of microcomputer application and teacher incentives.

2. Skills Development

   Specifically teacher competence in microcomputer operation and programming (learning the BASIC language).

3. Conceptual Control

   This phase reflects a recognition of microcomputer principles of operation, selection of an application for experimentation, and courseware construction.

4. Classroom Enactment

   Specifically the utilization of the prepared courseware within a classroom setting.

5. Application Assessment

   Individual and group reflection and evaluation of the classroom experience.

6. Refinement - Revision - Reapplication

Consistent with this model of implementation, on the basis of the assessment of the first classroom experience, the application would be modified and retried within the classroom.

7. Instructional Integration and Institutionalization

On the basis of the earlier experience, the micro-computer would be added to the teacher's instructional repertoire and the school's operation.

8. Paradigmatic Shift

This phase represents a modification of the teacher's basic approach to instruction. An example might be a transformation from a skills oriented drill and practice orientation to utilization of the micro-computer in a higher level problem solving approach.

ANALYSIS OF THE DATA

The information obtained from the previously described instruments will be used on two levels. First, the information will be utilized to portray or describe the <u>process</u> of implementing the microcomputer into the school environment. This portrayal of the change process is valuable in another sense. Recognition that the pre-implementation plan is to be "adaptive" implies the existence of forces or factors which have a determinant influence on the development of the project. In a Batesonian sense, these factors are "about" the project and as such represent a higher level of abstraction. The discovery of these factors is deemed essential to the development of further research of a more "traditional" nature.

CHAPTER IV

RESULTS OF THE STUDY

INTRODUCTION

Chapter III involved considerable discussion of the pre-implementation planning and the intended implementation activities. The focus of this chapter will be threefold. First, it is necessary to describe the process of the actual implementation, paying particular attention to the teacher concerns at the various stages of the project. It is hoped that this format will portray the developmental character of the change process, which simple analysis of the input and output will not reveal. Second, the chapter will focus on the domain of degree of implementation. The researcher will attempt to relate extensity of the project to the previously defined "phases of development." Finally, the focus of attention will center on the implementation process. The chapter will then close with direct transcriptions of the teachers' final perceptions of the microcomputer project.

THE PROCESS OF IMPLEMENTATION

Late in 1979 the principal of the junior high school was contacted (see Appendix A) in order to convey to him the intentions of the project and a tentative schedule of events. He was requested to convey this information to the staff concerned and to contact the researcher to indicate the teachers' interest. The teachers were made to understand at this point that they would be able to attend the Orientation Phase (Session I) with no further commitments if they so wished. These procedures were designed to ensure the teachers' participation in the project was truly of their own volition, and as such they truly represented "teacher volunteers."

Session 1

Six full time teachers and the principal agreed to meet and a meeting was arranged for December 7, 1979 from 12:00 to 1:00 p.m. The basic aim of this first session was to explicate the intention of the proposed project in order to give the teachers adequate data on which to base their "go-no-go" decision. The topics of discussion were specifically directed to the potential uniqueness of this project in terms of its implementation paradigm. Considerable time was spent discussing areas of microcomputer potential, delimitation of the courseware scope, teacher development of the materials, and classroom experimentation. The teacher concerns at this stage are interesting not only for their perceptiveness, but also for their persistence throughout the project. The following are brief excerpts of teacher comments at this point:

Programming.

T-5 My brother-in-law has one of these outfits (a microcomputer) and he has been spending weeks trying to get a program going, so he can play games. He has no background in computing science at all, and just for a layman to come in and buy the equipment and say we were going to embark on programming a drill and practice program - it takes a lot of time - and prework. You know to get the thing going, just to be able to get something on and then to work out all the bugs - this is a pretty substantial task.

Classroom Operation.

T-3 So you have the one unit, which means it is only operated by one student and if you have a class learning how to program, you will have quite a backlog on the machine.

Educational Application

T-3 Could you define computer literacy?

Pre-History

T-3 One of the magnificent failures of bringing computers into the schools was in the area of Industrial Arts. Unfortunately technology wasn't up to us - we had to use (computer) simulators which caused its downfall.

Subsequent to this session, the teachers were given the opportunity to decide on project continuance or not. It was stipulated, though, that continuance of the project would imply participation for its duration. On this basis all but one teacher decided to continue with the project.

On this basis an "APPLE" microcomputer was obtained on loan from the Edmonton Public School Board and a date was set for the second session.

Session II

On February 18, 1980 from 11:45 to 1:00 p.m. the second session of the project took place. The basic purpose of this session was to demonstrate the operation of the microcomputer in order that teachers were able to learn on their own. Since each teacher's schedule was rather full during the day, it was suggested that the teachers take the microcomputer home to learn its operation and some fundamental "BASIC" programming. Additional time was spent discussing areas of potential application, a future sessional outline, tasks of the participants, and potential research instruments (see Appendix B). Concerns of the teachers focused on the commands for operating the floppy disc operating system. For example:

P How many programs can you put on one disc?
T-3 Which disc do we store our programs on?
T-2 Once you start a program - you can take the disc out of the floppy disc unit?
T-5 How do you unload the disc?
T-2 Say you've got that program there in the computer, and I take my disc and put it in the disc drive. Can I save the program on my disc?

The teachers also made the valuable suggestion that more than one TUTORIAL MANUAL would enable them to read about the computer's operation before they took it home. It was decided that the school would purchase any additional manuals required. The researcher also devoted considerable energy attempting to explain the implementation approach as witnessed by the following excerpts:

R My component of this study is to help you as much as possible, and let's discover the potential areas of use - and some of the problems you come across as we try to do this.

Later:

R So I would really recommend this approach. Focus on something small - go in and try it - come back out and think about it a bit - where were the bugs? - make those modifications - go back in again and retry it.

Although this area of explication may have been necessary, the focus of the teachers' concern at this time was clearly concerned with the computer's operation.

Individual Operation

At this point it was envisioned that each teacher use the microcomputer at home for a period of four or five days to learn its operation and some simple programming. The teachers were to use the TUTORIAL MANUAL, sections of "The Basic Workbook," and sample programs (see Appendix E) for additional guidance. Each teacher was requested to use a "buddy" system to help set up the microcomputer (connect the disc controller, T.V., etc.) for the next teacher. The consultant felt this stage of the project would take approximately one month. As the teacher interviews conducted from March 17 to March 25, 1980 will presently reveal, this was not the case.

Interview I

The interviews revealed an incorrect assumption made concerning the teachers' available time. As the following excerpt shows, the teachers did not have adequate time for learning during the week.

> T-3 Well I didn't take it for the week because I knew I wouldn't work on it at all.

This time restriction thus caused further problems as to its accessibility as evidenced by the following comment:

> T-2 The problem right now is not getting it often - we're sharing it. It would be nice if a guy had it two hours any evening.

At the time of the interviews another teacher had not even used the microcomputer for the following reasons:

> T-5 The time element right now is crucial to me - so I told the others go ahead and book the computer out because in April I'll have a little more time.

The teachers though still felt that taking the computer home was a good idea as evidenced by the following comments:

> T-2 Oh - Yes. You wouldn't have enough time around the school to work on it.

> T-3 Yes. I liked that. We have a color T.V. and a black and white T.V. in the family room, so I was with the rest of the family.

Another purpose of the interview was to determine the educational application which each of the teachers wanted to pursue. Each of the interviews revealed that the teachers were actively forming ideas for classroom experimentation. In fact, every teacher at this stage had decided on the area of application which was subsequently developed for use in their classrooms. As subsequent experience revealed, though the teachers had seemingly readily determined areas of application, there existed wide variances in the complexity of these applications.

> T-5 Before the end of the year I would like to program up some dissection tests.

> T-1 I would like to program a drill for the grade seven differentiated math students in multiplication tables.

> T-3 In very general terms what I would like the kids to do is - develop a basic understanding of the computer itself, be able to interact with the computer, and perhaps be able to manipulate some information.

Although the teachers were able to select areas of educational application with considerable ease, the same was not true for their development. Interestingly, the teachers found the operation of the computer relatively easy to learn, unfortunately this was not true for computer programming. The following was the first teacher response in an interview, even <u>before</u> a question had been asked:

> T-2 I understand we are going over Tuesday afternoon to try some programming - I hope I'm more successful!

This view was corroborated by the others:

> T-4 This (programming) is the toughest area.

> T-2 Now the thing is programming, what do you mean by programming?

> T-3 I think what almost everybody is saying is - no one is really going to be in a position to sit down and program something right from scratch and get it running,

> especially the fellows who have had no computer experience.... The other problem is time - as programming is so time consuming.

On the basis of this feedback the teachers suggested and the consultant agreed to hold a programming session at the university to assist them with this problem. This phase of the project is important from two aspects. First, it was a teacher suggestion, which reinforced the view that they would have influence in the direction of the project. Second, this was strong support for the necessity of "adaption" during the implementation process to satisfy project needs.

The teachers though did not feel that the time and the obvious frustration spent trying to learn programming on their own was a waste. A teacher commented on this point thusly:

> T-3 ...maybe it was important that we all got to play with the machine, because now I can really understand some of the things, but when we get down to this one... I know where I struggled with it - and then when you talk about it I'm going to be able to relate to it better. So maybe playing with the machine for a few days was good.

<u>Programming Session</u>

On March 25, 1980 from 4:00 to 6:00 p.m. an extra programming session was held specifically to address the teacher identified programming needs. The purpose of the session was not to make sophisticated programmers of the teachers, but it was felt that a basic knowledge of programming was essential for creating a feeling of teacher control "over" rather than "by" the microcomputer. It was also felt that knowledge of programming would facilitate teacher understanding of the capabilities and deficiencies of the microcomputer medium. The format for the session can be seen in Appendix B which culminated in the creation of a simple mathematics drill and discussion of how this basic program might be sophisticated. Following this session, since the teachers had selected an area of educational application, a session was proposed to address the scheduling needs of the teachers' applications.

<u>Session III</u>

On April 3, 1980 from 1:00 to 3:00 p.m. a meeting was convened at the school for this purpose. It is of interest that this meeting occurred <u>during</u> the spring break on the teachers' own time. This meeting time was their suggestion and can be seen to be an indication of their increasing commitment to the project. Since the time for experimentation was rapidly disappearing, initial concern was centered on the area of a timetable of future events. The suggested outline for these can be seen in Appendix B.

The teachers were also requested to convey to the group a brief description of their projects. The following is a transcription of their comments:

> T-1 Very simply, just a program to drill them on whole number addition, multiplication, subtraction, and division. As yet I haven't programmed it to the point that they have feedback on the percent right and so on, but that's basically what I intend to do - whole numbers only. At the moment I have five students who would be working on it.
>
> T-4 The same thing, but I would have more than five students involved and the program would deal with integers rather than whole numbers.
>
> T-3 Computer literacy, as I found, is a huge area... the idea that's going through my mind is to get a select group of students to the computer and to teach them how to access the information they need, how to manipulate that information, and perhaps do some very simple programming just so they can understand what a computer is, what it can do and what it can't do.

> T-2 Elementary drill in chemical symbols and/or valences to start with, but I was hoping to get to something where I could also challenge some of the brighter ones.

Since the last teacher was absent from this meeting, his application was expressed by the researcher.

> T-5 This teacher wants to work on an application in grade seven science. He has kids going through various labs on dissection. Since they end at different times, he wants to test them with the computer.

Location of the microcomputer in the school, the selection of a co-ordinator, and weekly microcomputer timetables took up the balance of this meeting.

Program Development

The balance of the month was spent developing the programs and beginning the classroom experimentation with the microcomputer. The researcher's assistance during this period varied from extensive programming assistance on the chemical drill (as this involved rather complicated files creation (see Appendix E), suggestions on the mathematics drills and materials support for the teacher developing the literacy application. Although assistance was offered to the teacher on the grade seven science application, it was not accepted, and unfortunately this application was not developed further.

Interview II

From May 2 to May 6, 1980 the teachers were interviewed again. This was a fairly intense and exciting period of the project as the microcomputer was in the classrooms and the teachers were experiencing a number of interesting effects in its operation. The following areas seem most pertinent:

Student improvement and interest.

T-1 The kids that have worked with it for 10 to 15 minutes or something...it's amazing they are actually doing a better job at multiplying.

T-4 I'm just using it in the differentiated 8 class, and only two students get to the computer per period... but it's good...they (the students) can't get to it fast enough.

Computer location.

T-1 I prefer the computer in the classroom - I really do - if only for the fact that you can access the kid and you have access to the computer if you want to do something.... If the kids run into trouble, you're there to help.

Computer utilization.

T-4 It's being used - just about five hours a day. It's being used constantly. I'm only using it for one class, so I'm not interfering with someone else's use of it. You could almost say that it goes from 8:45 in the morning until 4:00 at night.

Deficiencies.

T-4 The only actual drawback I can see to is is its strictly a one-to-one situation and the time factor - it takes you a whole week to run through a class.

Possibly the most important aspect of this phase of the project was its continuance for the following year. The teachers had invested considerable time and energy into the project and were beginning to experience rewards for this work. That this is becoming a dominant concern is perhaps evidenced by the following concern:

T-4 We got this far now - in a short time I think, since we started at zero, knowing nothing, to the point now where we are picking out these things.... There's no end of use to it. I think it's great, but the trouble is now we are at the point where we are going to lose it. It's really discouraging - the people here are certainly enthused about it - we want one - we definitely want one.

Session IV

On May 30, 1980 from 12:00 to 1:30 p.m. the major concern was the future of the project, especially computer availability for the school the following year. As an indication of this concern, the teachers had prepared a draft proposal to the Edmonton Public School Board, but unfortunately it was submitted too late and was not accepted. The following teacher comments perhaps convey the teachers' frustration at this point, but also their perception of the value of the micro-computer in their classrooms.

> T-4 I for one really want the computer in here badly next year.
>
> T-2 I might be taking a course this summer on computer programming.
>
> T-4 If we could just get one (computer) next year, all these things would start to fall in place.
>
> T-3 Maybe we should run on the assumption that come hell or high water we are going to end up with one, even if we have to go and sell chocolate bars.

Since it was already June and the school was in the process of finalizing the school year, it was decided not to reapply modifications of the programs. A deeper problem though existed. The teachers had embarked on the project specifically to test a new medium to see if it would assist them in the instructional process. From their limited trials in the classroom they felt the computer had educational potential, but they now felt there was no point in continuing their energy expenditure if there was no hope of obtaining a computer in the future.

This area of difficulty should have been obvious from the beginning of the project. If the teachers were successful in using the computer in the classrooms, then they would obviously want to continue using it the following school year. This was a major source of frustration for both the teachers and the consultant during the later stages of the project, as the microcomputer was only available for the duration of the research project. Future research of this type must be cognizant of the need to continue support after the research ends and not to leave the teachers without anything to show for their energies.

Session V

In June, 1980 the teachers and their principal agreed to meeting for a final wrap-up session. The discussion was very congenial, with both the teachers and the researcher expressing views of appreciation on the value of the project and the interest and dedication throughout its duration. The major disappointment to the teachers at this time was the continued uncertainty of obtaining a computer. On a happier note, contact with this school the following year revealed they had been able to obtain five microcomputers and were actively pursuing their interests in this domain. In fact, three of the microcomputers were purchased from school funds. Perhaps a well worn aphorism might be apropos here; "where there's a will - there's a way!"

THE DEGREE OF IMPLEMENTATION

An attempt has now been made to describe the developmental characteristics of the implementation process. Consistent with the research design, an attempt will be made to assess the degree of implementation. The measurement of this field will be facilitiated by the researcher defined "phases of implementation." (See Chapter III).

Informational Awareness

This phase refers to a necessary first component to this form of implementation plan. Consistent with the need for "teacher volunteers," this was the focus of Session I. The teacher (T-6) who decided after this session not to continue with the project, when interviewed, stated his perception that the amount of time necessary for the project was beyond what he had available. Of the teachers who remained in the project, 100 percent responded on the final questionnaire that they understood the purpose of the microcomputer within education. This can be seen as an early and relatively easy phase of the project.

Skills Development

This phase can be separated into two components; computer operation and computer programming. Remarkably the teachers and students had very little difficulty with operation of the microcomputer. On the final questionnaires 100 percent of the teachers and 86 percent of the students found the computer easy to operate. This is a positive factor potentially ensuring the rapid utilization of preprogrammed courseware within the schools.

Programming competence was not quite as easy to learn. While 60 percent of the teachers responded that BASIC was somewhat more difficult to learn, at project completion fully 100% of the teachers felt competent in the programming area and that they had learned enough of the language for their application. The following teacher comments substantiate this view:

> T-2 From the start I thought the problem was programming, I didn't understand it. Now I feel more relaxed.... Now that to me is not a problem, I know what I'm doing now.

When asked when this transition had occurred this teacher responded:

> T-2 I think it was the session I spent with you programming at the university. After that I saw that the machine will work. Up until then, you put something in and it doesn't work - you type it in wrong - I was very disgusted there for a while - very discouraged. After that session then I could see the program worked, you could see the end coming.

This is a powerful argument for the "adaptive" approach to implementation research. Without teacher input at this stage the progress of the teachers may have remained at this phase.

Conceptual Control

This phase of development might be characterized as recognition of elemental computer capabilities, making an educational application decision, and construction of the necessary courseware. All of the teachers still in the project entered this stage by Session III. The relative ease with which the teachers chose their educational application area was not expected. Discussions with the teachers revealed they had many ideas of potential application, which in the researcher's view were all very applicable. 80 percent of the teachers responded that educational application areas were easy to identify and that their choices, upon reflection, were very much appropriate. For example:

> T-1 Drill is a tedious, boring job at best. A computer adds a new dimension of enthusiasm to the chore.

The domain of courseware construction was not as simplistic.

The researcher found that the amount of success at the construction stage was directly related to the complexity of the application. Those teachers (T-1 and T-4) who developed simple drill packages were able to do so with very little researcher assistance, whereas the teacher (T-2) who was developing a more sophisticated learning program in the sciences required more extensive assistance. T-2 comments as follows:

> Programming is, I think, beyond the average teacher's ability for sophisticated programs (simulations, etc.) but I think it isn't beyond them (the teachers) to put in a little drill, or reinforcement of some kind on a small scale.

With assistance, though, this teacher was able to utilize a fairly sophisticated science program (see Appendix E), which the other teachers immediately recognized as having possibilities in their areas as well.

At this stage, one teacher (T-5) was seen to drop out of the project in terms of the courseware production. Although assistance was offered, this teacher did not actively pursue the application and as such the possibility of classroom experimentation was negated.

Classroom Enactment

All the teachers who developed courseware (T-1, T-2, T-3 and T-4) were able to enact the classroom experimentation portion of the project. Since there was only one microcomputer for four teachers, weekly scheduling was problematic, but manageable. The following statistics reflect the extensity of usage at this point:

a. most of the students involved used the microcomputer only once;

b. there was an average of 13 students per class;

c. approximately 50 students in total were involved;

d. students used the computer on a one-to-one basis;

e. the average student access time was 15 minutes per session. This was both the students' and the teachers' perception;

f. the teachers felt this amount of time per session was optimal; and

g. a teacher, on average, used the microcomputer 3 hours per week.

As was previously mentioned, this was an exciting period for the teachers after what seemed like extensive preparation. As will be seen in the next phase, this was perhaps the most valuable stage of the project in terms of the teachers obtaining feedback for their labors.

Application Assessment

All the remaining teachers continued to feel that the computer offered strong educational possibilities. They all felt that the computer had helped the students to learn and considering the brief experience in the classroom this was quite positive. Eighty percent of the teachers though felt that they did not have time to fully evaluate the computer's potential with comments like:

T-4 I would have preferred a full year.

T-2 I could have used much more "hands-on" time.

One factor did emerge, though, from all the teachers which can be seen as a major inhibitor to the utilization of this medium in the classroom. This is the one-to-one operation in the classroom.

> T-4 The only actual drawback I can see to it, is it's strictly a one-to-one situation and the time factor -- it takes you a whole week to run through a class.

This application involved a relatively small number of students in a mathematics drill application. This teacher comments further:

> T-4 One kid is on it - 20 minutes at a time so that the student loses 20 minutes - so they're not losing very much.

In this classroom, the one-to-one operation for 20 minutes per student session was not seen as a problem. In contrast, another teacher, using a more difficult conceptual program comments:

> T-2 Right now I use the computer during my classes and the kid goes out and works on the program for 10 to 15 minutes - he misses 15 minutes of class - this has a detrimental effect.

Later when asked how much time the students were taking:

> T-2 About 20 minutes - I think if you cut that time down, they're not going to concentrate on what they're doing.... I think on something where you are trying to get a concept across, more difficult information, then you need a little more time.

It must be noted that this teacher (T-2) was instructing in classes typically of 30 students and was operating with a less individualized curriculum. One solution to this problem would be to delimit the number of students accessing the system. In the computer literacy area where students were learning programming and required extensive "hands-on" time, the size was delimited to about 10 students, but this still posed massive problems.

T-3 They all want more time - they all find that frustrating they want to get on-line - the computer literacy course for say 15 to 20 students as an option with one computer - I think I would pick up a can of worms.

Clearly then, teachers using the computer as a drill device in either classrooms with a small student-teacher ratio or using individualized curricula can experience success. Teachers attempting to instruct in typical classrooms of approximately 30 students, using teacher directed curricular materials, and attempting to use one microcomputer to instruct in the higher cognitive areas (requiring more student access time) are going to experience enactment difficulties.

Refinement - Regeneration - Reapplication

This phase of the project was not carried out. The reason was lack of time. In-situ adaptive implementation research takes much more time than the more undirectional fidelity approaches. Although the teachers did not regenerate their programs, this is not to say they were not thinking about the kinds of changes necessary.

T-4 What I'd do now is put on the Rule - if they get it wrong. It's so easy to do now - we know how to do it.... You always have to reteach - so if you had these computers and you program the Rule in - it's not a straight drill - now it becomes a re-teaching machine.

Instructional Integration

The teachers were asked if the computer had any effect on their teaching style. This role change would take far longer to effect than the short period which the teachers used the microcomputer in their classrooms. Most felt that given time this would happen.

T-1 Not yet, but in time yes.

T-2 Would improve my approach to teaching.

T-3 So far, no effect. If I continued to use it the computer would probably become an appendage.

T-5 It would complement my teaching style rather than effect it negatively.

T-4 We still need a chance to prove its effective-ness.

Paradigmatic Shift

This phase did not occur! The possibility exists for the microcomputer to "raise" the conceptual level of activities within the classroom, but this phase would require far more time than was available in this project.

IMPLEMENTATION FACTORS

During the course of explication of the developmental process of implementation a number of factors emerged which had a determinant influence on the teachers' utilization of the microcomputer. Although numerous categorizations are possible, considering the multiplicity of factors involved, the descriptor's interpretation may be facilitated by the following groupings:

1. Nature of the Innovation - refers to the inherent "qualities" of the microcomputer medium at this point in time.
2. Organizational/Structural Factors - refers to the implementation mechanism and support services used to facilitate the change process.
3. Sociological Factors - refers to the influence that the "working group" of teachers had on the change process.
4. Implementee Factors - refers to the transitions teachers made in order to utilize the microcomputer in their classrooms.

Following a more complete delineation of these dimensions there will be an attempt to <u>interrelate</u> these in a "model" of implementation.

1. <u>Nature of the Innovation</u>

<u>Reliability</u>

There was considerable initial concern as to how the microcomputer would fare within a junior high environment. As it turned out this initial concern was unjustified - the microcomputer performed flawlessly throughout the duration of the project. This dimension has certainly improved with the introduction of large scale integration of electronic components within the computer.

Ease of operation.

All of the teachers and 86% of the students found the microcomputer easy to operate. The disc operating system instructions proved to be simple and straightforward. If the teachers encountered difficulties in operating the microcomputer, then it could be simply turned off and "rebooted" to become operable again. Though this simplified operating system is in all likelihood much less powerful than those in the mini and mainframe computers, it certainly facilitates relatively quick utilization of the microcomputer, especially with preprogrammed courseware.

Programming Complexity.

Although 100% of the teachers felt minimally programming competent in their application area by the completion of the study, 60% of these same teachers responded that BASIC language programming was somewhat difficult to learn. Whereas microcomputer operation was learned in a matter of days, microcomputer programming was a major teacher concern for at least the early stages of the project. Computer programming for courseware production is much more than a simple association of BASIC language instructions with their corresponding computer operation. This level of programming potentially requires a collection of relatively complex interrelations of instructions to reach the desired courseware goal. The instructional approach used in this project might be linked to a problem solving model consisting of focusing on simple discrete educational applications, flowcharting these, programming and debugging, classroom experimentation, reflection on their educational viability, and finally refinement and reprogramming of the application on the basis of these experiences. This problem solving approach seems to lead to a better understanding of the interrelation of computer instructions within a program and also a clarification of the educational viability of the particular application. This process can be seen to be enormously time consuming, resulting in considerable expenditure of teacher energy to get fully functional courseware. The teachers were able to develop simple drill routines on their own and slightly more sophisticated conceptual programs with consultative assistance, but more extensive programming would have been too time consuming and generally beyond their abilities.

One-to-one restrictiveness.

All of the teachers identified the one-to-one limitation of the present generation of microcomputers as a major impediment to effective classroom utilization. Typically teachers are responsible for 20 to 30 students per classroom and scheduling computer usage within this context proved to be difficult and at times exasperating. Not all teachers though experienced the same degree of frustration. Those teachers involved in smaller differentiated classrooms, using an individualized curriculum, and a drill and practice application experienced the least degree of frustration. On the other hand, those teachers involved in regular classrooms, using a teacher directed instructional mode, and a higher conceptual computer application (thus requiring more student computer time) experienced a much higher level of frustration. One microcomputer per classroom in these applications is clearly insufficient.

In fact one microcomputer per classroom in a drill application might be inadequate. The teachers felt that each student should receive about two sessions of about 15 minutes per week on the microcomputer. With two students typically using the microcomputer per period and six periods per week, a class of 30 students would require five microcomputers. This is clearly a costly enterprise at this point in time, but with the advent of the 16 bit microprocessors and the possibility of time-sharing microcomputers and cheaper terminals this difficulty should be somewhat relieved.

Educational potential.

The teachers continued to feel that the microcomputer had considerable educational potential. This potential was exhibited in two major areas.

The first of these is the utilization of the microcomputer as an instructional aid. The teachers seemingly had little difficulty in perceiving a number of potential applications for the microcomputer in their classrooms. Their educational selections for the project were exceedingly appropriate and with one exception became operable within a relatively short period of time. Their perception of the instructional microcomputer potential can be seen as a powerful motivator for utilization of these devices in the classroom. One teacher commented:

> T-1. With some imagination, the computer is versatile enough to fit into most existing situations.

The other area of perceived educational potential is related to direct use of the microcomputer in teaching aspects of computer literacy. Perhaps the teachers express this point best:

T-1 Students, by the time they leave school will deal with computers in many aspects of life. They now look on computers as mystical and the more use students have of computers the better.

T-3 Computer literacy is as vital to a graduating high school student as is math. There are very few professional or technical jobs which are not dependent upon computer technology.

And their principal:

P The world is changing rapidly and computers are an integral part of this change. Students should be aware of how technology (computers) affect their lives and how they can use this knowledge to improve their lives.

Student interest.

Although this dimension may not initially seem to be appropriately categorized, closer analysis reveals some rather interesting student perceptions of the microcomputer. Perhaps most glaringly obvious of all the data was the exceedingly high student interest in utilization of the microcomputer. All of the teachers agreed that the students were very excited about using the microcomputer, all of the students enjoyed using the microcomputer, 93% of the students felt that learning about computers was important, and when given an opportunity to take a computer literacy option the following school year the students responded in numbers far exceeding any other optional area. One explanation for this interest might be the "now" aspect of this technology in relation to the more traditional aspects of the school curriculum. In this area the views of the teachers and the students are entirely congruent. Both groups view the microcomputer as having significant effects on their future chances for success. In school systems where the students' views are often in opposition to the teachers' views, this is a powerful motivating force which should be recognized and utilized.

One other area pertaining to student interest is possibly a bit more difficult to characterize. This relates to the students' perception of the microcomputer's operation. The pseudo intelligence the microcomputer exhibited was very interesting to the students. The opportunity to learn from another source which was clearly competent in calculational abilities, but which also "communicated" with the students, albeit in a rather simplistic manner, was highly motivational. This "quasi-other" notion can also be used as a powerful device by teachers to stimulate students in other areas of the curriculum.

Portability.

This generation of microcomputers proved to be extremely portable in contrast to their earlier bulkier predecessors. This facilitates more effective use both in and between classrooms. The teachers' comment:

> T-1 I prefer the computer in the classroom; I really do, if only for the fact that you can access the kid and you have access to the computer if you want to do something. If the kids run into trouble, you're there to help.

> T-4 I'll tell you what's working particularly well. Three of us are all downstairs and we have put the computer on a dolly so we can move it about quickly between classes and set up. That's important, bring the computer into the class rather than the kid out.

2. Organizational/Structural Factors

This section includes mention of the structural support services (materials, administrative, and implementor) as well as the implementation mechanism for the project.

Materials support.

This dimension includes both the print and courseware materials which enable the teachers to employ the microcomputer medium effectively. The APPLE Tutorial Manual provides a relatively simple introduction to the microcomputer operation, but it does not readily facilitate programming competence. Sample programs (see Appendix E) were included to assist the teachers in focusing on various aspects of the BASIC language, but more assistance in the form of an extra programming session and individual assistance was required. Even though the teachers readily found areas of educational application, there was a critical lack of courseware exemplifying the various potential applications of the microcomputer. If well documented, this material might not only have facilitated easier initial clarification of potential applications, but also provided a resource base for teacher modification or generation at the later stages of the project.

Administrative support.

All of the teachers agreed that projects of this type must have administrative support. The principal makes the following point:

> P If you're talking about this kind of project coming into a school, then I think the principal should play a leading role in talking to people on staff and saying, here's another potential tool, maybe we should do something.

Support systems must also extend beyond the school boundaries. Courseware production and financial arrangements for hardware purchases cannot usually be handled with each specific school and would be facilitated by a more central agency.

Implementation mechanism.

Specifically the implementation mechanism chosen for this study was a delimitation of the courseware scope, teacher preparation in the BASIC computer language, and close correspondence with the teachers in their environment to develop the application areas, before any application within the classroom. On this point the principal comments, the teacher should:

> P ...find out what it's all about before they actually go into the classroom, which I think is a very important part of it. I think that's the proper approach. You get people familiar with the computer before they take it into the classroom, so it doesn't go into the classroom as a gimmic. The teacher has to feel comfortable with the machine, otherwise I don't think it will work.

This view is corroborated by the following statistics:

All of the teachers responded they felt clear about the potential of the microcomputer in education.

Four-fifths of the teachers felt their application was very much appropriate.

All of the teachers were satisfied with the implementation process.

3. Sociological Factors

Size of the group.

The importance of the size of the teacher group was not initially identified as critical to project success, it simply became obvious during the course of the study. The teachers responded that five teachers in a group project of this type was optimal and three teachers would be considered minimal. On this point a teacher comments:

> T-4 You can't go with one person in a school, that won't work! If you get five of the teachers going on a project in a school, then it wouldn't be hard to get the other people going on it.

The following factors are indicative of the importance of this social dimension.

Peer interaction and communication.

The teachers responded that they communicated more than once per day with other teachers in the group on project related matters. A teacher states:

> T-4 We sit around here and have our own discussions all the time. We're forever talking about the computer with five people.

Collaboration and mutual assistance.

100% of the teachers reported that they worked with other teachers in the project and 60% considered this very important to project success for the following expressed reasons:

> T-2 For further extension of ideas.
>
> T-1 To discuss problems encountered and their solutions.

T-3 To get help in working out a problem and to have someone to bounce ideas off of.

Morale and cohesiveness.

All of the sessions were both professional and friendly with the complete absence of bickering and infighting. The teachers formed around a common purpose (microcomputer utilization) and worked together towards that end. Perhaps the following indicate a sense of this assertion:

80% of the teachers were very satisfied with the project.

100% of the teachers felt the time they spent was very worthwhile.

100% of the teachers wanted to continue to use the micro-computer in the next school year.

4. Implementee Factors

Perhaps two of the most important factors also within the domain are educational potential and student interest. For any innovation to be successful the implementees must have some incentive. In this case their perception was that the computer could help them in their instruction, that the microcomputer in itself is important, and students are interested in using and learning about the microcomputer.

Teacher entry characteristics.

The teachers who participated in this project were all very experienced teachers. 80% of them had more than 9 years of experience in the classroom and in this sense represented considerable capabilities in teaching at this level. Their previous experience with the computer was though extremely varied. One teacher had spent hundreds of hours interacting with a computer at the University of Alberta and at the other extreme, a few teachers had no previous experience with a computer. Within the scope of this study, previous computer experience was seen as not having appreciable effect.

Teacher growth.

Initially the teacher difficulty was in the programming area, but this concern disappeared during the course of the project as indicated by the following excerpt:

> T-2 From the start I thought the problem was programming. I didn't understand it. Now I feel more relaxed.

Growth in the area of computer competence was not the only area of interest. The teachers were also becoming aware of how this device could be used to improve their instructional capabilities. The principal made the following comments:

> P I think the project has really helped to enthuse the teachers, and that to me from my point of view, besides the help that the kids get, is one of the major benefits. It's got them into a whole other area, got them thinking about what's available, what they can use, what they can be thinking about.

This is a powerful positive motivator for the utilization of the microcomputer within the school. In the researcher's view, all the teachers wanted to improve their instructional capabilities and if the microcomputer was seen as a vehicle in accomplishing this purpose, then they were very interested in learning how to use it.

Teacher recognition.

Recognition from others on the teaching staff was also observed as having a positive influence on the teachers in the project. The principal made the following observations:

> P I think it (the microcomputer project) has had an effect on the total staff in the sense that people are realizing that others are doing things in the school that are a little more up-to-date and a little more in tune with things that are happening.... There are a lot of people on staff saying, 'what is this computer talk, what are you talking about when you talk about loops?' People are getting interested and saying, 'what can we do with it in other areas, can we use it in Language Arts, can we use it in other fields?'

Adequate time.

As was indicated in the phases of development section of this chapter, implementation of this sort takes enormous amounts of time. Considerable time was allocated to the development of teacher expertise before classroom experimentation, but perhaps the most time-consuming portion of this type of implementation is within the classroom. It requires considerable experience for the teacher to effectively utilize the microcomputer within the classroom setting and this takes time and energy. One teacher comments:

> T-2 This computer takes more time. It is another aspect of planning you have to put into the lesson. How are you going to utilize it? A lot of teachers are overworked at this point now where they will say, 'I've got enough to do now, to h... with it!'

Fully 80% of the teachers felt that the time they had within the classroom with the microcomputer was inadequate. It must be recognized that effective utilization of these devices within the classroom will not occur immediately. In order to make the necessary role changes, the teachers will require both support and suitable amounts of time.

THE TEACHERS' VIEWS OF THE PROJECT

The final question on the post project questionnaire was conducted to give the teachers an opportunity to express their views directly in the thesis. They were asked to comment on their perceptions of the value of the microcomputer in their classrooms and their views concerning the necessary preconditions for a successful implementation in this area. Table II represents these final comments:

TABLE II

Teacher - T-1

It is essential to have teachers who are willing to put in some extra time and effort to develop something worthwhile. With this in mind it was most helpful having a consultant to teach us programming and in helping us with our individual projects. The project seemed to take off after the session on programming.

A "hands-on" computer is also essential for the implementation of a micro in a school.

With these essentials a micro is a most rewarding experience in a junior high.

Teacher - T-2

Using the microcomputer in the classroom turned out to be a very rewarding experience. Slightly hesitant at first, because of a lack of computer literacy, I became much more aware of the possible uses of the computer as a valuable educational aid as my knowledge of programming increased.

Student interest was very high and remained so throughout the experiment although their individual involvement was at a minimum due to limited availability of the computer.

The project, to me, was an excellent introduction to the use of microcomputers and I am convinced they are a very valuable teaching aid. Each teacher should be encouraged to obtain a knowledge of computer literacy and programming in order to utilize the computer as an instructional aid. As programs become available, the potential is unlimited. However, computers must be available for use on a one to each teacher basis, so that it will receive maximum use rather than receiving a hesitant approach if there is limited availability.

Teacher - T-3

In today's society the effect of computers on our everyday lives is increasing at a logarithmic rate. Unless the general population becomes knowledgeable about computers, abuses by a few will diminish our personal freedoms. This modern 'slave' (the computer) could be used 'for' us or 'against' us, as witnessed in the field of atomic energy. For example, when education became available to the common man, society changed in a most profound way.

With the information explosion, it is vital that every citizen be able to access it with ease.

The future is here, now, if we don't move our butts, technology will overwhelm and devour us.

Teacher - T-4

The difficult part of the project was the time it takes in order to feel at least partly comfortable with the microcomputer. Once I was able to do some elementary programming I became quite fascinated with the many possibilities the microcomputer has.

Educational application of the computer is endless. I'm sure with more programs I would like to have the computer for the entire day and have students working on it most of this time.

Having three or four teachers in the project was very valuable as we always had someone to turn to when difficulties arose. I think this also increases the interest level.

Basic computer programming knowledge is necessary in order to implement the computer into the classroom. This programming gives the teacher confidence with the computer. This confidence will probably be transmitted to the students.

Although many hours are required, I now feel kind of fortunate to have been able to work on the project. I certainly would like the continued use of a computer in my classroom.

The Principal

I am not sure that I can comment extensively on the application of the microcomputer in education on the basis of this one project. However, the potential is there and the extent to which the applications are successful depends largely upon the energy and initiative of the staff. There is no doubt that the physical presence of the microcomputer in the school excites and interests students. The reason is obvious - the microcomputer relates to the 'now' generation and what is happening. This is not to say that other learning materials and teaching methods are out of step. However, to the student they are interpreted as being the more traditional or expected way of doing things - largely teacher directed. Students appreciate the 'hands-on' opportunity that the microcomputer presents.

As educators, we must be careful that the microcomputer is not another fad. If the applications are limited mainly to drill and practice or financial reporting, the impact will be minimal. If the teaching-learning process is structured to emphasize problem-solving approaches, the value will be lasting.

CHAPTER V

SUMMARY, CONCLUSIONS, AND FURTHER RESEARCH

THE EXPERIMENT

As a result of recent large scale integration of electronic components, microcomputer technology is now available to the classroom teacher. Tremendous reductions in both the size and cost of computing hardware have prompted a number of policy groups (NCTM, NSF, etc.) to advocate a pressing need for reflective microcomputer utilization within the schools. A basic assumption underlying this experiment is that the implementation process enabling teachers to use these devices effectively is certainly non-trivial. The purpose of this study was then to design and investigate an implementation paradigm involving the introduction of the microcomputer medium into the classroom. Consonant with this view, considerable attention was given to the selection of a microcomputer implementation model and the underlying assumptions it engendered.

Extensive research by the RAND reserchers (Berman and McLaughlin, 1976) revealed the necessity of teacher adaption of the curricula to meet the needs of the classroom setting. In order to enable this adaption process, the teachers would require a minimal knowledge of the BASIC programming language. Since a review of the literature also revealed a critical shortage of microcomputer courseware, a teacher and consultant developed curriculum was necessitated. Unfortunately, since the development of computer courseware is somewhat tedious and difficult, the implementation model also included delimitations on the scope of the courseware development in order to maximize classroom experience in a minimal amount of time. Since the utilization of the microcomputer within the classroom was considered as an essential component of the implementation process, an <u>in-situ</u> research paradigm was selected. Finally an "adaptive" model of implementation was utilized in order to correct implicit errors or assumptions in the preimplementation plan.

The research was carried out from December 1979 to June 1980 at a junior high school within the City of Edmonton. With two exceptions the teachers were able to choose a microcomputer application area, design and construct computer courseware, utilize this courseware within the classroom, and reflect on the efficaciousness of their selection and the potential of the microcomputer. During the course of the research, the remaining teachers became highly committed to the project, actively involved in courseware production, and excited about the possibilities of the microcomputer medium within their classroom.

A MODEL FOR MICROCOMPUTER IMPLEMENTATION

To this point the project has focused on the development of a preimplementation plan, enactment of this plan within an "adaptive" paradigm, and elucidation of the various determinant factors which have significance in the domain of microcomputer implementation. A further level of analysis might be to attempt to relate these factors into a schema or model of microcomputer implementation. What follows is a "conceptualization" of a potential model which attempts to interrelate the identified factors of implementation.

The model rests on the following assertions:

A Clear Need

The teachers must perceive a clear need or gain from the innovation before they will actively devote themselves in the necessary ways. In this project the teacher gains were identified as both personal (learning, growth, and recognition) and professional (improvement of instruction, opportunity of the microcomputer, and utilization of the high degree of student interest).

Complexity of the Innovation

The degree of change or perhaps more correctly the rate of change may be a function of the complexity of the innovation. Programming the microcomputer was the first major problem faced by the teachers. Figure I shows this stage as solved in a relatively short period of time. The one-to-one restrictiveness of the present microcomputer presented serious managerial problems in the classroom enactment stage. More teacher time and support was necessary before instruction was improved.

Implementee Frustration

Any change which is non-trivial will involve a period of personal frustration or possibly higher instructional cost. In this project the necessity to learn a new language (BASIC), and the one-to-one restrictions of the present generation of microcomputers were major contributors to this instructional cost.

Individual Security Threshold

If the complexity of the change and the resultant frustration is considerable, then the initial motivation for instructional gain may lose preeminence. The resultant may be a return to the original state or "adoption" of the innovation (adoption in this case might refer to use in principle but not in substance).

Catalytic Frustration Reduction

In innovative situations of high complexity and the resultant increased levels of frustration, the role of the consultant is to decrease the "transition" difficulty such that the implementation can proceed expeditiously. This role may involve multiple methodologies. The transition stage frustration level may be reduced via the inclusion of support structures inherent in the implementation plan. A number of these might include consultative assistance, orientation, coaching, administrative support, materials support, adaptive feedback mechanisms, mutual assistance and collaboration of the implementee group. Social interaction within the implementee group may also have the effect of raising the individual's security threshold (i.e. an individual may be willing to experience more frustration if there is cognizance that others in the group are involved in similar problematic situations).

Clearly, the role of the consultant is then to create an <u>environment of support during the implementation stage</u> in order to assist the teachers. This role is in rather radical divergence from the traditional input-output model consistent with a number of implementation projects in the past.

The following schematic may clarify some of the aspects of the preceding assertions.

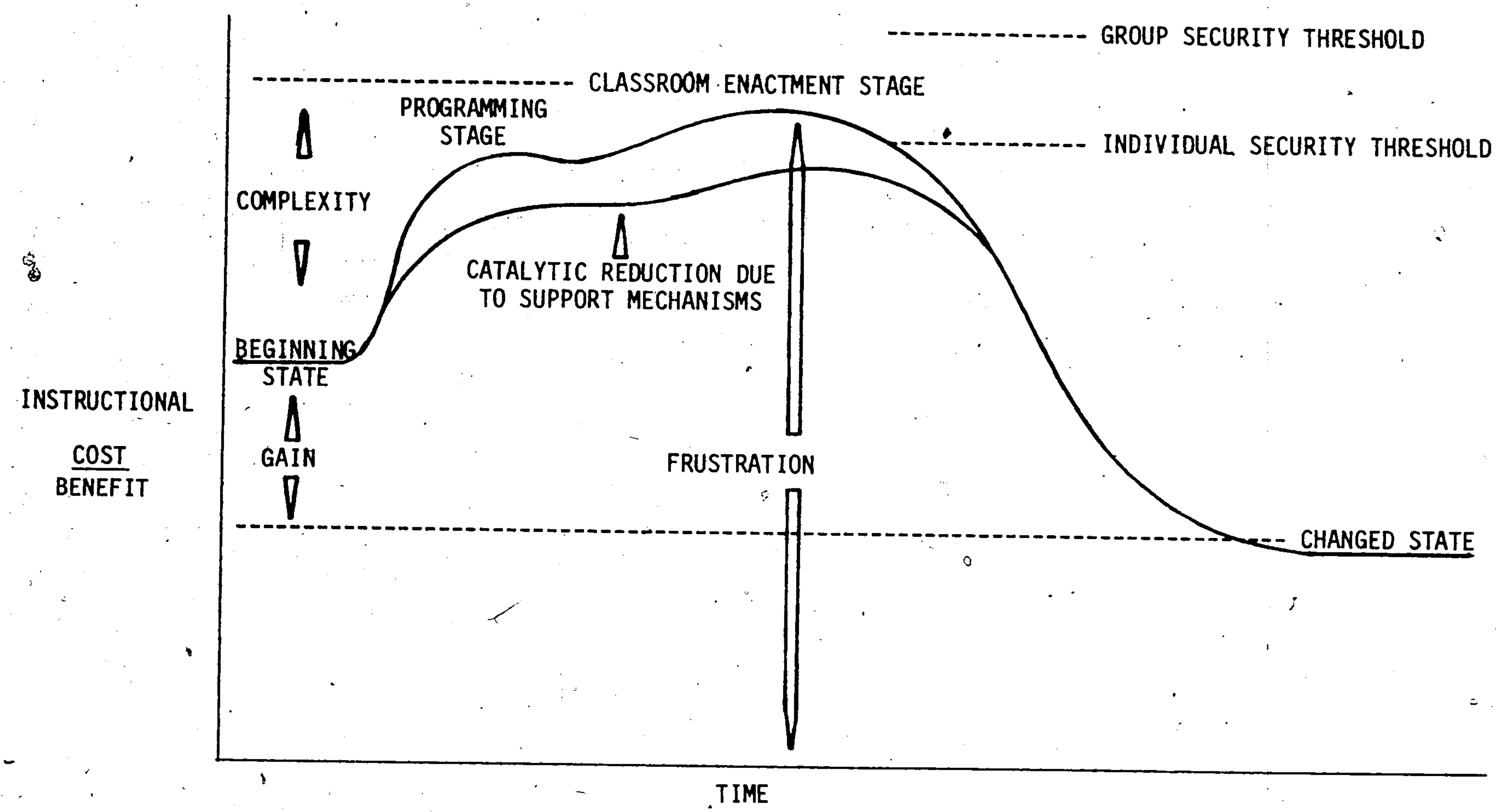

FIGURE I

AN IMPLEMENTATION SCHEMATIC

CONCLUSIONS

The Microcomputer

The microcomputer proved to be remarkably easy for the teachers to operate, extremely reliable, and in the teachers' perceptions had numerous potential applications within the classroom. On the other hand, the teachers experienced considerable initial difficulty in learning the computer language (BASIC) and coping with the one-to-one restrictiveness of the microcomputer within their classrooms. In certain applications (computer literacy with programming, tutorial applications, etc.) one microcomputer per classroom proved to be entirely inadequate in a junior high school setting.

Student interest in using the microcomputer was very high and remained so throughout the project. The students as well as the teachers perceived that knowledge about computers was essential to their future success. The teachers also perceived the microcomputer to have considerable educational potential and that their chosen application represented a portion of this potential domain.

Organization

A number of support areas are required before teachers can effectively utilize the microcomputer within the classroom.

The most pressing need is for courseware development. Although the teachers were able to develop small drill and practice modules on the microcomputer, they generally did not have the time or expertise to develop more sophisticated courseware.

This study reveals that experienced teachers are capable of understanding the capabilities of the microcomputer within the educational setting and generating ideas for potential application within the classroom. This is a potent resource which is not at this point being tapped. Teams of experienced teachers working with programming experts who are interested in developing applications with this technology, if financially supported, could develop microcomputer materials directly applicable to the curriculum and the classroom. Since drill and practice applications fit most easily into the present day classroom, this application might be used as a vehicle for initial entry. Later, teams of similar make-up, could develop more sophisticated applications such as computer managed instruction, computer assisted instruction, tutorials, problem solving applications, and simulations.

The teachers also need support beyond available "quality" courseware. Ongoing support was necessary to assist the teachers in developing their microcomputer instructional competencies. Consultants, knowledgeable in both their subject area and microcomputer applications, could play a pivotal role in assisting the teachers' instructional development with this medium.

Above all, adequate time must be allocated for teachers to develop these new instructional skills. The role changes necessary for microcomputer utilization within the classroom may require an extended period, possibly one to two years. Real change in this area can be seen to be a costly enterprise but well worth the effort.

Social Factors

There are clear advantages in establishing a "working group" of teachers in this kind of innovation. The reciprocity, mutual assistance, sharing and collective support a group of teachers can provide is invaluable to project success!

Implementee Factors

In a professional sense the teachers perceived a clear need for the inclusion of the microcomputer into their classrooms. They recognized both the timely nature of microcomputer development and the potential improvement of instruction resulting from utilization of the device. They also recognized the student's interest in the microcomputer and clearly sought ways to use this motivation to assist them in their teaching.

In a personal development sense, the teachers were stimulated by the potential for individual growth and recognition from other teachers. In this domain, the learning of BASIC programming was considered essential to facilitate the teachers' control "over" rather than "by" this technology. This knowledge not only made the teachers capable of creating programs for their own applications, but also gave them the capability of adapting existing courseware to suit their individual needs.

These are powerful forces which must be recognized as extremely determinant to implementation success.

SUGGESTIONS FOR FURTHER RESEARCH

The following suggestions for further studies arise from this research and are indicative of the exploratory nature of the work.

1. Would the inclusion of "quality" courseware diminish the need for knowledge of computer programming? Certain teachers may be content to simply learn operation of the courseware, but others may still require more knowledge. Would courseware modification be considered an essential teacher capability?

2. Studies could be extended to the elementary and high schools to explore the potential applications of these devices. In the author's opinion, computer programming for the gifted students in the elementary schools is entirely feasible. In the high schools multiple opportunities exist for the utilization of microcomputers to improve the reasoning abilities of the students.

3. More than one microcomputer is clearly advantageous per classroom. Would five microcomputers present significant opportunities for more sophisticated conceptual development or computer literacy applications? This research might be extremely timely in the sense that the next generation of microcomputers will be 16 bit processor based and probably capable of time-sharing applications (i.e. one microcomputer with five or more terminals).

4. There is today a <u>critical</u> lack of "quality" courseware which is adaptable to a wide variety of teaching styles and

situations. The microcomputer manufacturers have not shown a willingness to develop educational courseware and there is considerable doubt that they could. A number of commercial courseware packages are now being marketed in a "locked" form to ensure copyright and duplication protection. This procedure unfortunately renders the program unmodifiable and much less valuable in terms of instructional malleability. There is a critical need for research in the area of courseware development and the underlying learning theories on which it is based.

5. Recently a number of higher level languages and authoring systems have appeared for use on the microcomputers (PILOT, Pascal). Would these languages facilitate easier courseware production and teacher utilization?

6. The proposed model of microcomputer implementation presents numerous opportunities for research and experimentation. Are the suppositions on which this model is based, correct? This research might be able to provide an insight into a more general view of the implementation process within the educational system.

Final Comments

Teachers desperately want to improve their instructional abilities, but at the same time are equally fearful of dysfunction within the classroom (Stenhouse, 1975). Innovations which involve considerable changes in the teacher's pedagogies may result in initial instructional difficulties within the classroom. The teachers must be supported during this stage with a mixture of orientation, encouragement, and coaching (Joyce, 1979). In-service activities which are to reveal the goals and aims of the innovation must be couched in pragmatic activities pertinent to the classroom operation. This presupposes the consultant not only understands the teachers' difficulties, but also CARES about the teachers and is ready to support them when the going gets rough. Recognition of this intimate involvement of the implementor and the implementees, during the process of change, is absolutely essential to innovative success!

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APPENDIX A

PRINCIPAL'S LETTER

Sol Sigurdson

John Travers

Department of Secondary Education

U of A

Edmonton, Alberta.

Dear Mr. Tessari:

As Sol has possibly indicated to you previously we are interested in the implementation of a microcomputer into your school. This is a relatively new and unique project as the microcomputer has only been recently introduced as a marketable item. This product holds, in our opinion, considerably more potential that its larger and more expensive cousins, specifically in the areas of education. In our view, the time is right for a critical assessment of this technology in our public school systems. Assessment of this area, though, cannot be achieved by a simple purchase of a machine and its placement in the classroom. The microcomputer will not be a plug-in-teaching-machine! It can, though, with reasonable amounts of thought and energy become a valuable adjunct to our educational efficacy.

The following is a program which Sol and I believe would be adequate to acquaint you and your interested staff members, if you wish to develop an implementation strategy for this device.

APPENDIX B

IN-SERVICES

SESSION I

Date: December 17, 1979 Time: 12:00-1:00

The topics for this session are:

a. discussion of my background and interest in this area

b. introduction to a microcomputer and its capabilities

c. applications with educational potential

d. discussion of the implementation strategy

e. project impediments and incentives

My background and Interest in Educational Computing

My involvement since 1975 with attempting to integrate the computer into the school is in fact instrumental with my coming to Edmonton and in a sense the reason I am here today. Specifically I am most interested in how the computer can be introduced to teachers who are interested in learning about it, but need assistance in utilizing the computer in the classroom.

The history of computer usage within education is not very long, but one fact consistently has shown to be true. The computer will NOT replace the teacher. I am convinced though, that the computer can improve the instructional process. The basic questions then are, in what ways can the computer assist instruction and what kinds of support are necessary in order that this assistance becomes a reality? To answer these questions it is necessary to briefly consider a computer's attributes. These might be summarized into four simple statements:

1. The computer is very fast. Some are capable of one million operations a second.

2. The computer is accurate. Computers rarely make mistakes, but humans or programs may contain errors.

3. The computer is capable of remembering. The new breed of microcomputers can typically store up to 48,000 characters in their "core" memory.

4. The computer can make simple binary logical decisions. i.e. if something is true then do something - if it is not then do something else.

The combination of these four attributes then potentially make the computer viable in some educational applications. The fact remains that the computer has not been extensively used within education. There are good reasons for this but technological advances have changed the situation considerably. To understand these changes it is necessary to briefly review the developments of computational technology.

The first truly electronic computer built was called the ENIAC. It became operational in about 1945, consisted of about 18,000 vacuum tubes, gave off enormous quantities of heat, and was quite unreliable. Subsequent discoveries of the transistor, integrated circuit, and now the microprocessor have resulted in two major changes. Computers with the same or more computational power can be constructed in a much smaller space with very significant reductions in cost. Today a microcomputer with the necessary peripherals typically cost in the neighbourhood of $2,000.00. The potential now exists for a school to purchase one of these units, but the fact remains that though these units might be purchasable by a school, it does NOT make them educationally effective. The opportunity now exists for teachers to use these devices, but how should we go about it? This is the basic question of this project!

Impediments

1. It will take time to develop the expertise needed to construct the necessary materials. This obviates the need to start small, but still be applicable.
2. You will need access to the necessary hardware (computer) to develop the material. If these is only one microcomputer for this project, then we will have to schedule carefully.

Incentives

1. A historical perspective would seem to imply the future of the microcomputer in education is "now." This project should certainly increase your knowledge in this area.
2. This knowledge coupled with successful applications should result in recognition among educators.
3. The microcomputer will conceivably improve your instruction.

My incentive will be a clearer knowledge of the factors which affect the development of microcomputers in education.

The following areas have shown potential for computer application within education:

a. Drill and Practice

b. Computer Literacy

c. Computer Programming

d. Simulation

e. Computer Managed Instruction

f. Computer Assisted Instruction

g. Test Item Banking

In order to develop any one of these applications, an approach might be to have a curricular specialist develop the programs for you to use in your classrooms. The trouble with this approach is that these programs might not fit into the needs of your classroom. The implementation process I am interested in is to have the teachers develop their own materials for use in their classrooms.

There is a possibility for this approach to be considerably more tedious than selecting and using ready-made programs. The way to reduce this problem is to reduce its scope. The approach I would like to try is; focus on something necessary but small, construct a program to handle this area, try it in the classroom, reflect and diagnose the problems, refine the program, retry it in the classroom. In this way you develop both programming competence and the techniques in making programs educationally valuable.

This approach has some impediments and incentives which should be considered.

SESSION II

Date: February 18, 1980 Time: 11:45-1:00

The objectives of this session are:

- to demonstrate the "APPLE" microcomputer operation
- to schedule a plan for the microcomputer's initial use
- to briefly discuss potential educational usage of a microcomputer
- to discuss a future sessional outline
- to discuss the role descriptions of the participants
- to discuss evaluation instruments and ethics
- to tentatively set the next session date

It has been my experience that teachers are busy people (at least during the day). My experience with computers, especially programming them, is that learning is much more effective if adequate uninterrupted time is available. Unfortunately, adequate time is not usually available during the day. Since the APPLE is quite portable why don't you take it home and work on it. I think three to four days should be adequate to learn a significant amount of computer operation and programming. If you would like to pair up, then the process becomes even more efficient. There are only three things to watch out for. These are:

The disc unit is quite fragile and must be handled carefully.

Do not plug in the disc board with the power on! This is critical.

Try not to spill food or ashes into the computer through the keyboard. It is a good idea not to have any food or smoke around the unit.

Otherwise the unit is very stable. Your guide is "The Applesoft Tutorial" manual. It is well written and you should not experience many difficulties. If you do, my phone number at home is 451-3579 and at the university is 432-3760. When the unit is being exchanged it might be a nice idea for the past user to help set it up in the new location.

While you are learning the computer's operation would you start to think about the potential educational areas you might be interested in trying. The most successful areas in the past have been:

A unit on computer literacy.

Some drill and practise programs.

A simulation (see the program HPLOT on the sample programs disc.

Problem solving using a computer.

Or anything else you would like to try.

The strategy here should be to develop small segments which can be tested in the classroom to discover the "bugs."

We must begin to consider the needs this project has. It would be nice to see the computer used effectively in education to improve instruction. I am convinced that if teachers develop materials for this medium, the materials become useful additions to education. The following seem to be necessary teacher tasks.

1. Understand the computer's operation and how to program it.

2. Select an area of educational interest using the computer.

3. Either select or prepare program material (I can help here).

4. Plan for classroom experimentation.

5. Report to the group on the classroom experiment.

6. Assist the group in identification of any problem areas.

My role would seem to be:

1. Assist in the preparation of computer materials.

2. Assist in any area of teacher concern.

3. Develop any research evaluation instruments.

4. Feedback to the group on the project's developments.

One of the research instruments which I would like to use is a logbook. This gives a good indication where the problem areas are in using the computer in education. I would like this to be anonymous. How would you like to do this? I do not want this to be too onerous, but it would help me to establish the difficulty areas.

Please feel free to comment on any phase of this project. Your concerns are valuable. If you wish to change any portion of the project I want you to feel you have that latitude.

COMPUTER PROGRAMMING SESSION

Date: March 25, 1980 Time: 4:00-6:30

I. COMPUTER COMMANDS

LOAD name (loads a program from the disc)

RUN (executes a program starting from the lowest line number)

LIST (lists the program statements)

NEW (erases the program currently in computer memory)

SAVE name (saves the program in computer memory onto the disc)

INIT name (initializes the disc with the disc operating system)

II. COMPUTER STATEMENTS

A. Line numbers - begin each program line; the computer will follow these in ascending order unless told otherwise.

B. PRINT statement

```
NEW

    10  PRINT 3+2

    20  END

RUN
```

What does PRINT do?

C. LET statement

```
NEW

    10  LET A=2

    20  LET B=3

    30  PRINT A+B

    40  END

RUN
```

What does LET do?

D. Algebraic Operators - (=,-,^,*,/,+,-)

Try 30 PRINT A*B   Note: When you type in this line the old line 30 is erased.

E. Formatting in the PRINT statement

```
30 PRINT "THE SUM OF 2+3=";A+B
```

Note: anything in quotes in the print statement is outputed as it is.

F. The INPUT statement

```
10 INPUT A
20 INPUT B
```

LIST

RUN What does INPUT do?

G. Program Control - the GOTO statement

```
40 GOTO 10
50 END
```

LIST

RUN What does GOTO do?   Note: to get out of the RUN sequence use CTRL/C.

H. Program Control - the FOR - NEXT loop

NEW

```
10 FOR I=1 TO 5
20 PRINT I
30 NEXT I
40 END
```

RUN What is happening? HINT - look at the printout and the program listing.

Change line 10

```
10 FOR I=5 TO 45 STEP 9
```

RUN What is happening?

I. Program Control Logic - the IF - THEN statement

```
NEW
        1Ø  PRINT "WHAT IS 5 TIMES 5"
        2Ø  INPUT A
        3Ø  IF A=25 THEN 6Ø
        4Ø  PRINT "WRONG"
        5Ø  GOTO 7Ø
        6Ø  PRINT "RIGHT"
        7Ø  END
LIST    to check the program is in okay
RUN     How does this program work?
```

J. Relational and Logical Operators

Relational operators

```
 =  equal
<>  not equal
 <  less than
 >  greater than
<=  less than or equal
>=  greater than or equal
```

Logical operators

NOT, AND, OR

for example

```
IF A=B AND B=C THEN PRINT "A EQUALS C"
```

K. Math Functions

INT(3.5)=3   INT(-4.2)=-5

This function will return the integer value of the variable. If A=5.6 then INT(A)=5. Use in the form.

```
1Ø  LET B=INT(A)
```

RND(1) - returns a random number from Ø to .999999999

to return a random integer from Ø to 1Ø use

```
LET A=INT(1Ø*RND(1))
```

also ABS(X) and SQR(X) are useful. Try them - for example

```
PRINT SQR(47.87)
```

---

1. Strings - where A represents a variable which stores a number
   A$ represents a string variable which stores any character usually <u>letters</u>.

1Ø INPUT A$	this statement will accept character input such as a person's name.
2Ø PRINT A$	will print out the person's name.

M. Restricted Word List

You should be aware of an <u>extensive</u> restricted word list which can not be used for variable names. For example OR is a restricted word so the variable ORDER will be interpreted as OR DER and give you an error in program execution.

N. Programming Problems

a. Write a program which will drill a math student in integer addition. The range of integers should be from 0 to 20. The program should give the student 10 problems then stop. After each question the computer should tell the student whether he is right or wrong.

Optional Extras:

If the student is wrong tell him the right answer. Give the student two tries then give the correct answer. Count up the number of questions the student got right. Input the student's name at the start and respond with the student's name on either the correct reply or the incorrect reply. Tell the student their correct answer % for the 10 questions.

SESSION III

Date: April 3, 1980

Time: 1:00-3:00

The following areas would seem to be the necessary dimensions to be handled today:

a. a timetable of future events
b. the various projects which you have chosen to undertake
c. the physical location of the micro, etc.
d. scheduling the various projects
e. selection of a co-ordinator
f. experimental needs
g. programming assistance

1. A tentative Timetable of Future Events

Since the end of the 79-80 school year is rapidly approaching and you will get another two month's vacation, we should consider the timetabling of the project's events. The following is a suggested outline which we might use for discussion.

a. educational programming completed by about April 25
b. classroom experimentation from April 28 to May 16
c. session 4 somewhere between May 20-24
d. continued experimentation May 28 to June 2
e. session 5 and final wrap up June ?

Let us negotiate these dates, but I think we should be finished in the classroom by the end of May.

2. Teacher Projects

The following projects are my interpretation of your individual choices concerning the educational applications of the microcomputer.

Would you consider a short comment to each of the other project members concerning your thoughts and plans to date.

a. T-1 - math drill in the differentiated 7's

b. T-4 - math drill in the differentiated 8's

c. T-3 - computer literacy to select IA students

d. T-2 - drill and/or testing in chemical symbols, valences, etc.

e. T-5 - computer managed instruction in science 7

3. Computer Location

The following physical concerns seem to be emerging:

a. a central location for the micro (library)

b. loan of a couple of T.V.'s from media for the various floors

c. some form of case for the micro and especially the disc unit

d. what to do about a printer (alternatives??)

4. Weekly Computer Scheduling

Unfortunately one computer must be shared among five teachers. This may present some difficulties and we should prepare some fair ground-rules on which to operate. In Lethbridge we found a weekly reserve list in the computer room worked well. If the computer had not been reserved for a specific period it was available on a first-come-first-served basis. A timetable form could be prepared in which teachers could enter their classroom period selections for the project. If conflicts arise they could be considered immediately. This necessitates you begin to consider:

a. what classes you wish to use the computer in?

b. for what duration you will need the computer?

c. what dates you will use the computer?

d. will the computer be available for you in the evening?

Also, will the computer be available to "select" students during the lunch hour and after school? I am sure there are a number of students who would be very interested. In Vancouver every secondary school has access to the computer, via a time-sharing system which students supervise. They indicate in about 10 years of operation there have been no incidents of vandalism. If you wish to allow students out of school time to operate the machine, you might consider the "appointment" of some student supervisors???

5. Selection of a Co-ordinator

I hesitate to continue bringing this point up, but I feel you should have a "resident authority" who oversees the computer operation here. This person could also be a contact for me if any problems emerge. How would you like to choose such a person? It may be of note that one of the first tasks would be to set up the computer reserve schedule.

6. My Experimental Needs

The classroom experimentation of the computer is a most important part of this research project. Once this portion of the research is complete, any data missed is gone forever. I do not want to become onerous on your time, would the following be reasonable:

a. a detailed account of what you did, your lessons with the computer, the student involvement, comments, etc.
   - should I come into a class to observe the student's usage?

b. student evaluation if applicable (possibly a pre and post test on the material)

c. your final assessment of the computer's educational usefulness

d. possibly a small number of student interviews of those individuals involved with the computer

e. a final "formal" assessment by you which would be published in the thesis.

All these are negotiable, let us discuss them. Specifically what I am looking for is a "typical" school's assessment of the implementation difficulties and usefulness of the microcomputer. How might we structure the assessment such that this question is answered?

7. Programming Assistance

As I indicated to you at the programming session, I will assist you in the programming necessary. What assistance do you need? Would you be interested in an evening session working with me?

If any problems emerge that present difficulties, please do not hesitate to call me.

SESSION IV

Date: May 30, 1980 Time: 12:00-1:00

Although this project and the school year are both almost concluded, it would seem advantageous to consider some important topics before we conclude. The following seem to be worthy of mention at this point:

1. What will be the fate of this project or rather the possibility of utilizing a microcomputer at the school next year? One suggestion is that we consider making a proposal to Alberta Education. In many ways you are in a very favorable position to assess the possibilities of the microcomputer in your school. If a proposal was to be created, you would have to specify the areas you would be willing to pursue. Let us discuss this.

2. Would you be willing to discuss each of your experiences so far, especially those which occurred when the micro was introduced into the classroom. What problems emerged? Did you find solutions? Were these adequate?

3. I would like to evaluate some (or all) of the students involved with the microcomputer. Would a questionnaire be possible? If so, which of the following items would seem to be useful?

   a. Did you enjoy your experience with the computer?

   b. Do you feel you benefited from the experience?

   c. Did you have any difficulties operating the computer? If so, what were they?

d. Do you think a computer could assist you in learning?

e. Would you like to use a microcomputer next year in the school?

f. What was the most interesting aspect about using the computer?

4. We should briefly consider the format of the final session this school year. (When, What, Who and Where).

Note: The MECC software is in. Would you like to spend a bit of time and quickly evaluate it?

Also, would you still be agreeable to me observing the computer in operation in your classes?

APPENDIX C

INTERVIEWS

Interview Schedule:

Interview I

From March 21-25, 1980.

Interview II

From May 2-16, 1980

Interim Administration

May 22, 1980

INTERVIEW I

Sample Transcription

Location: School   Teacher - T-2

Date: March 21, 1980

Time: 2:00 - 3:30

Problems 2:00

> T - I understand we're going over Tuesday afternoon to try some programming - I hope I'm more successful.

This was the first statement of the interview which clearly indicates the difficulty this teacher is having. The apprehension can be seen throughout the interview.

> T - This is the problem (programming) that I have and I'm looking forward to the session Tuesday. I worked through that manual (THE TUTORIAL MANUAL) followed all of the steps and my biggest error is in typing and learning how to get the cursor to move and edit the screen and I've got that part. Now the thing is programming, what do you mean by programming?

I explain the possibility of editing an already written program or delimiting the scope of the problem.

> R - What problems arose when you were trying to program?

> T - Typing (having to get everything right) and time consuming until I found out how to use the cursor control.

> R - What about computer operation - did you have any problems there?

> T - Not really - once you find out what the CATALOG is etc.

Additional Problems 2:15

> R - Was there any problem in getting it hooked up?

> T - Oh-No once you explained that - it was easy. The problem right now is not getting it often enough - we're sharing it. It would be nice if a guy had it two hours any evening. One is the accessibility of the computer.

R - Maybe what you are saying is that with five teachers you need more than one machine.

T - Maybe two teachers per machine would be more feasible.

It becomes apparent that the teachers are too busy through the week to use the machine, so weekends are the only available time. Also that to learn the teacher must spend extended periods of time to be efficient.

R - Do you feel it was a good idea to take the computer home?

T - Oh - Yah. You wouldn't have enough time around the school to work on it.

Things Which Have Gone Better Than Anticipated 2:20

T - Well I enjoyed it more than I thought I would, but when it gets to this programming. That's a lot of programming to do.

Educational Applications 2:25

T - I can see it on an individual basis - limited to one student. I'm still not sure whether I'll use it for remedial or teaching.

T - Is there any way to project the computer output onto a big screen? In this way you could use it in a small room for teaching.

Discussion centered around how to project and the requirements for using the computer to instruct to the whole class.

T - Terminology is a big thing in Science - getting kids to understand what you're talking about. I can see this machine quite effective in getting kids to learn Chemistry symbols.

R - The trouble with the APPLE is that it doesn't have lower case.

The discussions begin to focus on the possibility of this application and the ways of doing this. Topics included: the number of questions asked, the number of symbols to learn, etc. Extensions of this application are explored (identifying compounds, balancing chemical equations, and using the periodic table). Sophistications of these programs are discussed with the possibilities of "chaining" the programs together.

Scheduling 3:15

Discussion focused on the requirements of the classroom experimentation and the problems of moving the microcomputer. Scheduling also emerges as to the needs of this teacher in the classroom.

INTERVIEW II

Sample Transcription

Location: School Teacher - T-4

Date: May 6, 1980

Time: 3:00 - 4:00

Current Teacher Perception 3:00

This teacher has had the computer in use within the classroom for a number of weeks.

R - What are your thoughts so far on the computer's use within education?

T - We feel we can use it - we want it.... I'm just using it in the differentiated 8 class, and only get two students to the computer per period and strictly holding them to integers, but it's good...they (the students) can't get at it fast enough.... It's really good - what I'd do now is put on the Rule if they get it wrong.... It's so easy to do now - we know how to do it - so that's something I would like to do.

R - So what you would like to do then is take this drill program and make it into an instructional package.

T - We got this far now - in a short time I think, since we started at zero, knowing nothing, to the point now where we are picking out these things.... There's no end of use to it. I think it's great, but the trouble is now we are at the point where we are going to lose it. It's really discouraging - the people here are certainly enthused about it - we want one - we definitely want one.

On Computer Usage 3:10

T - It is being used - just about five hours a day. It's being used constantly. I'm only using it for one class so I'm not interfering with someone else's use on it. ....You could almost say that it goes from 8:45 in the morning till 4:00 at night.

On Student Interest 3:15

T - I was sitting in the class the other day, and of course I'm busy with the others, and half the period goes by and some kid says 'isn't John supposed to go on that now?' You know they're watching - they want to get everybody through.

On Classroom Scheduling 3:20

R - Has it been a difficulty in the classroom?

T - ...one kid is on it - 20 minutes at a time so that the student loses 20 minutes - so they're not losing very much.

R - You don't feel that this is a detriment at all?

T - Not at all - it has been working really nice for them. In fact I think it adds a little bit of enthusiasm in the class.

On Deficiencies 3:25

T - The only actual drawback I can see to it is it's strictly a one-to-one situation and the time factor - it takes you a whole week to run through a class. Maybe that's alright.

T - It could be a two on one in some cases if the program was written.

On the Project 3:30

T - My biggest gripe right now is that we can't completely evaluate the computer - running it for a month in the classroom. It's something we have started and I think we need all of next year really to sit down and answer these questions.

R - In what ways can you see yourself using the computer next year?

T - Well I would extend it to almost every math class that I could get a hold of the computer.

R - In drill and practice?

T - Yes - as an actual monitor in front of the class - you wouldn't use it...you can't read it. You always ha[illegible] to reteach - so if you had these things (computers) and you program the rule in, etc. - so it's not a straight drill - now it becomes a reteaching machine. So that's where I'd use it a lot.

T - If we had the printer - that would be super - with the random function and the printer and the parents would say can you give him extra homework - there you go you got it.

T - We could use one strictly in the math department - full time - with no problems and it would be used.

On Problems of Implementation 3:40

R - What kinds of problems did you have getting involved.

T - ...if we want to convince this school to buy one - then we have to sell it to everybody in the school - not just five people. In order to do that then I have to know an awful lot about it. If someone wants to know what it can do in Language Arts, then I should be able to tell them. At the present time I find that a little bit difficult, because my knowledge on it isn't that great yet - only because I myself don't really know all the things the computer can do yet. If I knew a little more about the computer - spent more time on it, then it would be easier to sell it to anybody.

On Programming Knowledge 3:50

T - If they (teachers) don't have any background in it (programming) I tell you what will happen. The machine will get put in the storeroom and collect dust much of the day. It's the same old story, if the people don't feel confident with the machine, then they don't use it.

On Teacher Group Size 3:55

T - If you can get five of them (teachers) going on the project in a school then it wouldn't be hard to get other people going on it.... You can't go with one person in a school - that won't work!... We sit around here and have our own discussions all the time, we're forever talking about the computer with five people.

T - I'll tell you what's working particularly well - three of us - are all downstairs and we have the computer on a dolly - we can just move it about so quickly between classes - and set up. That's important...bring the computer into the class rather than the kid out - that's a good deal.

INTERVIEW ADMINISTRATION

Sample Transcription

Location: School

Date: May 22, 1980

Time: 1:00 - 2:00

Perceptions of the Project 1:00

R - What is your perception of the project so far, maybe at its initial stages and where it is now. Have your perceptions changed or been confirmed?

P - I would say the project has moved along fairly well - I wasn't quite sure whether or not in the initial stages whether the teachers really understood what you wanted to get across. I think they felt, even you had made it fairly clear, at the first few meetings, that probably here was a computer and here were some programs, how would these run at the school. I don't think they initially understood the amount of time it takes to program, I don't think they initially understood what is involved in all the steps. But I think once they got into it, and had a couple of in-services with you and started looking at the programming, then I think the enthusiasm started to come and they realized these are how things happened, these are how things are done, and these are how things can be used, these are the things I can do, and now, of course the next step, what would be the next step to get it to the kid level.

Later:

P - I think this has really helped to enthuse the teachers and to me, from my point of view, besides the help that kids get, is one of the major benefits - it's got them into a whole other area - got them thinking about what's available, what can I use, what can I be thinking about.

The Principal's Role 1:15

P - I was approached by you regarding the project, I put it out to the staff, because if you don't have the teacher support, it won't go, so we seemed to get that. Once that happened, since it was an external research project, then I left it pretty well in your hands to co-ordinate and run.

Later:

P - If you're talking about this kind of project coming into a school, then I think the principal should have a leading role in talking to people on staff and saying here's another potential tool, maybe we should do something My philosophy as an administrator is, if I see a need and approach people on staff and they seem gung-ho, then I should facilitate whatever I can to get that project.

R - What are your feelings about facilitating a microcomputer in the school next year or the following years?

P - I would like to - we haven't budgeted for it - but I would like to now. I am a little more pro now than I was earlier, I'll be quite honest, because I think the project has shown some positive results. We were in the process of writing up a research proposal, but unfortunately we didn't get it in in time.

Effect on the School 1:30

R - Has, in your perception, the microcomputer affected the operation of the school in any way?

P - I think it has had an effect on the total staff in that people are realizing well hey some people are doing things in the school that are a little more up-to-date, a little more in tune with things that are happening.

Later:

P - There is a lot of people on staff - in the staffroom that say well hey I'm going to have - what is this computer talk -- what are you talking about - when you talk about loops - people are getting interested and saying, what can we do with it in other areas - can we use it in Language Arts, can we use it in other fields?

R - Would you see yourself using it next year, if you had access to a microcomputer?

P - Oh yah, I would definitely like to get involved with it.

On Implementation 1:40

P - ....other computers for people who wanted to do some tinkering, find out what it's all about before they actually got into the classroom, which I think is a very important part of it. I think that's the proper approach, if you get people familiar with the computer before they take it into the classroom. So it doesn't go into the classroom as a gimmic.... The teacher has to feel comfortable with the machine, otherwise I don't think it will work.

<u>On Student Interest</u> 1:45

P - I have heard no negative comments from any students. In fact, a lot of kids ask, are we going to be able to work on some of the computer programs.

APPENDIX D

QUESTIONNAIRES

TEACHER SURVEY

Name:____________________________ Date:____________________

As you are undoubtedly aware, there is a very obvious need to collect your perceptions of the computer's efficacy in education and also your perceptions of this in-service project. Your honest assessment in this domain is essential to further positive development of the computer's successful implementation. Please be as candid and terse, if need be, in answering the following questions. Be also assured that your replies will be held in the strictest confidence.

Thanks - John Travers

1. How many years of teaching experience do you have in junior high school?

( ) a. 1-2 years
( ) b. 3-4 years
( ) c. 5-6 years
( ) d. 7-8 years
( ) e. more than 9 years

2. What is your subject area specialization?

( ) a. Mathematics
( ) b. Science
( ) c. Other, specify____________________

3. The number of university courses taken in a computing related field.

( ) a. none
( ) b. 1/2 - 1 course
( ) c. 1 1/2 - 2 courses
( ) d. 2 1/2 - 3 courses
( ) e. more than 3 courses

4. What was the approximate total number of students you involved with the microcomputer?

( ) a. 1-5 students
( ) b. 6-10 students
( ) c. 11-15 students
( ) d. 16-20 students
( ) e. 21-30 students
( ) f. more than 30 students. Please specify________

5. How many classes did you involve with the microcomputer?

( ) a. 1 class
( ) b. 2 classes
( ) c. 3 classes
( ) d. more than 3 classes

6. In how many subject areas did you utilize the microcomputer?

( ) a. 1 subject area
( ) b. 2 subject areas
( ) c. more than 2 subject areas. Please specify______________

7. Which subject area did you utilize the microcomputer?

____

8. Did you program your own materials for the microcomputer?

( ) Yes ( ) No

9. How much time (approximately) did you spend programming the microcomputer for the duration of this project?

( ) a. 1-10 hours
( ) b. 11-20 hours
( ) c. 21-30 hours
( ) d. 31-40 hours
( ) e. more than 40 hours. Please specify__________

10. Would you say the development of computer materials is:

( ) a. very easy
( ) b. no more difficult than developing materials in other areas
( ) c. more difficult than developing materials in other areas
( ) d. very difficult
( ) e. often beyond your ability

11. Did your lesson preparation take more time when you incorporated the microcomputer with your regular class presentations?

( ) Yes ( ) No

if Yes, how much more?

( ) a. 25% more
( ) b. 50% more
( ) c. 75% more
( ) d. 100% more
( ) e. more than 100% more time. Please specify__________

12. How satisfied are you with the introduction of the microcomputer into your school?

( ) a. very satisfied
( ) b. generally satisfied
( ) c. undecided
( ) d. somewhat dissatisfied
( ) e. very dissatisfied

13. The computer application you chose was directed to:

( ) a. all of your students
( ) b. most of your students
( ) c. some of your students
( ) d. a few of your students

14. Is the grouping in your classes:

( ) a. homogeneous with respect to ability
( ) b. heterogeneous with respect to ability
( ) c. Other, please specify________________________

15. To what extent did your students have a say in the way the microcomputer was utilized?

( ) a. to a great extent
( ) b. to some extent
( ) c. very little
( ) d. none at all

16. Do you feel the microcomputer helped your students to learn in the intended area?

( ) a. to a great extent
( ) b. to some extent
( ) c. very little
( ) d. none at all

17. The number of students from your class which were working with the microcomputer at any one time was:

( ) a. 1 student
( ) b. 2 students
( ) c. 3 students
( ) d. 4 students
( ) e. more than 4 students, please specify________

18. Approximately how many times did each student get to use the microcomputer?

( ) a. 1 time
( ) b. 2 times
( ) c. 3 to 5 times
( ) d. 6 to 10 times
( ) e. more than 10 times

19. How much time did the "average" student use the microcomputer <u>for each session</u>?

( ) a. 1 to 5 minutes
( ) b. 6 to 10 minutes
( ) c. 11 to 15 minutes
( ) d. 16 to 20 minutes
( ) e. more than 20 minutes

20. In your opinion, what is the optimum amount of time per session during your classroom periods that a student should spend with a microcomputer?

( ) a. [illegible] minutes
( ) b. [illegible] minutes
( ) c. [illegible] minutes
( ) [illegible] minutes
( ) e. [illegible] than 20 minutes

21. To what extent did the introduction of the microcomputer to the classroom influence or disrupt the normal operation of the class?

( ) a. to a great extent
( ) b. to some extent
( ) c. very little
( ) d. none at all

22. Do you feel the time the students spent on the microcomputer was worthwhile?

( ) a. to a great extent
( ) b. to some extent
( ) c. very little
( ) d. not at all

23. How much <u>time per week</u> were you able to utilize the microcomputer in your classes?

( ) a. 1 to 2 hours
( ) b. 2 to 3 hours
( ) c. 3 to 4 hours
( ) d. 4 to 6 hours
( ) e. more than 6 hours, please specify ____________________

24. Do you feel the amount of time you had to use the microcomputer was adequate for your needs?

( ) a. very adequate
( ) b. adequate
( ) c. not adequate

If "not adequate" how much more time do you feel you would need?

____

25. Did the students have to wait long to use the microcomputer?

( ) Yes ( ) No

If Yes, approximately how long?________________

26. In your opinion, how many microcomputers would you feel are necessary for each classroom?

____

27. If you had $2,000.00 (two thousand dollars) to spend on educational supplies, which of the following would you choose to spend the money on?

( ) a. one microcomputer
( ) b. a calculator for each student
( ) c. a DataMan or Little Professor for each student
( ) d. Other, please specify________________

Why did you make the above choice?________________________

____

____

28. In your opinion, what is the optimum amount of time per week a student should spend with the microcomputer? (In your educational application).

( ) a. 1/4 to 1/2 an hour
( ) b. 1/2 to 1 hour
( ) c. 1 to 1 1/2 hours
( ) d. 1 1/2 to 2 hours
( ) e. more than 2 hours, please specify________________

29. In your opinion, what is the optimal <u>ratio</u> of "microcomputers to teachers" for effective use of the device and STILL be <u>cost-effective</u>?

( ) a. 2 microcomputers per teacher
( ) b. 1 microcomputer per teacher
( ) c. 1 microcomputer per two teachers
( ) d. 1 microcomputer per three teachers
( ) e. Other, please specify________________________

30. In your opinion, did the students have difficulty with the <u>operation</u> of the microcomputer?

( ) a. never
( ) b. very seldom
( ) c. moderately
( ) d. frequently
( ) e. very often

31. Did you:

( ) a. move the microcomputer to your room for instruction
( ) b. move the students to another room to use the microcomputer
( ) c. both of these

32. Did either the movement of students or the microcomputer cause disruptions?

( ) a. never
( ) b. very seldom
( ) c. moderately
( ) d. frequently
( ) e. always

33. In your opinion, did the students who were using the microcomputer miss appreciable amounts of regular classroom instruction?

( ) a. to a great extent
( ) b. to some extent
( ) c. very little
( ) d. not at all

34. If your students missed regular classroom instruction, do you feel this harmed their education?

( ) a. to a great extent
( ) b. to some extent
( ) c. very little
( ) d. not at all

35. Do you feel that the purpose of introducing the microcomputer into education is clear to you?

( ) Yes ( ) No

36. Do you feel that your subject should be altered to meet the needs of the microcomputer if this device could improve your instruction?

( ) a. very much so
( ) b. sometimes
( ) c. seldom
( ) d. never
( ) e. undecided

37. Do you feel that your school operation should be altered to meet the needs of the microcomputer if the changes improve instruction?

( ) a. very much so
( ) b. sometimes
( ) c. seldom
( ) d. never
( ) e. undecided

38. To what extent did the microcomputer's introduction to your classroom change your overall workload?

( ) a. a great increase
( ) b. some increase
( ) c. no change
( ) d. some decrease
( ) e. a great decrease

39. Do you feel the time you spent was worthwhile?

( ) a. very worthwhile
( ) b. somewhat worthwhile
( ) c. undecided
( ) d. not worthwhile
( ) e. useless

40. Did you find the microcomputer of assistance to you in your regular instruction?

( ) a. great assistance
( ) b. some assistance
( ) c. little assistance
( ) d. no assistance
( ) e. undecided

41. Do you feel the microcomputer provided you with alternate teaching opportunities?

( ) a. to a great extent
( ) b. to some extent
( ) c. very little
( ) d. not at all
( ) e. undecided

42. Which of the following areas would the microcomputer assist you in the instructional process?

( ) a. lesson introduction
( ) b. lesson development
( ) c. post lesson reinforcement
( ) d. general maintenance of skills
( ) e. enrichment
( ) f. motivation
( ) g. Others, please specify ____________________

43. In which of the following areas did you use the microcomputer?

( ) a. lesson introduction
( ) b. lesson development
( ) c. post lesson reinforcement
( ) d. general maintenance of skills
( ) e. enrichment
( ) f. motivation
( ) g. Others, please specify ____________________

The next three questions use a five point rating scale. Please encircle the number you feel best represents your viewpoint.

Note: the not useful extreme corresponds to 1 and the very useful extreme corresponds to 5.

44. To what extent did you find the microcomputer academically useful for:

	not useful				very useful
Gifted students-----------	1	2	3	4	5
Average students----------	1	2	3	4	5
Slow learners-------------	1	2	3	4	5

45. To what extent do you feel the microcomputer could be academically useful for:

	not useful				very useful
Gifted students-----------	1	2	3	4	5
Average students----------	1	2	3	4	5
Slow learners-------------	1	2	3	4	5

46. To what extent did you find the microcomputer motivating for:

	not motivating				very motivating
Gifted students-----------	1	2	3	4	5
Average students----------	1	2	3	4	5
Slow learners-------------	1	2	3	4	5

47. In carrying out this project, indicate under the "at present" column the extent you utilized the microcomputer in the following modes of instruction. Under the "potential" column indicate the extent you feel the microcomputer could be used. Indicate your choice by encircling the appropriate number in both columns. You may also add more to the list if I have missed an approach you used or feel could be used.

AT PRESENT (never)1 2 3 4 5(often)	Mode of Instruction	POTENTIAL (never)1 2 3 4 5(often)
1 2 3 4 5	Teacher lecture	1 2 3 4 5
1 2 3 4 5	Teacher demonstration	1 2 3 4 5
1 2 3 4 5	Class discussions	1 2 3 4 5
1 2 3 4 5	Small group discussions	1 2 3 4 5
1 2 3 4 5	Individual projects	1 2 3 4 5
1 2 3 4 5	Small group projects	1 2 3 4 5
1 2 3 4 5	Lab experiments	1 2 3 4 5
1 2 3 4 5	Drill practise	1 2 3 4 5
1 2 3 4 5	Class projects	1 2 3 4 5
1 2 3 4 5	Games approach	1 2 3 4 5
1 2 3 4 5	Individual learning packages	1 2 3 4 5
1 2 3 4 5	Field trips and excursions	1 2 3 4 5
1 2 3 4 5	Student directed class discussions	1 2 3 4 5
1 2 3 4 5	Resource persons from the community	1 2 3 4 5
1 2 3 4 5		1 2 3 4 5
1 2 3 4 5		1 2 3 4 5

Ratings to be used

1 = never
2 = seldom
3 = moderately
4 = frequently
5 = often

48. Did discussions with the other teachers in the project assist you in your understanding of difficulties?

( ) a. very much so
( ) b. to some extent
( ) c. very little
( ) d. not at all
( ) e. undecided

49. How often did you discuss the computer project with other teachers?

( ) a. once a week
( ) b. twice a week
( ) c. three to five times a week
( ) d. two to three times a day
( ) e. more than three times a day, please specify____________

50. In your opinion, what is the <u>optimum</u> number of teachers to have involved in a computer implementation project?

( ) a. 1 teacher
( ) b. 2 teachers
( ) c. 3 to 4 teachers
( ) d. 5 to 6 teachers
( ) e. more than 6 teachers, please specify__________

51. In your opinion, what is the <u>minimum</u> number of teachers to have involved in a computer implementation project?

( ) a. 1 teacher
( ) b. 2 teachers
( ) c. 3 to 4 teachers
( ) d. 5 to 6 teachers
( ) e. more than 6 teachers, please specify__________

52. With the experience you have had so far using the microcomputer, would you recommend that <u>most</u> junior high school students should be able to use microcomputers in their schoolwork?

( ) a. very much so
( ) b. to some extent
( ) c. very little
( ) d. not at all
( ) e. undecided

53. Do you feel that junior high students want to use the microcomputer in their schoolwork?

( ) a. very much so
( ) b. to some extent
( ) c. very little
( ) d. not at all
( ) e. undecided

54. Do you feel that junior high students are interested in learning about microcomputers?

( ) a. very much so
( ) b. to some extent
( ) c. very little
( ) d. not at all
( ) e. undecided

55. Do you feel that students think that knowledge of computers is important?

( ) a. very much so
( ) b. to some extent
( ) c. very little
( ) d. not at all
( ) e. undecided

56. Do you feel the educational application you picked was appropriate to the microcomputer and to education?

( ) a. very much so
( ) b. to some extent
( ) c. very little
( ) d. not at all
( ) e. undecided

Comments____

____

57. Do you feel the project in-services and assistance were adequate in preparing you to use the microcomputer?

( ) a. very much so
( ) b. to some extent
( ) c. very little
( ) d. not at all
( ) e. undecided

58. Do you feel the materials presented to you were adequate in preparing you to use the microcomputer?

( ) a. very much so
( ) b. to some extent
( ) c. very little
( ) d. not at all
( ) e. undecided

Suggestions____

____

____

59. Do you feel you learned <u>enough</u> of the fundamentals of the BASIC language to adequately program your educational application?

( ) a. very much so
( ) b. to some extent
( ) c. very little
( ) d. not at all
( ) e. undecided

Comments____

60. Did your attitude towards the "usefulness" of the microcomputer in education change throughout the project?

( ) a. very much so
( ) b. to some extent
( ) c. very little
( ) d. not at all
( ) e. undecided

Comments____

61. Do you feel you had adequate <u>time</u> during the project to prepare you for introduction of the microcomputer to your classes?

( ) a. very much so
( ) b. to some extent
( ) c. very little
( ) d. not at all
( ) e. undecided

Comments____

62. Had you used a computer before you became involved in this project?

( ) Yes ( ) No

If Yes, where did you use it and how much time did you spend using it?

___

___

___

63. Would you now consider the purchase of your own microcomputer?

( ) Yes ( ) No

If Yes, how would you like to use it?

___

___

___

64. Do you feel that a microcomputer should be available for use by the school next year?

( ) a. very much so
( ) b. to some extent
( ) c. very little
( ) d. not at all
( ) e. undecided

Comments ___

___

___

65. Do you consider the microcomputer to have some strong educational possibilities?

( ) Yes ( ) No

Please comment ___

___

___

___

___

66. Do you consider the microcomputer to have weaknesses to its application to education?

( ) Yes ( ) No

Please comment

67. Do you see any changes in the curriculum or school operation to facilitate the microcomputer and education?

( ) Yes ( ) No

Please comment

68. Have you perceived the microcomputer as having any effect on your teaching style in the classroom? If you continued to use it, do you think it would have an effect?

69. Did you work with another teacher at any stage during this project?

( ) Yes ( ) No

If Yes, in what way was this advantageous?

70. Do you feel you gained an <u>operational</u> knowledge (basic commands) of the microcomputer?

( ) a. very much so
( ) b. to some extent
( ) c. very little
( ) d. not at all
( ) e. undecided

71. Do you feel you gained a programming knowledge (BASIC language instructions) of the microcomputer?

( ) a. very much so
( ) b. to some extent
( ) c. very little
( ) d. not at all
( ) e. undecided

72. Do you feel that learning computer programming is difficult?

( ) a. very much so
( ) b. to some extent
( ) c. very little
( ) d. not at all
( ) e. undecided

73. Do you feel that a knowledge of computer programming is necessary for successful microcomputer usage?

( ) a. very much so
( ) b. to some extent
( ) c. very little
( ) d. not at all
( ) e. undecided

Comments ______________________________

____

____

74. Did you find it difficult to identify suitable educational applications for the microcomputer?

( ) a. very much so
( ) b. to some extent
( ) c. very little
( ) d. not at all
( ) e. undecided

Comments ______________________________

____

75. Do you feel you understand the potential of microcomputers in education?

( ) a. very much so
( ) b. to some extent
( ) c. very little
( ) d. not at all
( ) e. undecided

Comments____

76. Do you feel that consultative support is necessary to successful microcomputer implementation in education?

( ) a. very much so
( ) b. to some extent
( ) c. very little
( ) d. not at all
( ) e. undecided

Comments____

77. Do you feel that administrative support is necessary for successful microcomputer implementation?

( ) a. very much so
( ) b. to some extent
( ) c. very little
( ) d. not at all
( ) e. undecided

Comments____

78. Each of the following areas have been identified as having potential for computers in education. Please rate them by encircling the appropriate number.

	COMPUTER APPLICATION	No need				Great need
A.	Computer Literacy	1	2	3	4	5
B.	Computer Programming	1	2	3	4	5
C.	Drill and Practise	1	2	3	4	5
D.	Mathematical Problem Solving	1	2	3	4	5
E.	Computer Assisted Instruction	1	2	3	4	5
F.	Computer Managed Instruction	1	2	3	4	5
G.	Simulations	1	2	3	4	5
H.	Administration (budget, scheduling)	1	2	3	4	5

79. Would you RANK these applications in their order of importance. (Use the letters adjoining the application to do this - i.e. C - F - D - and so on).

1. ______ 5. ______

2. ______ 6. ______

3. ______ 7. ______

4. ______ 8. ______

80. Which of the above computer applications would you be willing to pursue next year?

____

____

81. Which applications would be best suited to the programs in your school?

1. ______________ 2. ______________

3. ______________ 4. ______________

82. How is the structure or operation of your school suited to your first choice?

____

____

____

83. Can you think of a different structure that might make the micro-computer more effective?

____

____

____

84. What is the major <u>role</u> (what you do) change for you in your first application choice?

____

____

____

85. Would a teacher aide be valuable for this application?

( ) Yes ( ) No

86. How many prep periods would you need (absolutely need) per week to present this application?

____

87. Do you think parental explanation would be necessary for the proper functioning of your program?

( ) Yes ( ) No

88. Would this application require you to have outside consultative assistance?

( ) Yes ( ) No

If Yes, how much assistance do you feel you would need?

____

89. Would this application require extensive preprogrammed software?

( ) Yes ( ) No

If Yes, how do you see this need satisfied?

____

____

____

90. Would you be willing to co-ordinate the microcomputer project in the school?

( ) Yes ( ) No

91. If you were in charge of implementation of a microcomputer into a local junior high, what do you feel are the most important pre-conditions for your project's success?

92. Would you comment on your initial reasons for becoming involved with the microcomputer project?

93. Certainly a very important part of any educational implementation is the teacher's "actual" perception of it. This last question (finally) pertains to this domain. I feel each teacher in the project should have a chance to express their perceptions "directly" in the thesis publication. This not only enforces the validity of my thesis, but also makes interesting reading for the audience. Would you please then comment on your perceptions of the value of the microcomputer in education, and also what you consider necessary preconditions for a successful implementation. I will reproduce your perceptions directly in the publication without, of course, identifying anyone individually.

(Thank you for your kindness and patience during the course of the project and in answering this rather lengthy questionnaire).

John Travers

STUDENT SURVEY

Class______________ Date______________

As you are probably aware, some of the teachers in your school have been experimenting with a microcomputer. Each of you have used the microcomputer in some form or other so we are very interested in your opinions concerning the experiences you had with it.

This is not a test and will not be used in any way to determine grades. Please answer the questions as truthfully as possible. This is very important for the future planning of microcomputers in your school. Thank you.

1. Did you enjoy your experience with the microcomputer this year?

   ( ) Yes ( ) No

2. What subject area did you use the microcomputer for? (Math, Science, etc.)

   ____

3. Did you use the microcomputer in your regular classroom?

   ( ) Yes ( ) No

   If No, where did you use the microcomputer?______________________

4. Do you feel the microcomputer helped you learn?

   ( ) a. to a great extent
   ( ) b. to some extent
   ( ) c. very little
   ( ) d. none at all

5. Did you have difficulties in operating the microcomputer?

   ( ) Yes ( ) No

   If you did, what kind of difficulties did you have?

   ____
   ____
   ____

6. How many times did you use the microcomputer?

( ) a. 1 time
( ) b. 2 times
( ) c. 3 to 5 times
( ) d. 6 to 10 times
( ) e. more than 10 times

7. How much time (approximately) did you have the microcomputer for in each session?

( ) a. 1 to 5 minutes
( ) b. 6 to 10 minutes
( ) c. 11 to 15 minutes
( ) d. 16 to 20 minutes
( ) e. more than 20 minutes

8. Do you feel the time you spent on the microcomputer was worthwhile?

( ) a. to a great extent
( ) b. to some extent
( ) c. very little
( ) d. not at all

9. Do you feel the amount of time you had to use the microcomputer was adequate for what you had to do?

( ) a. very adequate
( ) b. adequate
( ) c. not adequate
( ) d. no opinion

If answered c., how much more time do you feel you would need?

____

10. Were the microcomputer's instructions about what you were to do clear?

( ) a. very clear
( ) b. clear
( ) c. not clear
( ) d. no opinion

11. What was the typical size of the group of students using the microcomputer when you used it?

( ) a. just yourself
( ) b. one other student
( ) c. two other students
( ) d. three other students
( ) e. more than three other students. If so how many? ________

12. Did you miss regular classroom instruction when you used the microcomputer?

( ) Yes ( ) No

13. If you missed regular classroom instruction, do you feel this harmed your education?

( ) a. to a great extent
( ) b. to some extent
( ) c. very little
( ) d. none at all

14. Was a teacher available to help you, if you had difficulties?

( ) Yes ( ) No

15. Did you ever need assistance?

( ) Yes ( ) No

If Yes, how many times?__________

16. Did you have to wait long to use the microcomputer?

( ) Yes ( ) No

If Yes, approximately how long?__________

17. Did the introduction of the microcomputer to your classroom influence other things going on in the classroom?

( ) Yes ( ) No

If Yes, were these influences for the better?

( ) Yes ( ) No

Explain____

____

18. In your opinion, how many microcomputers would you feel are necessary for each classroom?

____

19. If your class had $2,000.00 (two thousand dollars) to spend on educational supplies, which of the following would you choose to spend the money on?

( ) a. one microcomputer like the one you used
( ) b. a calculator for each student
( ) c. a DataMan or Little Professor for each student
( ) d. Other, please specify ______________________

Why did you make the above choice? ______________________

____

____

20. Would you like to see your school:

a. Present a course which teaches students the computer basics. (What a computer can do and can't do, a simplified explanation of how it works, and some of the effects the computer will have on your future).

( ) a. strongly agree
( ) b. agree
( ) c. undecided
( ) d. disagree
( ) e. strongly disagree

b. Present a course in learning how to program the computer.

( ) a. strongly agree
( ) b. agree
( ) c. undecided
( ) d. disagree
( ) e. strongly disagree

c. Design part of a course in which you are taught by a computer.

( ) a. strongly agree
( ) b. agree
( ) c. undecided
( ) d. disagree
( ) e. strongly disagree

d. Use a computer to select the topics you will learn, administer your tests, and keep track of your marks.

( ) a. strongly agree
( ) b. agree
( ) c. undecided
( ) d. disagree
( ) e. strongly disagree

e. Use the computer to help you solve problems and "simulate" or show you subjects in Math and Science which can't be shown by books (e.g. a simulation of real-life situations in a prairie ecosystem and the effects on the whole system when one part of it is changed).

( ) a. strongly agree
( ) b. agree
( ) c. undecided
( ) d. disagree
( ) e. strongly disagree

21. Which of the following courses would you be interested in taking?

( ) a. A course in computer basics (what a computer can and can't do, basically how it works, and some of the effects it will have on us in the future).

( ) b. A course in computer programming (learning how to give the computer instructions in the BASIC language).

22. Have you ever used a computer outside school?

( ) Yes ( ) No

If Yes, where did you use it and how much time did you spend using it?

____
____
____

23. Would you like to own a microcomputer?

( ) Yes ( ) No

If Yes, how would you like to use it?

____
____
____

24. With the experience you have had so far using the microcomputer, would you recommend that most junior high students should be able to use microcomputers in their schoolwork?

( ) Yes ( ) No

Why, or why not?

____

____

____

25. Do you feel other junior high students would want to use the microcomputer in their schoolwork?

( ) a. very much so
( ) b. to some extent
( ) c. very little
( ) d. not at all
( ) e. undecided

26. Do you think that knowledge about computers is important?

( ) a. very much so
( ) b. to some extent
( ) c. very little
( ) d. not at all
( ) e. undecided

Any comments ____

____

____

27. What kinds of things did you particularly like about using the microcomputer?

____

____

____

____

28. What kinds of things did you particularly not like about using the microcomputer?

____

____

____

____

29. Do you feel that other junior high students are interested in learning about computers?

( ) a. very much so
( ) b. to some extent
( ) c. very little
( ) d. not at all
( ) e. not sure

30. Do you have any other comments which might be valuable for us to know?

____

____

____

____

____

Thank you

APPENDIX E

PROGRAMS

SAMPLE PROGRAMS

TEMPERATURES

Print the centigrade equivalents of all Fahrenheit temperatures from 0 to 250 degrees in differences of ten degrees.

```
10 PRINT "A PROGRAM TO PRINT THE CENTIGRADE EQUIVALENTS OF FAHRENHEIT
TEMPERATURES"
30 F = 0
40 PRINT "FAHRENHEIT   CENTIGRADE"
45 PRINT
50 C = 5 / 9 * (F - 32)
60 PRINT F;" DEGREES ", C;" DEGREES"
70 F = F + 10
80 IF F< = 100 THEN 50
90 END
```

AVERAGING

Write a program which will compute the average of a list of numbers of unknown length. The program should also report the number of numbers in the list.

```
10 PRINT "A PROGRAM TO AVERAGE NUMBERS"
20 PRINT " THE LAST NUMBER TO STOP THE PROGRAM SHOULD BE 999999"
30 SUM = 0
40 N = 0
50 PRINT "INPUT YOUR NUMBERS PLEASE"
60 INPUT X
70 IF X=999999 THEN 110
80 SUM = SUM + X
90 N = N + 1
100 GOTO 60
110 IF N < > 0 THEN 140
120 PRINT "YOU DIDN'T INPUT ANY NUMBERS"
130 GOTO 150
140 PRINT "THE AVERAGE IS";SUM/N
150 END
```

SQUARE ROOTS

Write a program which, when given any positive number, will find the square root of that number by using an averaging method.

```
10 PRINT "WHAT NUMBER DO YOU WANT THE"
20 INPUT "SQUARE ROOT OF";ROOT
30 GUESS = 1
40 QUOTIENT = ROOT / GUESS
50 AVERAGE = (GUESS + QUOTIENT) / 2
60 IF GUESS = 1 THEN 80
70 IF ABS (AVERAGE - GUESS) < .00001 THEN 120
80 GUESS = AVERAGE
90 GOTO 40
120 PRINT "THE SQUARE ROOT IS";AVERAGE
200 END
```

FIBONACCI

Generate the Fibonacci sequence with a last term not to exceed 20,000. As you do this, also print the ratio between successive terms.

<u>Note</u>: The Fibonacci sequence is a string of numbers in which each successive number is formed by adding the two previous numbers. The sequence begins:

0 1 1 2 3 5 8 ....

```
10 FIRST = 0
20 SECND = 1
30 SUM = FIRST + SECND
40 PRINT "TERM = ";SECND;"    RATIO = "; FIRST /SECND
50 IF SUM > 20000 THEN 100
70 FIRST = SECND
75 SECND = SUM
80 GOTO 30
100 END
```

TEACHING ADDITION

Prepare a simple drill program for addition exercises. Print two random integers in a suitable format, for which the user must compute the sum. INPUT the user's answer and compare it with the correct answer. If the user's answer is not correct, repeat the same problem. If the user's answer is correct, print a message of encouragement and repeat the procedure with a new pair of numbers.

```
10 REM  DRILL PROGRAM IN INTEGER SUBTRACTION
20 PRINT "THIS IS A PRACTICE DRILL IN SUBTRACTING"
25 PRINT "INTEGERS"
30 PRINT
40 DIM NAME$(15)
50 INPUT "WHAT IS YOUR FIRST NAME?";NAME$
60 PRINT
70 PRINT NAME$;", THERE WILL BE 16 QUESTIONS AND"
75 PRINT
80 PRINT "YOU WILL HAVE 2 TRIES FOR EACH.  TYPE"
85 PRINT
90 PRINT "IN 'BEGIN' TO BEGIN THE PROGRAM AND 'ST'"
95 PRINT
100 PRINT "IF YOU WISH TO STOP BEFORE COMPLETING"
103 PRINT
106 PRINT "ALL 16 QUESTIONS. GOOD LUCK";NAME$
110 INPUT ST$
120 IF ST$ = "ST" THEN  END
130 REM  N IS THE NUMBER OF
135 REM  QUESTION COMPLETED
140 REM  QT1 IS THE QUESTIONS
141 REM  CORRECT ON THE FIRST
142 REM  TRY.
150 REM  QT2 IS THE QUESTIONS
151 REM  CORRECT ON THE SECOND
152 REM  TRY.
160 REM  INC IS THE NUMBER OF
162 REM  CONSECUTIVE INCORRECT
200 REM  LOOP X CONTROLS QUESTION TYPE
210 REM  LOOP Y CONTROLS INDIVIDUAL
215 REM  QUESTION GENERATION
220 FOR X = 1 TO 4
230 FOR Y = 1 TO 4
240 GOSUB 1000
250 PRINT
260 PRINT "#";M;" ";A;" = ";B;" = ";: INPUT C$
261 PRINT
270 REM  CHECK TO SEE IF RUN IS TO BE
272 REM  TERMINATED.  C$ IS THE STUDENT
274 REM  RESPONSE.
275 REM  7000 FINISHING EARLIER THAN 16 QUESTIONS
280 IF C$ = "ST" THEN GOSUB 7000
282 C = VAL (C$)
285 REM 4000 IS RIGHT RESPONSE SUBROUT
```

```
290 IF C = A - B THEN  GOSUB 4000
291 IF C = A - B THEN  GOTO 310
300 IF C <> A - B THEN ON TRIAL GOTO 302,307
301 REM 5000 IS DIAGNOSIS SUBROUTINE
302 GOSUB 5000
304 GOTO 250
306 REM  3000 IS WRONG RESPONSE SUBROUT
307 GOSUB 3000
310 PRINT
320 NEXT Y
325 NEXT X
350 GOSUB 6000
1000 REM  SUBROUTINE QUESGENERATION
1010 IF INC = 4 THEN  GOSUB 2000
1012 A = INT (25 * RND (16)) + 1
1014 B = INT (25 * RND (16)) + 1
1020 N = N + 1:TRIAL = 1
1030 ON X GOTO 1070, 1040,1050,1060
1040 A = - A: GOTO 1070
1050 B = - B: GOTO 1070
1060 A = - A:B = - B
1070 RETURN
2000 REM   SUBROUTINE TROUBLE
2010 PRINT NAME$;" YOU ARE HAVING TROUBLE WITH"
2015 PRINT
2020 PRINT "THESE QUESTIONS. ASK YOUR TEACHER FOR"
2025 PRINT
2030 PRINT "HELP AND THEN BEGIN THE DRILL AGAIN."
2050 GOTO 8000
3000 REM SUBROUTINE WRONG
3010 REM MUST ADJUST INC, NO. OF
3015 REM CONSECUTIVE WRONG
3020 INC = INC + 1
3030 PRINT "NO";NAME$;" THE ANSWER IS ";A - B
3040 PRINT
3050 RETURN
4000 REM SUBROUTINE RIGHT
4010 REM ADJUST QT1, QT2, INC
4015 INC = 0: ON TRIAL GOTO 4020,4030
4020 QT1 = QT1 + 1: GOTO 4040
4030 QC2 = QC2 + 1
4040 PRINT "GREAT, ";NAME$;"! THAT'S RIGHT!"
4050 PRINT
4060 RETURN
5000 REM SUBROUTINE DIAGNOSIS
5005 REM OF STUDENT RESPONSE IF WRONG
```

```
5010 TRIAL = 2
5012  IF C = - A - B THEN 5030
5014  IF C = A + B THEN 5040
5020 PRINT "NO, ";NAME$;" THAT'S WRONG.  TRY"
5024 PRINT
5028 PRINT "AGAIN AND BE MORE CAREFUL"
5029 RETURN
5030 PRINT "YOUR ANSWER IS NOT RIGHT. DID YOU"
5031 PRINT
5032 "REMEMBER THE NEGATIVE SIGN ON";A;"?"
5033 PRINT
5034 PRINT "TRY AGAIN ";NAME$
5035 RETURN
5040 PRINT NAME$;", YOU HAVE MADE A MISTAKE."
5041 PRINT
5042 PRINT "DID YOU NOTICE THE NEGATIVE SIGN ON"
5043 PRINT
5044 PRINT B;"?  TRY AGAIN."
5045 RETURN
6000 REM SUBROUTINE SCORES
6010 PRINT "YOU FINISHED";N;" QUESTIONS.": PRINT : PRINT
6020 PRINT "YOU HAD ";QT1;" OR "; INT (QT1 / N * 100);" %"
6021 PRINT
6022 PRINT "CORRECT ON THE FIRST TRY": PRINT
6030 PRINT "YOU HAD ";(QT1 + QT2);" OR "; INT ((QT1 + QT2) / N * 100);"%"
6031 PRINT
6032 PRINT "CORRECT WITH BOTH TRIES."
6040 STOP
6050 RETURN
7000 REM  SUBROUTINE DONEARLY  - USED WHEN
7005 REM STUDENT WISHES NOT TO ANSWER
7007 REM ALL 16 QUESTIONS.
7010 N = N - 1: GOSUB 6000
7020 RETURN
8000 END
```

TEACHER DEVELOPED PROGRAMS

```
LOAD HELLO
]LIST

5 SPEED = 255
6 A = INT (20 * RND (3))
7 FOR K = 1 TO A:B = RND (1): NEXT K
10 PRINT "HELLO I AM AN APPLE II PLUS COMPUTER"
12 PRINT
20 PRINT "I HAVE BEEN PROGRAMMED BY YOUR TEACHER"
25 PRINT
30 PRINT "MR. CURR TO INSTRUCT YOU IN CHEMICAL"
35 PRINT
40 PRINT "SYMBOLS AND USE OF THE PERIODIC TABLE"
45 PRINT
50 PRINT "I HOPE YOU WILL ENJOY THE TIME YOU"
51 PRINT
55 PRINT "WILL BE SPENDING IN MY INTELLECTUAL"
56 PRINT
57 PRINT "COMPANY"
60 PRINT
70 PRINT "BY THE WAY WHAT IS YOUR LAST NAME"
72 PRINT
75 INPUT NM$
76 HOME
77 SPEED = 255
80 D$ = CHR$ (4)
82 PRINT D$; "OPEN RANDOM"
83 PRINT S$; "READ RANDOM"
84 INPUT RA$
85 RA = VAL (LEFT$ (RA$,2)
86 R1 = VAL (MID$ (RA$,RA + 2,2))
90 FOR K = 1 TO R1:Q = RND (RA): NEXT K
91 RA = RA + 1: IF RA > 18 THEN RA = 1
92 IF RA < 10 THEN RA$ = "0" + STR$ (RA) + RIGHT$ (RA$,20): GOTO 94
93 RA$ = STR$ (RA) + RIGHT$ (RA$,20)
94 PRINT D$: "OPEN RANDOM"
96 PRINT D$; "WRITE RANDOM"
97 PRINT RA$
98 PRINT D$; "CLOSE RANDOM"
100 PRINT D$; "OPEN RECORD FILE, L40"
110 FOR I = 0 to 48
120 PRINT D$; "READ RECORD FILE, R";I
130 INPUT LNAME$, FINAME$, A, B, C, D
140 IF NM$ = LNAME$ THEN REC = I: GOTO 170
150 NEXT I
155 PRINT D$; "CLOSE RECORD FILE": GOTO 1000
170 PRINT D$; "CLOSE RECORD FILE"
175 SPEED = 100
180 PRINT "HI ";FINAME$;" GREAT TO HAVE YOU WITH US"
190 IF B > 8 THEN 240
```

```
200 PRINT D$; "BLOAD CHAIN, A520"
210 CALL 520 "CHEMICAL SYMBOLS"
240 IF D > 8 THEN GOTO 300
250 PRINT D$; "BLOAD CHAIN, A520"
260 CALL 520 "PERIODIC TABLE"
300 PRINT "YOU HAVE ALREADY PLAYED THE GAME"
310 PRINT "SORRY SEE YOU LATER": STOP
1000 PRINT "YOUR NAME IS NOT ON FILE"
1010 PRINT "CHECK WITH MR. CURR"
1020 END
```

```
]LOAD PERIODIC TABLE
]LIST

4 L = 0
5 SPEED = 100
10 PRINT "MR. CURR HAS INSTRUCTED ME TO WORK WITH"
11 PRINT
12 PRINT "YOU IN IMPROVING YOUR UNDERSTANDING OF"
15 PRINT
20 PRINT "THE PERIODIC TABLE.  I WILL PRESENT YOU"
35 PRINT
40 PRINT "WITH TWO FACTS FROM THE TABLE AND YOU"
43 PRINT
45 PRINT "ARE TO IDENTIFY THE CORRECT ELEMENT NAME"
46 PRINT
47 FOR G = 1 TO 5000: NEXT G
48 PRINT
50 PRINT "OKAY HERE WE GO---GOOD LUCK";FINAME$
51 FOR G = 1 TO 3000: NEXT G
52 HOME
53 FOR J = 1 to 10
54 PRINT "QUESTION NUMBER";J: PRINT
55 I = INT (51 * RND (2))
60 FOR H = 1 to J - 1: IF MID$ (I$, H,1) = STR$ (I) THEN 55: NEXT H
70 D$ + CHR$ (4)
75 SPEED = 255
80 PRINT D$; "OPEN CHEMICAL FILE, L40"
90 PRINT D$; "READ CHEMICAL FILE, R";I
100 INPUT NAME$, SYM$, ANO,AWT, VL$, GOUP$, PERIOD$
110 PRINT D$; "CLOSE CHEMICAL FILE"
115 SPEED = 100
120 FOR K = 1 TO 2
130 A(K) = INT (5 * RND (1))
140 IF A(K) = 0 THEN 130
150 IF K = 1 THEN 170
160 IF A(K) = A(K - 1) THEN 130
170 ON A(K) GOTO 200,300,400,500
200 PRINT "THE ATOMIC NUMBER IS ";ANO
205 PRINT
210 GOTO 600
300 PRINT "THE ATOMIC WEIGHT IS ";AWT
310 GOTO 600
400 PRINT "THE PERIODIC GROUP IS ";GOUP$
405 PRINT
410 GOTO 600
500 PRINT "THE PERIOD IS ";PERIOD$
505 PRINT
```

```
600 NEXT K
605 PRINT
606 PRINT
610 PRINT "WELL WHAT IS THE ELEMENT NAME WHICH"
615 PRINT
620 PRINT "IS DESCRIBED BY THESE TWO"
621 PRINT
622 PRINT "CHARACTERISTICS";
625 PRINT
626 PRINT
627 PRINT
630 INPUT AN$
635 PRINT
640 IF AN$ = NAME$ THEN PRINT "     RIGHT ON ";FINAME$:L = L + 1: GOTO 800
650 PRINT "SORRY"; FINAME$;" YOU ARE WRONG"
655 PRINT
660 PRINT "THE ELEMENT NAME IS ";NAME$
800 I$ = STR$ (I) + I$
802 HOME
805 NEXT J
806 PRINT "YOU HAVE NOW TRIED THE SECOND"
807 PRINT "PROGRAM WITH ";L;"OF 10 QUESTIONS CORRECT"
808 PRINT
809 PRINT
810 D$ = CHR$ (4)
815 SPEED = 255
820 PRINT D$;"OPEN RECORD FILE, L40"
880 C = C + 1
890 PRINT D$; "WRITE RECORD FILE, R";REC
900 PRINT LNAME$: PRINT FINAME$: PRINT A: PRINT B: PRINT C: PRINT L
910 PRINT D$; "CLOSE RECORD FILE"
915 SPEED = 100
920 IF L< 8 THEN PRINT "YOU NEED MORE PRACTISE":
  PRINT "REVIEW THE TABLE BEFORE TRYING AGAIN": PRINT "SEE YOU LATER ";F
INAME$: STOP
925 SPEED = 255
930 PRINT D$; "BLOAD CHAIN, A520
940 CALL 520 "MONITOR"
1000 END
```

```
]LOAD CHEMICAL SYMBOLS
]LIST

20 PRINT "THIS IS THE FIRST PROGRAM ON LEARNING"
25 PRINT
30 PRINT "CHEMICAL SYMBOLS AND NAMES"
35 PRINT
40 PRINT "YOU WILL BE GIVEN 10 QUESTIONS"
42 PRINT " GOOD LUCK ";FINAME$
44 PRINT
45 PRINT
50 FOR J = 1 to 10
52 PRINT
53 PRINT
54 HOME
55 PRINT "QUESTION NUMBER ";J: PRINT
60 I = INT (51 * RND (2))
62 FOR M = 1 TO J - 1
64 N$ = MID$ (I$,M,1)
66 IF I = VAL (N$) THEN 60
68 NEXT M
70 D$ = CHR$ (4)
75 SPEED = 255
80 PRINT D$;"OPEN CHEMICAL FILE,L40"
90 PRINT D$;"READ CHEMICAL FILE,R";I
100 INPUT NAME$,SYMS,ANO,AWT,VL$,GOUPS,PERIOD$
110 PRINT D$;"CLOSE CHEMICAL FILE"
115 SPEED = 100
120 K = RND (1)
130 IF K < .5 THEN 200
140 PRINT "WHAT IS THE SYMBOL FOR ": PRINT : PRINT "      ";NAME$;
145 PRINT
146 PRINT
150 INPUT AN$
160 IF AN$ = SYM$ THEN PRINT "CORRECT":L = L + 1: GOTO 500
170 PRINT "I'M SORRY "; FINAME$;"          ";AN$;" IS WRONG"
180 PRINT "THE CORRECT ANSWER IS ";SYM$
190 GOTO 500
200 PRINT "WHAT IS THE NAME FOR THE CHEMICAL SYMBOL ": PRINT : PRINT"   ";SYM$;
210 INPUT AN$
220 IF AN$ = NAME$ THEN  PRINT "RIGHT ON";FINAME$;:L = L + 1: GOTO 500
230 PRINT "I'M SORRY "; FINAME$;"
240 PRINT "THE CORRECT ANSWER IS ";NAME$
500 I$ = STR$ (I) + I$
510 NEXT J
517 PRINT "WELL YOU COMPLETED THIS SECTION"
518 PRINT "WITH " ;L;" OF 10 QUESTIONS CORRECT"
520 A = A + 1
525 SPEED = 255
530 PRINT D$;"OPEN RECORD FILE, L40"
```

```
540 PRINT D$; "WRITE RECORD FILE, R";REC
550 PRINT LNAME$: PRINT FINAME$: PRINT A: PRINT L: PRINT C: PRINT D
560 PRINT D$;"CLOSE RECORD FILE"
562 SPEED = 100
565 IF L< 8 THEN PRINT "YOU MUST STUDY THIS SECTION":
    PRINT "SOME MORE BEFORE YOU TRY AGAIN": PRINT "GOOD BYE SEE YOU
LATER ";FINAME$: STOP
570 PRINT D$;"BLOAD CHAIN, A520"
580 CALL 520"MONITOR"
1000 END
```

```
]LOAD MONITOR
]LIST

50 SPEED = 255
80 D$ = CHR$ (4)
100 PRINT D$;"OPEN RECORD FILE, L40"
120 PRINT D$;"READ RECORD FILE,          R";REC
130 INPUT LNAME$,FINAME$,A,B,C,D
170 PRINT D$;"CLOSE RECORD FILE"
190 IF B >= 8 THEN 240
200 PRINT D$;"BLOAD CHAIN, A520"
210 CALL 520"CHEMICAL  SYMBOLS"
240 IF D >= 8 THEN 300
250 PRINT D$;"BLOAD CHAIN, A520"
260 CALL 520"PERIODIC TABLE"
300 PRINT D$;"BLOAD CHAIN, A520"
310 CALL 520"LITTLE BRICK OUT"
1000 END
```

```
]LOAD MATH DRILL
]LIST

10 REM DRILL PROGRAM IN INTEGER SUBTRACTION
20 PRINT "THIS IS A PRACTICE DRILL IN SUBTRACTING"
25 PRINT "INTEGERS"
30 PRINT
40 DIM NAME$(15)
50 INPUT "WHAT IS YOUR FIRST NAME? ";NAME$
60 PRINT
70 PRINT NAME$'", THERE WILL BE 16 QUESTIONS AND"
75 PRINT
80 PRINT "YOU WILL HAVE 2 TRIES FOR EACH. TYPE"
85 PRINT
90 PRINT "IN 'BEGIN'TO BEGIN THE PROGRAM AND 'ST'"
95 PRINT
100 PRINT "IF YOU WISH TO STOP BEFORE COMPLETING"
103 PRINT
106 PRINT "ALL 16 QUESTIONS. GOOD LUCK ";NAME$
110 INPUT ST$
120 IF ST$ = "ST" THEN END
130 REM N IS THE NUMBER OF
135 REM QUESTION COMPLETED
140 REM QT1 IS THE QUESTIONS
141 REM CORRECT ON THE FIRST
142 REM TRY.
150 REM QT2 IS THE QUESTIONS
151 REM CORRECT ON THE SECOND
152 REM TRY.
160 REM INC IS THE NUMBER OF
162 REM CONSECUTIVE INCORRECT
200 REM LOOP X CONTROLS QUESTION TYPE
210 REM LOOP Y CONTROLS INDIVIDUAL
215 REM QUESTION GENERATION
220 FOR X = 1 TO 4
230 FOR Y = 1 TO 4
240 GOSUB 1000
250 PRINT
260 PRINT "#";N;" ";A;" - ";B;" = ";: INPUT C$
261 PRINT
270 REM CHECK TO SEE IF RUN IS TO BE
272 REM TERMINATED. C$ IS THE STUDENT
274 REM RESPONSE.
275 REM 7000 FINISHING EARLIER THAN 16 QUESTIONS
280 IF C$ = "ST" THEN GOSUB 7000
282 C = VAL (C$)
285 REM 4000 IS RIGHT RESPONSE SUBROUT
290 IF C = A - B THEN GOSUB 4000
291 IF C = A - B THEN GOTO 310
300 IF C < > A - B THEN ON TRIAL GOTO 302,307
301 REM 5000 IS DIAGNOSIS SUBROUTINE
302 GOSUB 5000
304 GOTO 250
```

```
306 REM 3000 IS WRONG RESPONSE SUBROUT
307 GOSUB 3000
310 PRINT
320 NEXT Y
325 NEXT X
330 GOSUB 6000
1000 REM SUBROUTINE QUESGENERATION
1010 IF INC = 4 THEN GOSUB 2000
1012 A = INT (25 * RND (16)) + 1
1014 B = INT (25 * RND (16)) + 1
1020 N = N + 1:TRIAL = 1
1030 ON X GOTO 1070,1040,1050,1060
1040 A = -A:GOTO 1070
1050 B + -B:GOTO 1070
1060 A = -A:B = - B
1070 RETURN
2000 REM NSUBROUTINE TROUBLE
2010 PRINT NAME$;" YOU ARE HAVING TROUBLE WITH"
2015 PRINT
2020 PRINT "THESE QUESTIONS. ASK YOUR TEACHER FOR"
2025 PRINT
2030 PRINT "HELP AND THEN BEGIN THE DRILL AGAIN."
2050 GOTO 6000
3000 REM SUBROUTINE WRONG
3010 REM MUST ADJUST INC, NO. OF
3015 REM CONSECUTIVE WRONG
3020 INC = INC + 1
3030 PRINT "NO ";NAME$;" THE ANSWER IS ";A - B
3040 PRINT
3050 RETURN
4000 REM SUBROUTINE RIGHT
4010 REM ADJUST QT1, QT2, INC
4015 INC = 0:ON TRIAL GOTO 4020,4030
4020 QT1 = QT1 + 1: GOTO 4040
4030 QC2 = QC2 + 1
4040 PRINT "GREAT, ";NAME$;"! THAT'S RIGHT!"
4050 PRINT
4060 RETURN
5000 REM SUBROUTINE DIAGNOSIS
5005 REM OF STUDENT RESPONSE IF WRONG
5010 TRIAL = 2
5012 IF C = - A - B THEN 5030
5014 IF C = A + B THEN 5040
5020 PRINT "NO, ";NAME$;" THAT'S WRONG. TRY"
5024 PRINT
5028 PRINT "AGAIN AND BE MORE CAREFUL."
5029 RETURN
5030 PRINT "YOUR ANSWER IS NOT RIGHT. DID YOU"
5031 PRINT
5032 PRINT "REMEMBER THE NEGATIVE SIGN ON";A;" ?"
5033 PRINT
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5034 PRINT "TRY AGAIN ";NAME$
5035 RETURN
5040 PRINT NAME$;", YOU HAVE MADE A MISTAKE."
5041 PRINT
5042 PRINT "DID YOU NOTICE THE NEGATIVE SIGN ON"
5043 PRINT
5044 PRINT B;"? TRY AGAIN."
5045 RETURN
6000 REM SUBROUTINE SCORES
6010 PRINT "YOU FINISHED ";N;" QUESTIONS."; PRINT : PRINT
6020 PRINT "YOU HAD ";QT1;" OR "; INT (QTL / N * 100);"%"
6021 PRINT
6022 PRINT "CORRECT ON THE FIRST TRY": PRINT
6030 PRINT "YOU HAD "; (QT1 + QT2);" OR "; INT ((QT1 + QT2) / N * 100);"%"
6031 PRINT
6032 PRINT "CORRECT WITH BOTH TRIES."
6040 STOP
6050 RETURN
7000 REM SUBROUTINE DONEARLY  - USED WHEN
7005 REM STUDENT WISHES NOT TO ANSWER
7007 REM ALL 16 QUESTIONS.
7010 N = N - 1: GOSUB 6000
7020 RETURN
8000 END
```