A SURVEY OF THE PHYSICS TEACHERS OF MANITOBA AS TO THEIR USE OF THE COMPUTER

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ABSTRACT

This study surveyed use of computers by Manitoba's secondary school physics teachers in 1988-89.

The most frequent use of the computer reported was for instructional management. Only 52.9% were classified as more than occasional users of the computer. The type of user a teacher was depended on age, school location and other demographic factors. In agreement with other studies, this study found computer use by physics teachers was low. Only 7% of the respondent group regularly used computers in class. All applications were evaluated favorably.

Most physics teachers who used computers were self-taught or had taken credit courses. In-service training was found to be the least effective. Lack of suitable software, access to computers and time were reported as the greatest barriers to computer use. A majority of the respondents did not see the computer as playing a significant role in their teaching at present but did see that role changing significantly over the next 10 years.

The findings were discussed, conclusions drawn and implications for future practice were made.

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Chapter I

INTRODUCTION

This study examined the use of the computer by the physics teachers of the secondary schools of the province of Manitoba. Computers have proven themselves as indispensable tools in both business and industry. As a form of educational technology, the computer has been used in education to perform many functions.

BACKGROUND TO THE STUDY, RATIONALE

Mainframe and mini-computers were losing favor with educators in the early 1970's but the introduction of the micro-computer or the personal computer regenerated interest in the computer as educational technology. (Kinzer, Sherwood, & Bransford, 1986). Since its introduction in 1975 the increase in its power and the decrease in its cost has brought the computer into nearly every school in the country and in the province.

Personal computers began appearing in the schools of Manitoba around 1980 (Educational Technology Program [ETP], 1989). A recent study (ETP, 1989) found that almost every school in the province had at least one computer and there were over 10,000 computers for the over 200,000 students in the schools of Manitoba.

Numerous studies have been conducted to determine the degree to which teachers use the computer. Prelle and Hiatt (1989) surveyed California physics teachers.

Collis, Kieren, Therrien & Wood (1988) surveyed grade 11 students as to their ineractions with computers. Another American study (Lehman, 1985) surveyed high school science teachers. ETP (1987) did a survey of all teachers in all subject areas and Becker (1983) did as well.

The surveys mentioned were agreement with each other; computer use is low. Physics teachers are adequately prepared to use the computer but are unable to make widespread use of the computer because of a lack of funding - to provide adequate numbers of computers, adequate software, and adequate time for training and preparation. Physics teachers use the computer most for wordprocessing, working with marks and demonstrations.

STATEMENT OF THE PROBLEM

Many claims about the abilities of the computer have been made and many millions of dollars spent on computer equipment and training. Teachers may feel pressure from many fronts to use the computer in their teaching and may well want to use the computer but encounter barriers that limit their efforts.

This study sought to determine what computer applications were being used, to what degree they were being used and the barriers encountered to computer use and how computer use was related to various demographic factors. Teacher opinion on several computer related issues was also sought.

This study should assist in the future implementation of computer in physics classrooms. It provides some data for comparison to other findings. Information contained in the study about barriers to computer application encountered by teachers will assist in guiding pre-service and in-service training. Areas of successful application may be shared among colleagues. Priorities may be set as to which applications should be strengthened first.

RESEARCH QUESTIONS

This study addressed the following questions:

- Which computer applications are being used by physics teachers and to what extent?
- Which computer applications would physics teachers like to use?
- Which computer applications would physics teachers not like to use?
- Which computer applications are physics teachers not aware of?
- Which computer applications are of most value to physics teachers?
- How do physics teachers evaluate those computer applications they have used?
- For which physics topics have teachers used the computer?
- To what extent have physics teachers seen various student initiated applications of the compter?

- What barriers do physics teachers encounter in their attempts to use the computer in their teaching?
- What is physics teacher opinion about the present and future role of the computer in their teaching?
- What is physics teacher opinion about their level of training?
- Do physics teachers view the computer as having more advantages or disadvantages?
- What do physics teachers think their students should know about the computer?
- How do physics teacher compare themselves to their colleagues in other subject areas in their use of the computer?

Physics teachers' responses to these questions will be related to various teacher and school demographic factors. The various factors considered will be: (a) sex, (b) age, (c) years of teaching experience, (d) university degrees, (e) number of university physics courses, (f) number of physics classes being taught, (g) training in computer applications, (h) location of school, (i) school enrollment, (j) number of science teachers in the school, (k) number of physics students enrolled, (l) number of computers available for physics use, (m) personal ownership of a computer, and (n) type of computer user.

CHAPTER II

Review of the Related Literature

The History of Educational Technology

Educational technology defined.

Cuban (1986) defined useful instructional technology as " any device available to teachers for use in instructing students in a more efficient and stimulating manner than the sole use of the teacher's voice" (p. 4). What educators (but not necessarily teachers, Cuban notes) have been looking for is greater productivity in education. This search for something that will make children learn more and learn faster is what Cuban called an "errant passion." It is errant because it denies the complexity of what happens between the teacher and the student in the classroom. Cuban said that in this search for efficiency educators have considered the lecture, film, radio, television, and microcomputers.

Introducing educational technology - Cuban's four step cycle.

Cuban (1986) studied the use of technology in education during this century by examining the use of film, radio, and television. According to Cuban film was first used in 1910, radio in 1923, and television in 1953. Based on his study, Cuban noticed a four step cycle that occurred with each form of technology.

The first step occurs with the introduction of the

innovation to education. This is accompanied by great claims and optimistic predictions of the impact the technology will have on education. It is claimed that what teachers do will be greatly different and students will learn much more efficiently. Adams (1985) says that " experience should make us wary of dramatic positive or negative claims."

Not long after the technology is introduced there comes the call for scientific study and demonstration of the claims made. The devices are invariably shown to be as effective as the conventional method but the optimism is marred by a few pockets of negative feedback.

Further study shows limited classroom adoption. This results in disappointment, a characteristic of the third stage of the cycle. Criticism is dealt against teachers and administrators.

The fourth stage is reached when strong feelings and negative opinions are directed towards educators blaming them for being closed-minded, conservative and a hindrance to better education. The British, as Cuban (1986) relates, call this " teacher bashing".

If, in fact Cuban is correct, at which of the above stages do educators in Manitoba find themselves? Dramatic claims have been heard here, studies have been and are being done. What use patterns are in evidence and how are the survey results being received? If dissatisfaction is voiced and fingers pointed are the educators being blamed?

History of the Computer

Four generations of computers and beyond.

In an effort to increase his calculating power, man has invented many machines. From the counting machines of Pascal, Babbage and Hollerith to the calculators of Stibitz and Aiken we have the precursors to the first generation computer, the ENIAC, made in 1946. This machine weighed 30 tons, was the size of a small house, used tremendous amounts of electricity and performed 5000 calculations per second. Later, improved versions were the EDVAC and the UNIVAC. The UNIVAC computer was made in 1951.

Second generation computers made use of transistors instead of tubes. Computers were now the size of a small room and could do 100,000 operations each second. The third generation of computers used silicon wafers or "chips" that incorporated many circuit elements in a very small space. These computers used micro-processors and were again reduced in size to that of a refrigerator. They could now perform millions of calculations a second. With miniaturization continuing, the fourth generation of the computer reached the desk-top size so familiar today. Today's machines use Large Scale Integrated circuits or Very Large Scale Integrated circuits, LSI or VLSI respectively. Today's personal computers are portable, can do 20 million operations a second and consume only a minimum of electrical energy.

Another way to classify the computer is by the task it is asked to do. Cartwright (1989) gave the following list.

First generation computers were number crunchers. Second generation computers became data processors and the next generation could handle word processing. The fourth generation computers of today are asked to process ideas. And the next generation? Cartwright suggests these will have artificial intelligence.

Personal computers.

According to Kinne (1982), the first micro-computer available was the Altair 8800. It sold in 1975 for $2000-3000. Today a machine of comparable computing power would cost about $500. In 1977 the first personal computers were on the market in the form of the PET and the TRS-80. Color graphics were added in 1979. In 1981 IBM entered the personal computer market with its PC at about the same time that Xerox and Hewlitt-Packard did and the personal computer became "legitimized".

Computers are here to stay.

Initially making an impact on business, the personal computer soon made a dramatic impact on education. In 1983 Time magazine named it "the newsmaker of the year". (Freidrich, 1983). Williams and McDonald (1982) in Newsweek remarked about the personal computer and education in an article entitled " The Great Computer Frenzy ". Cartwright (1989) says that " the infiltration (by computers) into business and education and all aspects of our society has

been nothing short of remarkable. Whether you believe in them or curse them, they are here to stay. They are not going to go away ; their march is steady and relentless and nothing can stop them" (p. 15).

The Impact of the Computer

Claims and myths about the computer.

The personal computer rekindled excitement in the possibilities of finding computer applications in education. There have been many claims made about the computer and there are also many myths held. Adams (1985) said that exaggerated claims, whether they are positive or negative, do no good. He conceded that the computer has the potentiality of making " the classroom a very different place - a place where teacher and student can exist as total human beings, reacting and interacting effectively with one another" (p. 35). Bork (1985) has speculated that over the next 25 years the computer will become the dominant delivery system for most subjects. The computer will not only affect how we learn but also what we learn. Reif (1985) stated that the computer has great potential as a versatile media of instruction, as a tool with powerful teaching capabilities and as a means of effective distribution of education.

People hold several myths about computers as well. Nathan (1985) listed and discussed seven such myths. The first myth dealt with the idea that the computer is neutral- just another tool. Cartwright (1989) gave several examples that show how technology changes us. Calculators have

changed the way we do math and banking machines have changed the way we handle money. Believing that the computer is the most effective way to teach most subjects was the substance of the third myth. Bork (1985) expressed such an optimism but also cautioned that nothing assures computers will be used successfully and will improve learning to that extent. Baker (1984) also refuted the myth. He said that technological advances brought into the classroom don't automatically lead to better learning, educational progress nor curriculum improvement. The fourth myth mentioned by Nathan stated that computers will revolutionize our schools. As previously noted, the impact of the computer is best discussed in terms of potentialities, in terms of possibilities. The fifth of Nathan's seven myths dealt with the feeling that the lessons learned from past attempts to introduce technology in the classroom were clear and obvious. Contrary to the case, Nathan stated that the value of educational TV is still being debated. Adams (1985) hoped that the mistakes made in that regard are not repeated with computers and other authors (Braun, 1980, and Cuban, 1986) have echoed the feeling.

The Role of the Teacher.

The computer will have an impact on the role of the teacher. Whether this impact is seen as positive or negative will depend largely on the teacher's first experiences on implementing the technology into their teaching. Adams

(1985) contended that the computer will provide more opportunity for human interaction, but like previous technologies the computer will also increase the responsibilities of the teacher. As an example of such a case Hawkridge (1983) pictured a teacher trying to deal with a computer, TV monitor and input device as well as handle a class that may choose to be uncooperative at the same time. This sets up a student - computer - teacher triangle that may or may not enhance the educational situation. Baker (1984) argued that if the computer, being equally effective as a person, were used to provide more time for teacher-student contact then why not use that same money spent on computers to lower the pupil-teacher ratio? After all, the teacher is more sensitive, flexible, adaptable and personable than a computer.

A more optimistic view was taken by Aiken and Braun (1980). The teacher role can change from one of lecturer and primary source of information to one of facilitator and consultant. However, Aiken and Braun said that anyone who thinks the computer can provide the total learning program is being overzealous. Bork (1985) characterized his role as having "shifted from functioning primarily as a lecturer to functioning primarily as individual tutor for students in difficulty" (p. 171). He was "effectively the court of last resort, the teaching-learning device students could appeal to when all else failed" (p.171).

The Role of the Student.

Properly used the computer can greatly change the role of the student as well as that of the teacher. Mitchell (1980) saw the student's role changing from one of passive information receptacle to that of active information processor; from synchronized with others to self-paced; from lock-step sequence to student controlled sequence and from teacher controlled to student controlled. The student will have much more control over aspects such as sequence, scope, approach, level of difficulty, pacing and other aspects of learning. Baker (1984) did caution, however, that the computer can lead to student passivity just like any other educational medium. Bork (1985) and others also mentioned that using the computer can lead to the student being more interactive with the material and receiving more individualized attention.

The Place of Education.

With the proliferation of computers in public places such as libraries, shopping centres, airports and other public learning centres there will be increased pressure to move education out of the schools and out into the world, anywhere computers can be provided. Bork (1985) envisioned such a possibility and Mitchell (1980) also saw a much more open learning system. More education can take place at home. According to Cartwright (1989), the Saturn School Project in St.Paul, Minnesota involved the providing of a computer and a

modem to every student. The school day would have the students spending about one-third of the day in each of three settings. These would be in project work with other students, meeting with specialized teachers and in working with the computer and other technology.

Not everyone was pleased with such a prospect. Hawkridge (1983) stated any move to reduce face-to-face education by too large a degree would weaken the educational system. Cuban (1986) was in agreement with this concern. He refered to the "DNA of the classroom" (p. 81) that is so difficult to understand and often not considered when educational technology is introduced.

Computer Applications

Models.

There are many metaphors used to represent various computer applications. Taylor (1980) described the computer as either a tutor, a tool or a tutee. Similar to this Lehman (1985) had described the computer as instructor, as tool or as an object of instruction. In an article by the Association for the Education of Teachers of Science [AETS] ad hoc committee on computers in science education (1985), Luerhman was mentioned as talking about learning from the computer, learning with the computer and learning about the computer. Also mentioned were Goldberg and Sherwood who added learning about thinking with the computer and managing learning with the computer. Edwards (1978) refered to the

computer as instructor, laboratory, object of instruction, calculator and teacher aide. The following discussion of computer application is based on Lehman's model.

The Computer as Instructor.

Under this category Lehman (1985) listed instructional computer applications such as drill and practice, tutorials, simulations, and games.

In the role of providing drill and practice the computer is tireless, patient, non-discriminating and can provide much needed extra exposure at the student's pace and control.

When the computer is used in the tutorial mode it can help the student review previously taught material and help fill in the missing pieces, consolidate concepts and develop better overall feeling for the topic. As a tutor, the computer deals with more complicated material than drill and practise but is not for first time presentation of the material.

There are many reasons why computer demonstrations or simulations can be justified. Dunkam (1977) gave the following reasons:

1. The equipment is not available, is to costly or is too complicated.

2. The real world contains too small a sample.

3. The real experiment is too difficult or time consuming.

4. Danger prevents doing the real experiment.

5. The time scale of the experiment is too slow or fast.

6. No direct experiment is available - in ecology, genetics, or disease.

7. The variable being measured is too difficult to quantify.

8. The computer creates an ideal world.

9. The real world can be compared to the non-real world of the computer.

Computer games provide a motivating setting in which the student may practice and apply the concepts learned.

The Computer as Tool.

Some would argue, as Tinker (1984) has put it, that labs are messy, uninteresting, too expensive, take up too much room and present too serious a safety risk. These same people see the computer as a simulation device that can safely and economically replace all the objectionable aspects of the lab before the computer came along. Tinker stated this was a grave mistake and misapplication of the computer's power. His solution is to use the computer as a laboratory instrument, a tool that allows students to quantify the world around them.

Tinker (1984) and Lehman (1985) suggested the computer may be used as a tool to collect, analyze and display laboratory data. Some of the date gathering and analysis possible using the computer are: measuring time, temperature,

light intensity, acoustical signals, frequencies, EMF's, pH, capacitor discharge, and the position, speed and acceleration of an object. The computer can also generate data tables and display the data in graphical form.

Some have argued that the computer is too complex to use, produces information mysteriously and is hardly necessary since adequate methods exist already. Tinker (1981) presented these arguments on behalf of sceptics and refuted each in turn. The sceptic says the introduction of computers in the lab will necessitate the learning of new skills such as programming. To this Tinker replies that most applications use "canned" programs that the student simply uses or accesses by pushing a few keys on the computer. The computer should be as easy to use as a pinball machine. Admittedly not all computers are but they could be.

The second reason for hesitancy on the part of the sceptic was the mystery of the machine. The computer produces numbers, graphs and tables as if by magic. The student won't understand any better and, perhaps, even less than if the computer had not been used. Tinker replies that any technology needs to be trusted. A feeling for cause and effect and a chance to use the technology allows the student to calibrate their experience. They can perform a certain action and almost immediately see the result as presented by the computer and make a connection. The use of the computer greatly reduces the time between the doing of the experiment and the final presentation of the results.

How necessary is the computer to the lab after all? Aren't present methods adequate? To this third argument Tinker (1981) replies that using the computer allows more experiments to be done, allows more trials during an experiment to be done, and permits the experiment to be done quicker and in less time. The student, having less calculation to do, has more time to think about the experiment and what actually went on.

The computer, as a tool, may be used as a writing aide when used as a word processor. The word processor may be used to generate written materials like tests, worksheets, reviews, notes, experiments and reports. The students can use the computer in this mode to write their reports. Spreadsheet programs can handle data from experiments, complicated calculations and even store, display and calculate student marks.

The Computer as an Object of Instruction.

Lehman (1985) asserted that the computer can be studied as an object of instruction in that students learn how the computer works or the students learn how to make the computer work for them - they learn how to program the computer.

Learning how the computer works involves studying the mathematics of binary code, hexadecimal notation, Boolian algebra and logic circuits with "and" gates, "or" gates and "nor" gates, for example. The circuitry and manufacture of integrated circuits could be studied as well.

Programming the computer, the computer being the "tutee", as Taylor (1980) has put it, has the student instructing the computer as to what to do. It has been said that you can't teach what you don't know. Successful programming of the computer requires that the student thoroughly understand the question, the concepts being taught and so use those concepts and related skills to "teach" the computer what to do.

Barriers to Use of the Educational Technology

Computer Film, Radio and Video.

Cuban (1986) looked at the introduction of film, radio and video to the classroom and noted the reasons teachers gave as to why they did not use that particular technology more. The records of film use show that teachers had not used film more because they had no training, the cost of films was prohibitive, the equipment and maintenance was too high, the equipment was not available at the proper time and it was difficult finding the right film and the proper place to use it in the curriculum.

Later, radio was introduced into the classroom. The surveys of teacher usage revealed the following reasons for the limited use of this technology: (a) no equipment - 50%, (b) schedule difficulties - 23%, (c) poor equipment - 19%, (d) no information - 14%, (e) poor reception - 14%, (f) program not related - 10%, (g) other activities more valuable - 10%, and (h) not interested - 7%.

At this point Cuban (1986) noted that these corresponded closely to the reasons given for limited film use. He then mentioned video with inconvenient broadcast time, no equipment or facilities, no time and inconvenient facilities comprising 75% of the reasons as to why teachers didn't use video programs more. While some of these reasons are peculiar to the technology, one can recognize some that might equally apply to the computer.

Computers.

Prelle and Hiatt (1989) found that the most reported constraints on computer use were inadequate funding, inadequate preparation time, and inadequate numbers of computers. Corresponding with this, Prelle and Hiatt found that the most reported enabling factors to computer use were having an adequate quantity of computers available, having appropriate
software, and having adequate preparation time.

In various studies the matter of software was the greatest barrier to computer use; teachers were not happy with the quality, the quantity nor the variety of software available. According to Aiken and Braun (1980) "teachers see the lack of high-quality courseware as the most serious obstacle to the wider use of the computer" (p. 45). Hawkridge (1983) stated that the quality of the courseware or software may be lacking in either the scope or content. The information in the program may be dated or of low standard

and it may not use the computer to its full ability. Bialo and Erickson (1985) stated that most courseware is poorly designed and does not take advantage of the potentialities and capabilities of the computer. Tashner (1984) indicated there have been tremendous gains in the quality of software available but that most is still of poor quality. Martin (1980) said that good courseware exists but "singularly unstylish programs are being written" (p. 13). Evans (1986) evaluated most software as being of poor quality and only reflecting the ordinary teaching style of the person who wrote it.

The quantity of courseware and software is also unsatisfactory to most teachers. Martin (1980) said it takes 1000 hours of writing time to produce 1 hour of good software. Braun (1980) noted that publishers of computer programs were reluctant to invest time and money where there was a low market and purchasers of programs were unwilling to spend their money unless there was an adequate supply from which to choose. This vicious cycle, Braun stated, will only be broken if governments step in with funding to help both sides.

Once given access to some software, a teacher must find the time to evaluate the item and place it at an appropriate place in the curriculum. Griffin (1984) said that educators do not have the time, training, resources or the inclination to develop their own materials.

Evans (1986) stated that the problem of temperamental

equipment and the idiosyncrasies of the technology have defeated the attempts of some teachers to implement the computer into their classrooms. This problem, according to Walker (1984), was not made easier by the fact that the technology is changing rapidly. When a teacher is just learning, it is easy to look foolish and do more harm that good. Evans went on to say that some teachers can't adapt their teaching style to suit the technology and others are threatened by the impact of computers in their teaching area. Tashner (1984) agreed in that he said many computers are still difficult to use and many teachers are still untrained to use them effectively.

The mismatch that can occur between the hardware and the software can also frustrate attempts to implement the computer into the classroom. A school may acquire software to fit a certain system. At some future date that system may be changed causing the software to be useless. The teacher is now faced with the question as to whether they learn a new system and whether they spend additional funds to restore that part of their curriculum previously taught using the computer.

The technology that is in the schools is not always available. McGee (1987) pointed out that computers kept locked in one room with the key kept elsewhere and the software in a third location will do little to draw teachers to the technology. Teachers need the technology in their classrooms. On the other hand, Bear (1984) found that

putting a computer in a classroom without training the teacher had no effect on student performance. One ETP study (1987) found that inadequate access to computers was one reason teachers did not use them more. In fact, less than 50% were happy with the degree of access they had to the computers in their school. Prelle and Hiatt (1989) concluded in their study that the number of computer systems available was insufficient to support extensive use and restricted teacher's selection of applications. Prelle and Hiatt found the computer being widely used, but only where a single computer was involved and not multiple computer uses.

McGee (1987) argued that methods of evaluating teachers that do not recognize the use of the computer in the classroom by the teacher will do little to encourage teachers to do so.

The degree of training a teacher has will effect the amount they implement the computer into the curriculum. Teachers may not take computer training for a variety of reasons. The Pepper-Wood survey (Scott, 1985) stated that lack of time and money were two such reasons. In addition, materials may not be available and keeping pace with advances in the area would require further commitments of time and money. Griffin (1984) suggested that teacher training facilities were not effectively training teachers to implement computer technology in their teaching methods.

For some teachers, the computer may not seem to be the way to go. Evans (1986) stated that some teachers feel

threatened by the new technology and find that they can not adapt their teaching style to implement the computer. When asked in the Pepper-Wood survey (Scott, 1985) about their concerns regarding computers in education, 61 out of 328 responses mentioned those attitudes and dispositions that prevent teachers from taking an active role in computer education. Cuban (1986) stated that " transforming the classroom practices through the computer will stretch well beyond what many teachers view as possible."

Predictions

The computer has had and will continue to have an influence on education. The opinions as to the extent and timing of changes are many and varied. There are optimistic views, which are stated first, and more pessimistic ones that follow. Lastly, some viewpoints falling somewhere in between are given. However, whatever the oponion, no author has called for the removal of the computer from the schools.

Optimistic forecasts.

Aiken and Braun (1980) predicted the computer will change not only the way we teach but also what we teach. Bork (1984) echoed this sentiment by stating that by the year 2000 our schools will operate with an entirely new learning system. The next 10 years or more, Bork said, will see continuing problems but eventually there will be new courses and curricula in place. There will be fewer teachers and

they will have different roles than today. Much more education will take place at home and in a much more flexible manner.

To what extent will the computer teach students? Braun (1980) considered 100% of teaching being done by the computer as a possibility. For the near future, Hawkridge (1983) extrapolating on the work of Melmed in 1982, indicated that computerized learning should be possible within some reasonable budget increases.

Hawkridge (1983) gave an optimist's forecast for the new information technology. This viewpoint saw some of the following as possible. Children at home will learn keyboarding and the basic skills (colors, numbers, letter recognition, counting, etc.) before going to school. As the student progresses through school more and more teaching will by done by the computer so that in secondary school each subject will have some aspect of its content presented by the computer with the entire math course, perhaps, taught by the computer.

Chambers and Sprecher (1983) predicted that great changes could happen by the year 2000. These changes would be made possible because of more powerful hardware for the same money, transportability of programs from one system to another, better intelligent authoring systems for the writing of CAI programs and better courseware available more easily through improved marketing great changes are possible by the year 2000. Chambers and Sprecher saw these changes happening

first in the colleges and universities, then the secondary schools and finally in the elementary schools. Full courses could be taken on the computer, even in the home.

A very optimist view was given by McLuhan and Leonard (1980) who said, "by the time this year's babies become 1989's graduates (if college "graduation" then exists) schooling as we know it may be only a memory." (p. 4) McLuhan and Leonard saw the mass production and standardization of the industrial age gone and replaced by diversity and originality as measures of exceptional student performance. Further, they predicted that teacher-lead instruction would no longer be used.

What were the realities of computer use at the end of the 1980's? Prelle and Hiatt (1989) found word processing and handling of marks were used on a weekly basis but demonstrations were used, on average, only 2 to 5 times yearly. Collis, Kass, Kieren, Therrien and Wood (1988) found that "little or no computer usage opportunities are occurring for most students within the contexts of their regular courses" (p. 20). Collis et al. stated that from 78.0% to 94.6% of students, depending on subject and student gender, had never used the computer in class.

Pessimistic forecasts.

In contrast to all this optimism, Hawkridge (1983) presented a pessimist's forecast. This forecast saw a number of pressures acting that lead to a general decline in the

quality of education. These pressures include budgetary restraint that reduces monies available for public education, the problems of an aging staff with few replacements and a trend towards more centralized control of education by government. These will be coupled with the trend of more education being dominated by private interests. Against these pressures the computer will have little counter-acting impact.

A tempered forecast - somewhere in between.

Hawkridge (1983) has given his personal forecast. On the optimistic side he saw good progress being made that will let information technology be user-friendly and able to help those poor in information. Many new developments will be made by the year 2000. Information technology will be reliable, reasonable and adaptable. The handicapped and the poor could get the most out of the new technology. Teaching via the computer could cost as little as 40 cents per hour of instruction. Many people and some countries will reject information technology. Finally, schools will not be deinstitutionalized, teachers will still teach in classrooms.

On the pessimistic side, Hawkridge (1983) had fears that information technology will be used in dehumanizing ways and will not be equally distributed through the industrialized societies. Most teaching could come under the control of large international corporations that have their own interests in mind first. Profits from information technology

will come firstly from the military, industry and commercial sectors, then from agriculture, domestic and government areas and finally from education.

Based on how other technologies have faired, Cuban (1986) made predictions about the computer in education. Cuban said, "Policy makers will discover how little teachers use the machines" (p. 99). He predicted no breakthroughs in teacher use patterns, and most teachers will use the computer as an aide--not unlike the radio, film or TV. Secondary school students will be scheduled into one or more elective classes taught in computer labs. General student use will not exceed 5% per week. Computer technology will be tailored to fit the teacher's perspective and the tight contours of the school and the classroom settings. If Cuban's four step cycle is correct, "teacher bashing" will occur.

Many authors have indicated they think the computer has great potential in education. Bork (1984) has likened the computer to fire and its potential for good or ill. Like any other tool, the computer can be used properly or poorly. Hawkridge (1983) claimed there is not enough knowledge about the computer to use it effectively but is encouraged by the fact that the body of experience is growing.

The actual impact the computer plays in education is the result of many factors. Many good things have and will be accomplished and many mistakes made, as well. Each individual will have their life changed by the presence of computers and, hopefully can use the computer to make this

world a better place.

Other Surveys

Of the surveys found, most were not limited to physics teachers but deal with teachers in general and outside of Canada. Prelle and Hiatt (1989) surveyed American physics teachers. The ETP (1989) survey was done with Manitoba teachers in all grade levels and subject areas. Collis et al. (1988) surveyed grade 11 students from across Canada. Lehman (1985) surveyed American high school science teachers but did not single out physics teachers. The John Hopkins study (Becker, 1983) was done across the entire grade school spectrum in the United States.

Several studies (Prelle & Hiatt, 1989; ETP, 1989, 1987) mentioned demographic factors. The ETP (1989) study mentioned the ages of the teacher population and found for the 1988-89 school year that less than 15% of teachers responding were 50 years old or more. However, the results showed that the general teacher population was increasing in age. The ETP (1987) study found about 12% of teachers had less than 5 years teaching experience while 66% had 11 or more years of experience. The earlier ETP study (1987) stated about 20% of teachers owned their own computer and found it was considerably more likely a northern teacher would own a computer than a teacher from an urban or rural district. Prelle and Hiatt (1989) found that their respondents had an average of 18 years teaching experience

and an average of 14 years physics teaching experience. Furthermore, over 30% reported having physics as their undergraduate major and 82% had earned advanced degrees.

Few sex differences in computer use were mentioned. The ETP (1989) study found that more females stated they found the computer not useful in their teaching. In addition, of those teachers who had been using the computer for four years of more, the males were almost twice the females. The other surveys reviewed did not mention teacher sex.

Teacher training in computer application has also been investigated. Prelle and Hiatt (1989) found their respondents averaged 7 years computer experience and concluded physics teachers should be well enough prepared to use the computer. Lehman (1985) reported that of those teachers using computers 75% reported having the equivalent of a 1 - 3 semester hour course. Lehman also reported that 58% of teachers learned about computers on their own, 57.1% from in-service and 50.1% through university or college courses. The ETP (1987) study said that about two-thirds of teachers reported having had some professional-development in the area of computers. Further, the 1987 ETP study found teachers were <u>hungry</u> for more training in computers. About 90% of teachers said they wanted additional training and about 60% said they were spending more time in professional development because of the computer. The ETP (1987) study said it was more likely a teacher from northern Manitoba had

taken computer training. Cuban (1987) stated a National Education Association survey found more than 80% of the respondents said they wanted to take computer courses and the area of application most frequently mentioned was in management.

The number of computers in the schools has been increasing each year. Prelle and Hiatt (1989) stated an average of 6.7 computers were available (if shared) or an average of 2.5 computers were available (if not shared) on a daily basis. The ETP (1989) survey had 678 responses from the 878 public and private schools surveyed. The responding schools reported that there were 10,212 computers in use. This was an increase of about 20% over the previous year. The last three years has seen a steady 97% of responding schools having computers. The ETP report also stated an average of 20 students per computer. Cuban (1987) reported that when a school acquired more computers it was usually found that instead of more students having access to the machines, the same students got more time on the computers.

To what extent were teachers using the computer? Prelle and Hiatt (1989) found between 40% and 50% of respondents had used most of the applications mentioned in their study, usually with a single computer and rarely with a class set of computers. Lehman (1985) reported 77% not using the computer in class, while 17% were occasional users and 6% were regular users. Lehman defined a regular user as a teacher who used the computer at least one hour per week per class. Cuban

(1986) refers to the John Hopkins study done in the 1981-1982 school year that found only one or two teachers per school were regular users. Cuban further reported that a National Education Association questionnaire found that, despite teacher interest in using the machines ran high, only 6% reported use of computers in their classrooms. Becker (1983) refers to another John Hopkins study done between December 1982 and February 1983. This survey found that in nearly half the schools only one or two teachers regularly used the computer. More optimistically stated, in over half the schools more than two teachers were regular users of the computer. Becker defined a regular user as a teacher who either used packaged programs or taught programming to students. The findings of Becker confirmed the findings of the previous year as reported by Cuban. All these surveys were in general agreement and showed that computer use was low, and has not changed substatially during the 1980's.

Some surveys reported how many teachers in the school use the computer. Lehman (1985) reports that 41% of the schools replying to his survey said that no science teacher used the computer in that school. Of these 41% there were 43.8% urban schools, 34.8% suburban schools and 52.1% rural schools. Further, Lehman noted that the size of the science faculty was a factor. In the non-using schools, 53.7% had science departments of 1 to 5, 34.6% from 6 to 10 and 37.1% had 11 of more science teachers. Lehman found that 84 of the regular users were from 44 schools. This seems to indicate

pockets of computer users located in schools with most schools not having very many teachers who frequently use the computer.

Different computer applications have been found to be used to various degrees. Prelle and Hiatt (1989) reported that between 40% and 50% of respondents had used the computer for laboratory simulations, as a laboratory tool (teacher use), drill and practice, tutorials, data plotter (teacher), word processing (student use), and educational games programs. The applications reported most, by more than 50%, were word processing (teacher use), handling of grades, and demonstrations. Word processing and handling of grades were used on a weekly basis while demonstrations were used 2 to 5 times a year. In addition, Prelle and Hiatt reported student use of laboratory simulations, drill and practice, tutorial, and word processing programs. Lehman (1985) reported the following applications: (a) simulations - 66.0 %, (b) drill and practice - 57.1%, (c) tutoring - 55.3%, (d) handling lab data- 43.7%, (e) problem solving - 41.9%, (f) programming - 27.6%, (g) homework / individual student projects - 25.8%, (h) recreational games - 16.0%, (i) student papers, word processing - 14.0%, and (j) interfacing probes for lab use - 8.9%. Becker (1983) mentioned to what degree teachers reported using various applications. Those that could apply to science and physics teaching were: (a) drill and practice- 31%, (b) programming to solve problems - 29%, (c) demonstrations, labs, simulations - 22%, (d) tutoring -20%,

(e) recreational games - 19%, (f) teacher record keeping-15%, (g) administrative uses - 14%, (h) teacher tests and worksheets - 10%, and (i) student papers, word processing-7%. While there was some agreement between the findings of these studies, it should be noted that each had a different type of population and so close comparison was not possible. Furthermore, some of the applications were not clearly defined and were sometimes grouped in one study but not in another.

Other studies have reported on physics teachers' evaluation of their attempts to use the computer in their teaching. The ETP (1987) study found, of those teachers who had used the computer, about 80% found it to be useful or very useful. For senior high teachers the level was 90%. While two-thirds of teachers thought the computer increased their effectiveness, only 45% of users felt the computer was a time saving device. That is, about 55% of teachers felt that using the computer involved more of their time than had they chosen not to use the computer. The other studies did not mention questions of evaluation of computer applications, but the level of usage may say the most about how teachers value the computer.

Computer usage in science subjects and in other subject areas was not found to be significantly different. Collis et al. (1988) found that occasional or frequent use in math, science, social studies, and English was 8.2%, 4.9%, 3.2%, and 7.5%, respectively. Lehman (1985) asked science teachers

in which classes (physics, biology, chemistry, earth science, etc.) they used the computer. The usage in physics, biology and chemistry was very similar, ranging from 43.3% to 42.1%.

Teachers, hopefully, are not the only ones in the classroom who are using the computer. Prelle and Hiatt (1989) reported student use of the computer in laboratory simulations, drill and practice, tutorial and word processing. Lehman (1985) reported student use of the computer was 27.6% for homework and student projects and 14.2% for word processing and lab reports. Becker (1983) stated that 7% of his respondents reported students using the computer for papers and word processing. Lehman's results were higher and this was to be expected since he surveyed high school science teachers while Becker surveyed elementary and secondary school teachers in all subject areas. Prelle and Hiatt did not report the degree to which students used the various applications.

Teachers may have any number of barriers preventing them from using the computer more than they have. Prelle and Hiatt (1989) stated that "the most frequently reported enabling factors were having adequate numbers of computer stations (24.3%), appropriate software (15.2%), and adequate preparation time (13.2%). The most frequently cited constraining factors were inadequate funding (18.4%), inadequate preparation time (17.8%), and an inadequate number of computer stations (15.9%)" (p. 5). Prelle and Hiatt also concluded that "physics teachers perceived that having

adequate funds to purchase computer systems and to provide for adequate preparation for their use was the most important constraining factor" (p. 16). The ETP (1987) study found that less than half of the teachers were satisfied with access to the machines. Also, teachers were generally not satisfied with the amount, quality and preview opportunities of software. Teachers were also deterred from using computers because of lack of training. Lack of time was the most important reason why teachers were not taking more computer training.

Similar barriers were mentioned by Lehman (1985). He mentioned that inaccessibility of computers within the classroom, lack of training - both pre-service and in-service and the inadequate amount of quality software limited teachers. Cuban (1986) said that inaccessible hardware, inappropriate software and untrained teachers may be the cause of the low estimates of use. The common thread to all these barriers is funding and none of the literature reviewed claimed to have the answer as to how any of these barriers could be easily overcome.

Klassen (1980) included questions about the expectations physics teachers had of their students concerning computers. These questions dealt with the students having a minimum understanding of computers, being able to write a simple program and appreciating the role computers play in today's society. The other questions from Klassen dealt with the teacher's feelings about their training, the effort needed to

implement the computer into their teaching and whether they saw the computer as having more disadvantages than advantages. Regardless of how much teachers use the computer at present, they may hold an opinion regarding the role computers will play in the future.

Are physics teachers using the computer to a greater extent than their colleagues in other subject areas? The findings of Collis et al. (1988) did not indicate they were. Prelle and Hiatt found a large number of physics teachers at the "awareness" and "information" stages of concern as developed by Hall and his associates. Further, Prelle and Hiatt quote Shavelson's suggestion that "science teachers may not be the ones to lead the technology revolution in education (1984, p. 71)" (p. 15).

Computers have had some impact to date. According to Cuban (1986), teachers control the door to their classroom and whether computers will cross that threshold. By design or by default, computers may have a greater impact in the near or far future.

Summary of the Review of Related Literature

Educators have been continually seeking ways to become more effective. Educational technology provides devices, rather than strategies to achieve this goal. The mainframe computer had gone through Cuban's (1986) four stage cycle and now the advent of the microcomputer has revived interest in the computer as educational technology. The microcomputer

has produced amazing changes to the way we live and work and play. Some authors claim the computer will change the role of teacher and student and will change the what, where, how and why of education. The computer can be seen to play three roles as either instructor, tool or object of instruction. The computer can be a patient, tireless presenter of information and questions. It can be used as a powerful tool to do many things better, faster and more accurately than before. The computer can be taught, that is programed, or it can be studied in detail as to its workings or impact on society. Despite their ever increasing numbers, computer use remains light. Barriers such as lack of time, training, access and software prevent teachers from using the computer more. Some people predict fantastic changes to education by the year 2000 because of the computer and others see a variety of pressures keeping education from really embracing this technology. To date, the literature has not shown much change in the way school is done, the computer has not been used to a great extent. Surveys have shown that few teachers in a school use the computer regularly with many schools saying that no teacher was a regular user of the computer. In other schools one finds a small number of teachers making frequent use of the computer in their teaching. Some differences in teacher use have been found to be related to demographic factors such as school location, science department size and teacher gender.

What impact the computer has on education remains to be

seen. From an examination of what other technologies have done to and for education Cuban (1986) has concluded that computers will be used to some extent, never as much as the manufacturers or the enthusiasts would like, but they will cause an incremental change that only time will reveal as significant.

Chapter III

METHODOLOGY

A survey instrument was designed and mailed out to all 185 physics teachers in the province. Prior to the general mailing, a pilot survey instrument was designed and sent to five physics teachers. Based on the replies a few changes were made and the final instrument was mailed in mid-February of 1990. Replies were accepted until the end of March 1990.

The survey instrument (see Appendix B) contained two parts. Part I comprised 15 questions requesting demographic information about the teacher and their school. Part II comprised 9 questions. The first four questions in Part II dealt with various computer applications and if they were used, which applications were valued most, how they were evaluated and how frequently they were used. The next question asked for which course topics the teachers had used the computer. Question 6 asked which student initiated applications of the computer the teacher had seen. Question 7 asked about which barriers the teachers had encountered to computer use. Question 8 requested the teacher's opinion on several computer related issues. The last question was a free response opportunity.

As the replies were received, data were tabulated, summarized and analyzed. The analysis consisted of frequency counts expressed as percentages and the use of crosstabulations to compare the different cases of the variables being considered.

DEFINITIONS OF TERMS

For the purposes of this study, the following terms were used.

In terms of geographic areas, three regions were chosen.

Urban: That area bounded by an inner city school division of a metropolitan area. This included schools not belonging to the division but found within its boundaries.

Suburban: That area found within the metropolitan area of the city but not including the area within the urban school division.

Rural: That area of the province not including the area found within the metropolitan area. This included schools (though few in number) in larger population centres that might closely resemble urban or suburban schools.

Five descriptors for computer users were used.

Non-user: Someone who did not use the computer.

Infrequent user: Someone who used the computer for three or less applications on a yearly basis.

Occasional user: Someone who used the computer for at least one but not more that three applications on a monthly basis or more than three applications on a yearly basis.

Regular user: Someone who used the computer for at least one but not more than three applications on a weekly basis or more than three applications on a monthly basis.

Intensive user: Someone who used the computer for at least one application on a daily basis or more than three applications on a weekly basis.

Several computer related terms were used.

Computer: This term usually refered to a desk top machine that stands alone. Microcomputer and personal computer are other terms that refer to the same item. This term should be distinguished from either mainframe computer or mini-computer.

Hardware: The computer or electrical or mechanical devices used in connection with the computer such as disc drives, printers, and laboratory probes.

Software: A computer program.

Chapter IV

RESEARCH FINDINGS

DEMOGRAPHICS

Population

The population consisted of 185 teachers, 174 (94.1%) were males and 11 (5.9%) were females. Of these, 23 (12.4%) were in urban schools, 54 (29.2%) were in suburban schools, and 108 (58.4%) were in rural schools.

Respondents

Of the 185 survey instruments sent out 118 were returned and 104 of these were usable as data. The respondents are described in Table 1.

Table 1

Comparison of Respondents to Population Based on School Location and Sex of the Respondents

	Location by Percentage					
	Urban		Suburban		Rural	
Sex	Pop.	Resp.	Pop.	Resp.	Pop.	Resp.
Male	10.8	12.5	27.0	30.8	52.6	51.0
Female	1.6	1.0	2.2	1.9	2.2	2.9

Since the demographic characteristics for the respondents closely paralleled those of the population, the

respondents were considered as representative of the population. Because of the low number of females in the population and in the response group it was felt that further distinction of the respondents as to sex would not be meaningful.

Age

The average age of the respondents was 42.7 years and the standard deviation of their ages was 8.7 (n=103). It was found that 10.6% of the respondents were in their 20's, 21.2% in their 30's, 51.9% in their 40's, 14.4% in their 50's and 1.0% was 60 years or older.

Teaching Experience

The teaching experience of the respondents is summarized in Table 2. The mean number of years of teaching experience was 18.0.

University Degrees

The physics teachers were asked to indicate which of five university degrees they held and to indicate if they had any degrees other than the ones listed. Of the 104 respondents 93 (89.4%) reported holding a B.Sc., 80 (76.9%) a B.Ed., 18 (17.3%) an M.Sc., 7 (6.7%) a B.A., 2 (1.9%) a Ph.D., and 19 other degrees or certificates were mentioned. Of the 80 respondents who had B.Ed. degrees, 55 also had B.Sc. degrees and 14 also had M.Sc. degrees.

Table 2

Years of Teaching Experience

Years	Respondents (%)
0-4	9.7
5-9	6.7
10-14	15.3
15-19	19.3
20-24	25.0
25-29	16.3
30-34	4.8
35-40	2.9

It was found that 33.7% indicated having a major in physics and 26.9% a minor in physics.

University Physics Courses

The physics teachers were asked to indicate how many full semester or 6 credit-hour courses they had taken in physics. The largest proportion of 26.0% had 6 or more such courses. The next largest group of 19.3% had 3 such courses. It was found that 17.3% had 1 course, 15.4% had 2 courses, 12.5% had 5 courses, 6.7% had 4 courses and 2.9% had not had any such courses in physics.

Table 3 indicates how the number of physics courses taken at university was related to the geographic location of

the school at which the respondent teaches.

A Bachelor of Science degree or a Bachelor of Education degree with a major in physics would imply that a person has had 30 semester-hours in physics and a person with a minor in physics has had 18 semester-hours. Based on these hours, 64.4% of the respondents have the equivalent of a physics minor or better and 38.5% have a physics major or better. Almost one-fifth (20.2) have had only one or no physics course at the university level.

When the regional differences were examined, it was found that the suburban schools had the teachers with the most physics courses. In the suburban schools 66.6% of the respondents had better than a minor in physics. The respondents from the urban schools who had better than a physics minor made up 57.8% of the respondents for that area. For respondents in rural schools it was found that only 29.1% had better than a minor in physics.

Table 3

University Physics Courses and School Location

No. of Courses	n	School Location					
		Urban		Suburban		Rural	
		% of resp.	% of area	% of resp.	% of area	% of resp.	% of area
0	3	1.0	5.3	0.0	0.0	1.9	3.9
1	18	1.0	5.3	4.8	16.7	11.5	21.8
2	16	2.9	15.8	2.9	10.0	9.6	18.2
3	20	2.9	15.8	1.9	6.7	14.4	27.3
4	7	1.9	10.5	2.9	10.0	1.9	3.6
5	13	2.9	15.8	5.8	20.0	3.8	7.3
6 & Up	27	5.8	31.6	10.6	36.7	9.6	18.2

Physics Course Teaching Load

During the survey 21.2% of respondents were not teaching Physics 200. It was found that 44.2% were teaching only one section of Physics 200, 21.1% were teaching two sections, 12.5% were teaching three sections and 1.0% had four sections during the year.

For Physics 300, it was found that 24.1% were not teaching this course during the survey year, 51.9% had one section, 17.3% had two sections, 4.8% had three sections and 1.9% had four sections of Physics 300.

Several respondents were not teaching any physics at the

time of the survey. They stated this was because their small school could not offer physics and chemistry in the same year and so alternated these two courses. The survey year found these respondents teaching chemistry.

Training in Computer Applications

Table 4 summarizes the amount of training as related to the school location.

Table 4

Computer Training and School Location

	Percentage of Respondents from each area		
Training	Urban	Suburban	Rural
In-service	63.2	53.3	65.5
Credit courses	47.4	40.0	41.8
Informally from others	73.7	53.5	47.3
Self-taught	68.4	76.7	60.0
Other	5.3	3.3	5.3
None	0.0	13.3	9.1

Table 5 relates training to age. It was found that the likelyhood of a respondent having had in-service training increased with age. The younger a respondent was the more likely they were to have had taken a credit course in computers. The youngest respondents were also the most

likely to have had informal training from others. The other age groups, except the 60's where there was only one respondent, were approximately the same near 50%. Age did not seem to make a large difference with respect to being self-taught except the respondents in their 50's were somewhat less likely to have had this type of training. The response rates for other training methods and no training were low.

Table 5

Computer Training and Age

		Type of training					
Age	n	In-service	Credit courses	Inform-ally	Self-taught	Other	None
20's	11	54.5	90.9	90.9	72.7	9.1	9.1
30's	22	45.5	54.5	50.0	77.3	0.0	4.5
40's	54	66.7	33.3	51.9	72.2	7.4	7.4
50's	15	73.7	26.7	46.7	33.3	0.0	13.3
60's	1	100.0	0.0	0.0	0.0	0.0	0.0

School Enrollments of the Respondents

Table 6 gives the student population of the schools as related to the geographic location of the school.

Table 6

School Enrollment and Location of School

	Location and Number of Schools		
Population	Urban	Suburban	Rural
0-99	0	0	5
100-199	0	1	13
200-399	2	2	21
400-599	4	9	9
600-799	1	5	3
800-999	4	7	2
1000-1199	1	3	0
1200-1399	6	3	1
1400-1599	1	0	1

These numbers were for schools with various grades, whether that was grades 10 to 12, 7 to 12, or even K to 12. The mean school enrollment was 540 and the mode was the 200-399 interval. For urban schools the mean enrollment of the 19 schools was 861. For suburban schools the mean enrollment was 718 for 30 cases. Rural schools had a mean enrollment of 331 for 55 cases.

Science Teachers in the School

The physics teachers were asked to state the number of teachers in their school who taught science. The results are reported in Table 7.

Table 7

Number of Science Teachers in the School as Related to School Location

	Location and Number of Schools		
Number	Urban	Suburban	Rural
1	0	0	3
2	0	2	23
3	2	2	15
4	1	1	3
5	5	4	3
6	3	7	1
7	2	1	4
8	1	5	2
9	1	3	0
10	4	3	0
11	0	1	0
12	0	0	1
20	0	1	0

The mean number of science teachers in the schools was 5.0. The mean number of science teachers per school for teachers from urban, suburban and rural schools were 6.5, 7.0 and 3.3, respectively.

Physics Enrollment in the Schools

The physics teachers were asked to state the total

number of physics students in their school. The results are given in Table 8.

Table 8

Total Number of Physics Students in the School and School Location

	Location		
Number	Urban	Suburban	Rural
0-19	0	0	20
20-39	2	2	18
40-59	2	1	6
60-79	2	6	3
80-99	2	3	1
100-119	0	4	1
120-139	3	1	3
140-159	3	2	0
160-199	2	3	1
200-239	1	5	1
240-279	1	2	0
280 & Up	0	1	0
Total	18	30	54

Note. For 102 cases.

The mean number of physics students per school was 79.5 for the 102 cases reported. This breaks down to 116.3,

131.2, and 38.6 for urban schools, suburban schools and rural schools, respectively. Two respondents stated that their schools alternate Physics and Chemistry, the survey year being the year for Chemistry.

Computers in the School

Table 9 shows how many computers were in the respondents' schools.

Table 9

Reported Number of Computers and School Location

	Location					
	Urban		Suburban		Rural	
No. of Computers	#	%	#	%	#	%
0	1	5.9	0	0.0	0	0.0
1-5	0	0.0	0	0.0	2	3.7
6-9	0	0.0	1	3.4	2	3.7
10-19	2	11.8	5	17.6	23	42.6
20-29	5	29.4	7	24.1	12	22.2
30-39	2	11.8	3	10.3	8	14.8
40-49	6	35.3	3	10.3	2	3.7
50-69	1	5.9	6	20.7	4	7.4
70-100	1	5.9	3	10.3	1	1.9
120	0	0.0	1	3.4	0	0.0
Total	17	100.0	29	100.0	54	100.0

The overall mean was 29.9 computers per school. The highest mean was 39.9 for suburban schools. This was followed by a mean of 32.2 for urban schools and a mean of 23.8 for rural schools.

One respondent reported 750 computers. This was not taken as correct. The respondent may have reported the number of calculators and not the number of computers. Three respondents did not answer this question.

The mean student to computer ratio was 21.0. The lowest mean student to computer ratio was 14.4 for rural schools. The highest mean student to computer ratio was 31.2 for urban schools in and the suburban schools had a mean student to computer ratio 27.4.

Availability of Computers for Physics Classrooms

Table 10 shows how the number of computers available for use in the physics classroom related to school location.

If a class set of computers is considered to be 10 or more computers, then approximately 44% or the respondents had access to a class set. The mean number of available computers was 9.2. Respondents from rural schools had the highest mean of available computers for use in physics class at 9.5. Respondents from suburban schools had a mean only slightly less of 9.4 and respondents from urban schools had a mean of 8.3 computers available for use in the classroom.

Table 10

Number of Computers Available for Physics Classroom Use and School Location

	Location		
Number	Urban	Suburban	Rural
0	1	9	11
1	8	4	4
2	0	2	2
3	2	3	0
4	0	1	4
5	0	0	1
6-9	1	0	3
10-19	4	2	22
20-29	3	6	5
30-39	0	2	2
40-49	0	1	0

Note. For 103 cases.

Ownership of a Computer

A slight majority (57.7%) of the respondents indicated they personally owned a computer. This study found that 40.0% of those teachers who owned a computer were from rural schools, 35.0% were from suburban schools, and 25.0% were from urban schools.

It was found that owners of computers were more likely than non-owners to use the computer in their teaching. 53.3%

of computer owners were classified as regular users of the computer, 20.0% as intensive users, 11.7% as occasional users, 8.3% as non-users and 6.7% as infrequent users of the computer. It was found that 54.5% of the non-owners were also non-users of the computer. Regular users comprised 18.2% of the non-owners, 15.9% were occasional users, 6.8% were intensive users and 4.5% were infrequent users.

Most non-owners did not plan on obtaining a computer. Of non-owners, 67.4% were not sure whether they would acquire a computer in the future, some 14.0% said they would likely obtain a computer in the next year and 12% reported they would never own a computer. About 5% planned to own a computer within the next 3 years. One non-owner did not respond to this question.

COMPUTER APPLICATIONS

Teacher Awareness of Computer Applications

In this question, the physics teachers were asked for information about computer applications they had used, would like to use, would not use or of which they were not aware. The results are given in Table 11.

Table 11

Respondents' Awareness of Computer Applications

Computer Application	Percentage of Respondents			
	HAVE USED	WOULD LIKE TO USE	WOULD NOT USE	WAS NOT AWARE
Computer Assisted Learning				
A. Drill and practice	26.0	46.2	19.2	2.9
B. Tutorial	20.2	47.1	17.3	3.8
C. Instructional games	16.3	36.5	25.0	7.7
Instructional Management				
D. Physics materials generation and word processing	48.1	21.2	16.3	6.7
E. Test scoring	19.2	31.7	35.6	2.9
F. Calculation and/or reporting of marks	46.2	26.0	20.2	1.0
Computer Based Laboratory				
G. Simulation/demonstration	38.5	45.2	8.7	2.9
H. Gathering data and data display	28.8	50.0	10.6	2.9
I. Analysis of data	29.8	50.0	8.7	2.9
Other				
J. Information retrieval from a database	15.4	45.2	14.4	13.5
K. Student problem solving or programming	21.2	43.3	22.1	2.9
L. Computer as calculator	20.2	23.1	44.2	1.0
M. Teach computer applications	17.3	40.4	29.8	1.0
N. Student papers/word processing	28.8	29.8	28.8	1.9
O. Electronics instruction	4.8	38.5	34.6	8.7
P. Communications	6.7	33.7	33.7	12.0
Q. Other (specify)	1.0	1.9	8.7	87.5

Note. Percent totals do not equal 100% because not all respondents answered for each application.

Most Valuable Applications

Of those computer applications listed in Table 11, the physics teachers were asked to indicate the four applications that would be the most valuable to themselves personally. The results are summarized in Table 12.

The area of application that received the most mention overall was the computer based laboratory. The area that received second most mention was computer assisted instruction and this was followed by the instructional management area.

The computer application considered most valuable--most chosen as their first choice--was using the computer as a simulation or demonstration tool. Using the computer as a word-processor received the next highest response rate, as first choice. This was followed by gathering and displaying data and finally, using the computer to present drill and practice.

In terms of their second choice, student problem solving or programming was mentioned most often. Drill and practice, analysis of data, tutorial and simulation/demonstration were mentioned about equally.

For third choice, using the computer in the laboratory for simulation / demonstration purposes or for analyzing data were the two applications mentioned most. Being used as a tutor or as a word-processor were the next applications of choice.

Table 12

Value Placed by Respondents on Certain Computer Applications

Computer Application	Respondent's Value			
	First	Second	Third	Fourth
Computer Assisted Learning				
A. Drill and practice	13	13	8	9
B. Tutorial	7	12	11	10
C. Instructional games	1	3	2	4
Instructional Management				
D. Physics materials generation and word processing	21	8	11	6
E. Test scoring	0	3	2	1
F. Calculation and/or reporting of marks	2	8	5	12
Computer Based Laboratory				
G. Simulation/demonstration	29	11	18	7
H. Gathering data and data display	15	16	8	9
I. Analysis of data	3	13	15	11
Other				
J. Information retrieval from a database	1	3	2	4
K. Student problem solving or programming	2	5	7	7
L. Computer as calculator	0	0	2	1
M. Teach computer applications	3	1	3	1
N. Student papers/word processing	2	2	1	5
O. Electronics instruction	2	1	1	5
P. Communications	0	0	0	1
Q. Other (specify)	0	1	1	0

Note. Not all respondents answered this question.

On their fourth choice, using the computer to calculate

and report marks, analyze data and give tutorial instruction were reported with about equal frequency.

Evaluation of Computer Applications that have been Used

In this section the physics teachers were asked to evaluate those applications they had used. All applications received a positive evaluation. The results are summarized in Table 13.

Frequency of Computer Application

The physics teachers were asked to indicate whether they used a particular application on a daily, weekly, monthly or yearly basis. They could also indicate if they had never used an application. The results for this question are given in Table 14.

The only applications that were reported to be used on a daily basis by more than one respondent were physics material generation and/or word processing (7.7%) and marks calculation and/or reporting (4.8%), both from the instructional management area.

Word processing and working with marks were also the ones most used on a weekly basis, 25.0% and 18.3%, respectively. As well, the choice of student papers/word processing was indicated 10.6% of the time.

Table 13

Respondents' Evaluation of Computer Applications Used

Computer Application	Evaluation (%)						
	Excellent	Good	All Right	Poor	Bad	Unable to answer	N/A
			Computer Assisted Instruction				
A	0.0	8.7	14.6	1.0	2.9	58.3	12.6
B	0.0	10.7	9.7	3.9	1.9	58.3	13.6
C	0.0	7.8	6.8	1.9	1.9	64.1	17.5
			Instructional Management				
D	25.2	16.5	6.8	1.0	0.0	41.7	8.7
E	4.9	5.8	6.8	1.9	0.0	62.1	17.5
F	28.2	9.7	6.8	0.0	1.0	44.7	9.7
			Computer Based Laboratory				
G	8.7	21.4	12.6	2.9	0.0	44.7	9.7
H	6.5	13.6	8.7	2.9	0.0	51.5	16.5
I	7.8	13.6	6.8	1.9	1.9	52.4	15.5
			Other				
J	5.8	4.7	3.9	1.0	0.0	67.0	17.5
K	1.9	5.8	8.7	2.9	0.0	63.1	16.5
L	4.9	6.8	6.8	1.9	0.0	61.2	17.5
M	3.9	6.8	6.8	1.0	0.0	64.1	17.5
N	6.8	14.6	5.8	0.0	0.0	58.3	14.0
O	1.0	1.9	0.0	1.9	0.0	74.8	20.4
P	2.9	1.9	1.9	1.0	0.0	71.8	20.4

Note. For the specific applications see Table 11 or 12.

Table 14

Frequency of Computer Application

Application	Frequency of Application by Percentage					
	Daily	Weekly	Monthly	Yearly	Never	N/A
	Computer Assisted Instruction					
A	0.0	1.0	12.5	12.5	60.6	13.5
B	0.0	3.9	9.6	10.6	62.5	13.5
C	0.0	0.0	4.8	9.6	67.3	18.3
	Instructional Management					
D	7.7	25.0	12.5	3.8	41.3	9.6
E	1.0	6.7	7.7	3.8	64.4	16.3
F	4.8	18.3	19.2	2.9	44.2	10.6
	Computer Based Laboratory					
G	0.0	4.8	15.4	20.2	49.0	10.6
H	0.0	7.7	7.7	11.5	56.7	16.3
I	0.0	8.7	6.7	14.4	56.7	13.5
	Other					
J	1.0	4.8	5.8	4.8	68.3	15.4
K	1.0	1.9	10.6	8.7	62.5	15.4
L	1.0	3.8	5.8	7.7	65.4	16.3
M	1.0	2.9	5.8	7.7	63.5	19.2
N	1.0	10.6	8.7	7.7	56.7	15.4
O	0.0	2.9	0.0	2.9	77.9	18.3
P	0.0	1.9	1.0	3.8	75.0	18.3
Q	0.0	1.0	1.0	1.0	62.5	34.6

Note. For the specific applications see Table 11 or 12.

On a monthly basis, calculation and/or reporting of marks was indicated 19.2% and simulation/demonstration was indicated by 15.4%. Drill and practice (12.5%) and tutorial (9.6%) from the computer assisted instruction area as well as

using the computer for student problem solving or programming (10.6%) and student papers/word processing (8.7%) were the applications most mentioned from the "other" section.

On a yearly basis, the simulation - demonstration mode was reported as the most widely used at 20.2%. The other computer based laboratory uses and those in the computer assisted learning area were also reported to a larger degree, 9.6% to 14.4% compared to the other applications which were 8.7% or less.

For those applications that had never been used, using the computer for electronics instruction was the most indicated (77.9%) and physics material generation and word processing was the least indicated (41.3%). The applications least used were those listed as "other". This group had an average of 65.3%, a maximum of 77.9% and a minimum of 56.7%. The computer assisted instruction group comes next. Here the average was 63.5% with a maximum of 67.3% and a minimum of 60.6%. Following this, the computer assisted laboratory has an average of 54.1%, a maximum of 56.7% and a minimum of 49.0%. The instructional management area had the lowest scores for non-use; that is, these applications were used the most. This group had an average of 50.0%, a maximum of 64.4% and a minimum of 41.3%.

Type of Computer User

Based on their response to question 4 of part II, as given in Table 14, each respondent was classified as to how

frequently they used the computer. The five categories of user were: non-user, infrequent user, occasional user, regular user, and intensive user.

Over a third (38.5%) of the respondents were classified as regular users of the computer. The next largest group was the non-user group at 27.9%. Intensive and occasional users were almost equal in number at 14.4% and 13.5%, respectively. Those who were classified as infrequent users made up the smallest group at 5.8% of the respondents.

Course Topics and Computer Use

Table 15, page 64, shows the course topics and the percentage of respondents indicating use of the computer in some fashion in relation to that topic.

The course topics were taken from the curriculum guide for Physics in Manitoba.

Student Use of the Computer

Table 16, page 65, shows the percentage of respondents who indicated seeing their students using the computer on the student's initiative for the applications listed.

As noted in the table, 26 respondents or 25.0% did not answer this question.

Barriers to Computer Use

The respondents were asked to indicate reasons why they did not use the computer or why they did not use the computer more. Table 17, page 65, summarizes the results.

Table 15

Course Topics and Computer Application

Topic	Percentage of Respondents
Physics 200	
A. Linear kinematics	49.0
B. Vectors	40.4
C. Newton's Laws of Motion	32.3
D. Circular motion	30.8
E. Momentum and Impulse	34.6
F. Work and Energy	26.9
G. Heat	3.8
H. Solar energy	1.9
I. Facts - nature of science	1.0
J. Motion: earth and sky	10.6
K. Fluids and hydraulic devices	1.0
L. Local option (specify)	1.0
Physics 300	
A. Waves	34.6
B. Static electricity	29.8
C. Electric forces and fields	29.8
D. Basic electric circuits	26.9
E. Basic magnetism	18.3
F. Electromagnetic induction and alternating current	17.3
G. Sound	9.6
H. Optics	20.2
I. Sunburn	1.9
J. Earthquakes	1.9
K. Radiation and biological effects	2.9
L. Special relativity	1.9
M. Nature of the atom	2.9
O. Energy futures	1.0
P. Alternatives to fossil fuels	2.9
Q. Science, technology and society	3.8
R. Local option (specify)	0.0

Table 16

Reported Student Use of the Computer

Computer Application	Percentage Response
A. As a calculator	14.6
B. Making data tables	26.2
C. Generating graphs	37.9
D. Analysis of data	18.4
E. Writing lab reports	48.5
F. Problem solving	9.7
G. Other (specify)	3.9
H. None	8.7

Note. Only 78 of the 104 respondents answered this item.

Table 17

Barriers to Computer Use

Barriers to Computer Use	Percentage of Respondents
A. None available in my school	6.7
B. School computers not easily available	51.0
C. No suitable software	55.8
D. No or not enough training	28.8
E. Not enough time to learn	33.7
F. Not convinced of the benefit	26.0
G. Negative previous experience	4.8
H. Software-hardware mismatch	17.3
I. Can better spend money elsewhere	15.4
J. Other	6.7

Note. $n = 98$.

There were 6 respondents or 5.8% who did not answer this question. Of the seventeen comments given along with choice J, it was found that six dealt with money in some aspect.

The respondents mentioned having too little money, the software was too expensive or other equipment was more of a priority. Three of the comments concerned time. There was not enough time to find good software nor enough time to learn how to use it effectively. Others felt the curriculum is already crowded, and couldn't see how the computer could fit in, unless at the expense of some other worthwhile topic. Two respondents stated that good software was hard to find and was expensive.

Teacher Opinion about Several Computer Related Issues

The last question of the survey asked for opinions on several issues concerning the computer. Table 18 gives the results to the 10 questions in this section.

Each question was to be answered using the following scale:

Strongly agree	Agree	Neutral	Disagree	Strongly disagree	No answer
1	2	3	4	5	6

Table 18

Teacher Opinion about the Computer in Physics Teaching

Question	Number of Respondents 1	2	3	4	5	6	Mean	SD	N/A
	Role of the Computer in Physics Teaching								
A	2	14	17	21	35	14	3.82	1.18	1
B	16	35	28	8	2	14	2.41	0.99	0
C	22	45	16	3	1	17	2.03	0.83	0
	Enough Training								
D	25	33	13	22	7	4	2.53	1.27	0
	Effort to Integrate the Computer not Best Time Use								
E	3	33	25	27	10	5	3.08	1.07	1
	Disadvantages more than Advantages								
F	3	12	16	45	20	7	3.70	1.04	1
	Physics Students and the Computer								
G	18	62	14	6	2	1	2.13	0.84	1
H	5	35	38	19	2	3	2.87	1.03	1
I	22	73	7	1	0	0	1.87	0.55	1
	Computer Application compared to Colleagues								
J	2	19	32	21	8	20	3.17	0.98	2

Age and Type of User

The age of the respondent as compared to the type of user they were is given in Table 19 on page 69.

Teaching Experience and Type of User

Table 20 on page 70 shows the comparison between how many years teaching experience the respondent had and the type of user they were.

University Degrees and Type of User

For a comparison between the type of degrees held by the respondent the type of user they were, see Table 21, page 70.

University Physics Courses and Type of User

Table 22, page 71, compares the type of user to how many physics courses that respondent had taken at university.

Physics Course Teaching Load and Type of User

Table 23, page 71, shows the comparison between the number of physics sections being taught and the type of user the teacher was classified as.

Training in Computer Application and Type of User

Table 24, page 72, gives the comparison between the type of training in computer application that the respondent has had and the type of user they were classified as.

Location of School and Type of User

Table 25, page 72, shows the relationship between the type of user the respondent was classified as and the location of the school where they were teaching in the year

of the survey.

Number of Science Teachers and Type of User

Table 26, page 73, compares the number of teachers in the respondent's school that taught some science and the type of user that teacher was.

Table 19

Age of Respondent and Type of User

		Type of User as % of Age Group				
Age	n	Non-user	Infrequent	Occasional	Regular	Intensive
20-29	11	17.8	9.1	9.1	46.3	17.8
30-39	22	13.6	9.1	18.2	40.9	18.2
40-49	54	27.8	3.7	14.8	44.4	11.1
50-59	15	46.7	6.7	6.7	20.0	20.0
60 & Up	1	100.0	0.0	0.0	0.0	0.0

Table 20

Teaching Experience and Type of Use

		Type of User as Percentage of the Row				
Experience	n	Non-user	Infreq.	Occass.	Regular	Intens.
0-4	10	20.0	10.0	20.0	30.0	20.0
5-9	7	14.3	0.0	28.6	42.9	14.3
10-14	16	6.3	6.3	6.3	62.5	18.8
15-19	21	28.6	4.8	19.0	38.1	9.5
20-24	25	24.0	0.0	12.0	48.0	16.0
25-29	12	52.9	11.8	11.8	11.8	11.8
30 & Up	8	50.0	12.5	0.0	25.0	12.5

Table 21

University Degrees Held and Type of User

		Type of User as Percentage of the Row				
Degree	n	Non-user	Infreq.	Occass.	Regular	Intensive
B.A.	7	42.9	0.0	0.0	42.9	14.3
B.Sc.	93	28.0	5.4	12.9	39.8	14.0
B.Ed.	80	28.3	5.0	16.3	38.8	11.3
M.Sc.	18	16.7	0.0	11.1	66.7	5.6

Table 22

University Physics Courses and Type of User

		Type of User as a Percentage of the Row				
Courses	n	Non-user	Infreq.	Occas.	Regular	Intensive
0	3	33.3	0.0	33.3	33.3	0.0
1	18	27.8	11.1	27.8	22.2	11.1
2	16	31.3	6.3	12.5	31.3	18.8
3	20	25.0	15.0	10.0	35.0	15.0
4	7	57.1	0.0	14.3	28.6	0.0
5	13	7.7	0.0	7.7	53.8	30.8
6	27	29.6	0.0	7.4	51.9	11.1

Table 23

Physics Course Teaching Load and Type of User

		Type of User as Percentage of the Row				
Classes	n	Non-user	Infreq.	Occas.	Regular	Intensive
0	8	12.5	12.5	50.0	25.0	0.0
1	24	33.3	4.2	16.7	29.2	16.7
2	33	33.3	6.1	12.1	30.3	18.2
3	16	25.0	12.5	12.5	31.3	18.8
4	12	16.7	0.0	0.0	75.0	8.3
5	6	50.0	0.0	0.0	33.3	16.7
6	5	0.0	0.0	0.0	100.0	0.0

Table 24

Training and Type of User

		Type of User as a Percentage of the Row				
Training	n	Non-user	Infreq.	Occass.	Regular	Intens.
In-service	64	21.9	9.4	15.6	39.1	14.1
Credit course	44	15.9	4.5	11.4	54.5	13.6
Informally	56	17.9	5.4	13.3	53.6	8.9
Self-taught	69	8.7	5.8	15.9	47.8	21.7
Other	5	40.0	0.0	20.0	40.0	0.0
None	9	100.0	0.0	0.0	0.0	0.0

Table 25

School Location and Type of User

	Location by Percentage						
Type of User	Urban		Suburban		Rural		Total
	Resp.	Area	Resp.	Area	Resp.	Area	Resp.
Non-user	3.8	21.1	5.8	20.0	18.3	34.5	27.9
Infrequent	0.0	0.0	1.0	3.3	4.8	9.1	5.8
Occasional	1.9	10.5	4.8	16.7	6.7	12.7	13.5
Regular	10.6	57.9	13.5	46.7	14.4	27.3	38.5
Intensive	1.9	10.5	3.8	13.3	8.7	16.4	14.4
Total	18.3		28.8		52.9		100.0

Table 26

Number of School Science Teachers and Type of User

Teachers	n	Type of User as a Percentage of the Row				
		Non-user	Infreq.	Occass.	Regular	Intens.
1-2	28	32.1	14.3	14.3	21.4	17.9
3-4	24	37.5	4.2	12.5	33.3	12.5
5-6	23	17.4	0.0	8.7	56.5	17.4
7-8	15	26.7	6.7	20.0	33.3	13.3
9-10	11	18.2	0.0	18.2	54.5	9.1
11-20	3	33.3	0.0	0.0	66.7	0.0

Barriers to Computer Application and Type of User

Table 27 compares the type of user a teacher was classified to the barriers they mentioned that kept them from using the computer or from using the computer more.

Table 27

Barriers to Computer use and Type of User

Barrier	n	Type of User as a Percentage of the Row				
		Non-user	Infreq.	Occass.	Regular	Intens.
Not available	7	57.1	14.3	14.3	14.3	0.0
Not easily available	53	30.2	3.8	15.1	37.7	13.2
No soft-ware	58	19.0	6.9	13.8	39.7	20.7
Training inadequate	30	40.0	3.3	26.7	16.7	13.3
No time to learn	35	42.9	2.9	14.3	31.4	8.6
Not sure of benefit	27	48.1	7.4	11.1	25.9	7.4
Had bad experience	5	40.0	20.0	20.0	20.0	0.0
Equipment mismatch	18	16.7	11.1	16.7	55.6	0.0
Other $ priorities	15	43.8	0.0	18.8	37.5	0.0
Other	7	0.0	0.0	0.0	85.7	14.3

Student Initiated Computer use and Type of User

The respondents were asked to indicate which of a list of computer applications they had seen their students use on the students' own initiative. Student initiated use of the computer was then related to the type of user the physics

teacher was. Table 28 shows the results.

Table 28

Student Initiated Computer Use as Related to Type of User

		Percentage of User Type Reporting Student Use				
Application	n	Non-user	Infreq.	Occass.	Regular	Intens.
Calculator	17	6.9	0.0	14.3	15.0	46.7
Data tables	28	6.9	0.0	35.7	42.5	26.7
Graphs	39	6.9	16.7	35.7	57.5	53.3
Analyze data	19	3.4	0.0	0.0	30.0	40.0
Report writing	51	17.2	16.7	50.0	75.0	53.3
Problem solving	10	0.0	0.0	7.1	17.5	13.3
Other	8	0.0	33.3	14.3	10.0	0.0
None	10	17.2	16.7	14.3	5.0	0.0

Note. n = 76.

Free Responses

The last item of the survey gave the respondents an opportunity to ask questions or make comments. Some 28 respondents did so.

The most frequent references were made about software. The comments mentioned the cost, the irrelevance to the Manitoba curriculum, the unsophisticated nature of most software and the desire to have more information about good

quality software.

Concerning the lack of computer availability and access, some 8 comments were made. Several respondents stated that if they had a computer in their class they would probably use the computer more.

Another 8 comments were made about the time factor. These respondents said they didn't have time to find, evaluate and become familiar with good software; they didn't have time to write their own programs; they didn't have time to get more training; they didn't have time in the year to teach even more to the students.

Four respondents mentioned the problem of finances. Small schools with limited funds must make some hard decisions as to where their science supplies budget should be spent. In any school, money spent on computers is money not spent on something else. Some teachers feel that the regular program should be made a quality program before money is spent on computer aided experimentation.

A further 4 comments were made about training. These respondents said they felt their training was inadequate but found that either lack of time or money was preventing them from acquiring more training. A willingness to learn was expressed by a few respondents, if time and money permitted.

One respondent mentioned a bad previous experience that was keeping him from being more involved with computers in his classroom.

There were 6 comments made on a variety of points.

These included:

1. Physics students and other students should know about the computer and our society.

2. Teacher use of the computer was more related to the individual than their subject area.

3. One institution was acquiring a laboratory with computers designated for physics lab work only

4. Computers can not replace " hands-on " physics, provide quality laboratory experienced first and then introduce the computer to further enhance understanding.

5. Using the computer should be like driving a car.

6. I consider myself a computer " illiterate ", yet I see much potential in use of computers. I am just beginning to learn, use and implement them now -- after 24 years of teaching!!
(The exclamations points were the respondent's.)

Two other comments were made that indicate the extremes that exist in the feelings teachers have about the computer. One respondents stated the following:

> With the computers in someone else's room that I can't access, no money for programs, no large screen for classroom display, no time for upkeep on software because of increasing workload and money diverted from laboratory equipment to get more computers I can't use I have truly come to resent the arrival of the computer. They are a misappropriation of precious limited resources. No new money is available. Other areas suffer and for what?

At the other end of the spectrum, the following comment was made:

> I am strongly biased to the use of computers in

> I am strongly biased to the use of computers in simulation, concept development, problem solving practice, general application. A whole class working in a Mac lab on physics and learning is a stimulating experience for both teacher and students.

Both of these comments show the strong feelings that can be held concerning the application of the computer to the teaching of physics. They indicate the range of experience, impact and emotion this topic can create in the life of someone teaching physics today.

Chapter V

DISCUSSION

Respondents

It was felt the respondent group fairly represented the population for two reasons. Firstly, over half the population provided usable data. Secondly, the make-up of the respondent group, as shown in Table 1, closely resembles that of the population. No comparison related to gender were made because the number of females in the population and the respondent group was low.

Age, Teaching Experience and Type of User

The younger respondents seem to have embraced the technology more than the older respondents. Perhaps this is because the youngest respondents will almost have grown up in the age of personal computers while the older respondents may feel they are to old to learn about computers. Being further on in their career, the older teachers may feel it is too late for them to learn to use the computer effectively or perhaps they don't see any point in changing their approach to teaching at this stage. Further, the older teachers may consider the computer to be another technological fad that will have no real impact on education. Elsewhere in the survey, a number of respondents did indicate they were not convinced of the computer's benefit. Some of these older teachers could have been rationalizing their reluctance to change.

With age comes experience. The trends discussed in the previous paragraph were evident in this comparison. As can be seen from Table 21, for every group up to 24 years experience, the largest portion of that group falls in the regular user category. However, for respondents with 25 or more years of teaching experience, the largest proportion was classified as a non-user.

The respondents with under 5 years teaching experience were almost equally distributed between the five user categories. However, with 5 or more years experience, a larger portion was classified as regular users. Since teachers new to the profession are so busy dealing with all the demands put on them in their first years, one would expect that they are too busy "surviving" to be innovative and introducing computer technology into their classroom. With a few years experience, it seems that more of them have found the time, energy and desire to use the computer in their teaching. At the other end of the experience spectrum, one sees that those respondents with 25 years or more experience have, generally, not taken up the technology. They may feel they have "missed the boat" or been born too early or they may be of the opinion "you can't teach an old dog new tricks". On the other hand, some of them have embraced the computer enthusiastically and are using it quite frequently on a regular or intensive basis.

One respondent said that after 24 years of teaching and despite some anxiety he was only now learning to use the

computer. Perhaps, those newest to the profession and those who are older should be given special consideration in overcoming the barriers to computer use they encounter.

The respondents to this survey had the same number of years teaching experience on average as the study by Prelle and Hiatt (1989). The respondents to this survey had more teaching experience than those of the ETP (1987) survey. The ETP (1987) study found that 60% of its respondents had 11 or more years of teaching experience while this survey had 78.9%. This may be because the ETP survey involved teachers from all grade levels while this survey only involved secondary school physics teachers. If secondary schools tend to have older, more experienced teachers, then the difference between the two surveys would be explained. In addition, this survey was done two years after the ETP survey and so each teacher still in the schools would have that much more experience.

Degrees Held and Type of User

From this study it would appear that physics teachers with a higher level of university degree (M.Sc. or M.Ed.) tend to use the computer more. This study found that the highest proportion of regular and intensive users was for those respondents with a Master of Science degree. This could be the case because these teachers are the most comfortable with the course material and so look for ways to enhance their teaching by being as innovative as possible.

The computer would provide a natural extension of their expertise and these teachers would feel very confident and comfortable with using the computer or any new technology in their classroom.

The number of respondents with a physics major was approximately the same, but slightly more than that found by Prelle and Hiatt (1989).

University Physics Courses and Location and Type of User

Teachers with more training in physics or science tended to use the computer more than those who had less training. To account for the relationship between computer use and advanced training an physics, as measured by the number of physics courses taken at university or advanced degree, one could speculate that with more familiarity with the subject matter would come the desire to make the subject being taught more interesting, up-to-date and in touch with the technology of the day. In addition, because of a good comfort level with the material being taught, the teacher with more knowledge of the subject would need less time to prepare the material and would have more time to try new things, like using the computer in the classroom.

Based on the number of university physics courses taken, this study seems to show the respondents from those schools in the metropolitan area were better prepared to teach physics than those outside. This may be because the larger population centres seem to hold a greater attraction for

people than do the smaller, rural or northern centres. With the demand for physics teachers in metropolitan areas being filled by the more qualified applicants, the schools outside the metropolitan areas would have to fill their demands from the remaining candidates, those with fewer university physics courses.

Physics Course Teaching Load and Type of User

The findings of this study imply that as a teacher has more physics in their job description they will tend to use the computer more. If a teacher had only a few sections of physics and had several other courses to prepare as well, they might not take the time to learn a certain computer application for the classroom if they were going to use it only a few times during the year. Consider the case of a teacher in a small school that offers physics every second year and to only one section of each level. Could a teacher justify the expense, time, and effort for a certain computer application and remember the proper procedure if they only used it once every other year? On the other hand, a teacher with several physics sections might take the time and effort to learn to apply the computer for some purpose if they were going to use that application repeatedly.

Training in Computer Applications and School Location

The fact that the respondents were most likely to have been self-taught showed a good degree of initiative in

providing their own training in computer applications. The nature of the technology makes this possible but also shows the desire teachers have to learn more about the computer and how to better use it in their teaching of physics.

The fact that respondents from schools in the rural area were least likely to have training informally from others implies teachers from schools in the rural area are less likely to be helping each other learn about the computer. The rural schools tend to be smaller and with fewer colleagues it would tend to be more difficult to share time and knowledge. Respondents from suburban schools did not have much more training informally. These respondents came from several school divisions and so act somewhat in isolation, but perhaps not to the same degree as those respondents schools outside Winnipeg. Respondents from urban schools showed a much higher amount of training informally. Being in the same division and coming from larger schools may have given these teachers more opportunity to get together and share their knowledge and learn from each other.

Credit courses, of the four main methods of training, demand the greatest commitment of time, effort and expense. This could explain why this method was reported the least. In contrast, in-service training is perhaps the easiest training to acquire with many school divisions offering training sessions of a few hours to full day sessions.

No new trends in the degree of use of the various training methods were revealed by this study. When compared

to the ETP (1987) study and to Lehman (1985) no significantly different levels of use were noted, despite five years passing since the Lehman study. This may be the case because the technology present in most schools today does not differ to any extent from what it was at the time of these earlier studies. Teachers today may not feel any different need for training than they did five years ago. In addition, the educational system may not be capable of changing any faster than it has over the last few years.

Methods of training other than the four major ones mentioned in this question of the survey do not seem to be a significant source of training. Very few respondents mentioned other types of training.

Training in Computer Application and Type of User

Self-teaching, reported most by regular or intensive users may be the most effective with teachers who are highly motivated to use the computer. Hence, the association between self-teaching and frequent computer use. It may also be that teachers with more physics courses have a greater aptitude at computers. The fact that being self-taught related so strongly to the respondent being a regular or intensive user was not surprizing. If someone has taken the time to teach themselves the technology, they will most likely put that skill to use.

Despite credit courses being the least used of the four main training methods, it was almost as strongly related as

being self-taught in producing a teacher who was either a regular or intensive user. Credit courses demand the largest commitment of time and money compared to any of the other training methods. Given that commitment, it is understandable that someone who had decided to take a credit course intends to put that knowledge to use.

When compared to the other methods of training, in-service is the least likely to be related positively to the respondent being a regular or intensive computer. In addition, of the four main methods of training, in-service had the highest percentage of non-users. The cause of this trend could be manyfold. Many teachers may have taken in-service training for fear of being left behind in the computer revolution but feel no desire, as yet, to use the computer in any way. They may have had to take this type of training but have an insufficient level of confidence or other support to implement computers in their teaching. In-service training tends to come in short introductory sessions rather than the more in-depth study of a credit course. With no real feeling for what they can do with the technology, someone who has had a few in-service sessions could easily become deterred by any small barrier they should encounter.

School Demographics and Location and Type of User

The fact that teachers not from metropolitan schools were the least likely to use the computer--had the lowest percentage of regular or intensive users and the highest

percentage of non-users--may be due to for several factors. Closely related to school student population is the number of teachers with science as part of their job description. Schools with the lower numbers of science teachers had the highest percentage of non-users and the lowest percentage of regular or intensive users.

With fewer colleagues around to share ideas and support each other, there may be less mutual encouragement to use the computer. In larger schools where one teacher was a regular user there would likely be at least one more regular user. In this sitting teachers could work together in applying the computer to their science teaching. Teachers in small schools are at a disadvantage compared to their colleagues in larger schools with more science teachers.

For schools with 5 or more teachers of science, there is probably a science department and the teachers only teach science or have the larger portion of their job description in the science area. These teachers may teach several courses with little change from year to year. This familiarity and comfort with the subject would give that teacher time to enhance the courses they teach and introduce new ideas and include the computer in this endeavor. On the other hand, a teacher from a small school with few science teachers will probably be teaching more science courses in more grade levels and so would have less time to try new things, such as implementing the computer into the classroom. As one respondent noted at the end of the survey:

I generally teach 12 different courses besides Physics on a two year basis so find it difficult to spend much time incorporating computers into ANY of the courses.

Despite many schools having a large number of computers, not all the computers in a school would be available for use in the physics classroom. This can be seen when one compares the mean number of computers in the school (29.9) with the mean number of computers available for physics classroom use (9.2). Some computers would be dedicated for use by the administration office only. Others may be in a room used every single period of the timetable for computer science, data processing or keyboarding classes. It would appear that other subject areas have priority and physics teachers do not always have access to the computers in the school to meet their need. Prelle and Hiatt (1989) had found an average of 6.7 computers available on a shared basis for class use. The difference between the findings of Prelle and Hiatt and this study was not seen as significant. Either number of computers, 6.7 or 9.2 for the average class, would still mean a student would work in a group of three or four students.

Small schools may be at an advantage in having a greater access to the computers present in the school. It may be that being in a small school, as are most schools outside the metropolitan area, could be an advantage in that the computer laboratory may not be completely booked during the day. This would leave it open for use by the physics class or any other class for that matter.

It seems that despite schools having computers, physics teachers do not have access to most of them. With regard to using the school computers in physics class, responses from teachers in suburban schools closely resembled those from teachers outside the metropolitan area. If a class set of computers is taken to be 10 or more computers, then only 7 of 19 respondents in urban schools, 11 of 30 respondents in suburban schools and 29 of 54 respondents outside the metropolitan area feel they have access to a class set of computers. Whether the respondents would take the time and trouble to arrange for the use of the computer laboratory is another question. Some respondents had indicated that they would not.

Ownership of a Personal Computer

Many more teachers today own a computer than did several years ago. The 57.7% of respondents who indicated they owned a computer was a dramatic jump from the 20% reported by the ETP survey of 1987. The ETP study continued to say that a teacher from a school in northern Manitoba was considerably more likely to own a computer. This survey found that it was more likely that a respondent outside the urban area will own a computer than a respondent from a school in the metropolitan area. The geographic descriptors of the ETP study and this study did not allow for any closer comparisons, although the two findings do not contradict one another.

It is interesting to note, that of the respondents not owning a computer, over two-thirds (67.4%) were not sure they would ever acquire a computer. It would seem that those who see the computer as having value have already obtained one and are using them in their teaching and those who do not yet own a computer have not been convinced the computer has enough worth to make them even plan on owning a computer in the future.

Owning a computer may an indicator of whether a teacher uses the computer at school. If a teacher thinks the computer is valuable enough to own one, they are likely to think it is valuable enough to use at school.

COMPUTER APPLICATIONS

Awareness of Certain Computer Applications

In agreement with a recent study (Prelle & Hiatt, 1989) the three most widely used applications were for word processing, handling of marks and demonstrations or simulations. However, the Prelle and Hiatt study reported higher percentages for the number of teachers who had tried most of the applications.

The most widely used applications reported came in the instructional management area. The increased use of these applications was evident when compared to the findings of Becker (1983), who surveyed the general teacher population. The computer-based laboratory area was the next most reported area of use. Here the computer was used more for simulation

and demonstration than for the collection and display of data or for data analysis. Usage for these purposes were less than those reported by Lehman (1985). Lehman's survey was to science teachers in general and not to physics teachers specifically. However, he found that teachers used the computer at about equal rates in their physics, biology or chemistry classes and at half that rate or less in their other science classes. Becker (1983) surveyed teachers at all grade levels in all subject areas. His findings were in closer agreement to those of this survey. When Lehman and Becker were compared, it seemed that science teachers used the computer for these applications more than teachers in general do. Some of the differences between these three surveys may also be attributed to the fact that Lehman's study was conducted 14 months after Becker's which was conducted about seven years before this one. Furthermore, the population for each study was different.

Student use of the computer either in drill and practice or as a word processor closely followed those of the computer based laboratory. This rate of use was about half those reported by Lehman (1985) and a little lower than those of Becker (1983). Becker may have found higher rates of use because he surveyed teachers of any subject at any grade level. It could be the case that drill and practice are used much more in the lower grades where basic skills are first taught. This writer has come across very few drill and practice programs for the high school level. It is not clear

why Lehman's findings were so much higher than those of this study's. Never-the-less, it seems that teachers in the United States have been using the computer more than those in this study.

Using the computer for student problem solving as a tutor, as a calculator, for test scoring and as an object of instruction where the educator teaches about computer applications received almost the same response rate. Again, these findings were about half the application rates reported by Lehman (1985). These results were comparable to the findings of Becker (1983).

Using the computer for instructional games does not seem to have changed in popularity over the last few years. This survey's findings were similar to Lehman (1985) and Becker (1983). Based on the comments of some respondents, it was clear most respondents do not consider computer games as a valid educational experience.

For applications not yet used, the respondents would like to use the computer most in the laboratory. This is discussed further in the next section of this chapter. The computer assisted learning area obtained the second highest response rate in this question. As well, the respondents reported the following application with comparable rates: using the computer to retrieve information from a database, to solve problems presented to the students and to teach computer applications to physics. It seems clear from the responses to this section that the respondents would like to

use the computer more in many areas but how readily this will happen remains to be seen. Desire is one thing, bringing that desire into reality is another matter.

There are certain applications physics teachers seem to have rejected. The physics teachers were also asked to indicate which applications they would not use. Use as a calculator was the application most rejected by the respondents. Perhaps today's calculators are powerful enough and the computer is redundant in this area. Test scoring was also mentioned to a high degree in this question. For scoring multiple choice items the computer is a valuable tool. However, I suspect this method of testing does not make up a substantial portion of the testing done by most physics teachers. Written answers may reveal more of how a student thinks than multiple choice answers. As an example of an electronic device and the computer as a communication tool were the uses next most rejected. These particular applications are not directly related to any topic in the curriculum.

While the respondents were generally aware of most of the computer applications, it is interesting to note that there was a low level of awareness of such commonplace uses as retrieval of information from a database and communication.

Applications of most Personal Value

The applications indicated as having the most personal value do not correspond to those being most used. The respondents indicated that applications from the computer based laboratory would have the most value and yet, those applications from the instructional management area were the ones being used most. This may be because instructional management uses: (a) were the easiest and quickest to learn, (b) may have been the least expensive, (c) may have been what the available equipment permitted, or (d) were the least threatening in that the teacher uses them alone and not in front of a class. Also, a teacher might prefer to first build up expertise with the computer for personal applications before trying to learn those applications that would be used in front of a class where there is more at stake should something not go as planned.

Evaluation of Computer Applications that have been Used

In this section teachers were asked to evaluate those applications they had used. All applications received a positive evaluation. This was in agreement with the ETP (1987) survey which reported 90% of senior high teachers found the computer to be useful or very useful.

The most negative evaluation was to the use of the computer for providing tutorial instruction. Perhaps the challenge of physics as a subject and the quality of most software does not provide for much success in this area.

It appears that teachers will only use those

applications that are serving them will. This assertion is based on the fact that applications in the instructional management area were the best received and most widely used while other application were rated lower.

Frequency of Computer Application

The only applications that were reported to be used on a daily basis by more than one respondent were physics material generation and/or word processing and marks calculation and/or reporting, both from the instructional management area. In agreement with Prelle and Hiatt (1989) these two applications were also the ones most used on a weekly basis. In addition, these findings agree with those mentioned in the previous two sections of this chapter, with those applications used and most valued.

On a monthly basis, calculation and/or reporting of marks and simulation/demonstration were indicated most and on a yearly basis, the simulation - demonstration mode was reported as the most widely used. Once again, this was found to be in agreement with Prelle and Hiatt (1989). The other computer-based laboratory uses and those in the computer assisted learning area were also reported to a larger degree compared to the other applications.

Again, it can be seen that the respondent group was using the computer more for purposes outside the classroom than in the classroom. Reasons for this may have to do with the particular barriers a teacher encounters. One computer

with a small screen in front of a large class is not effective. There may be a problem with a lack of suitable hardware and software. Other barriers are discussed in a section devoted to that topic.

Use of the computer in-class does not seem to have changed significantly over the past five years. If one assumes the only in-class use of the computer mentioned in this survey was in the computer-based laboratory , this study found that on a weekly basis around 7.1% of the respondents used the computer in this fashion. Lehman (1985) found a similar result.

Type of Computer User and Location

In agreement with Lehman (1987), this study shows a relationship between type of user and some school demographic factors. A respondent from a non-metropolitan school was least likely to be a regular user. As has been previously mentioned, it is the non-metropolitan schools that tend to have the smaller enrollments and smaller science departments where less computer use is found.

Most of the respondents labeled as intensive users came from schools outside the metropolitan area. However, these teachers made up the smallest proportion of respondents from their area. Once again, the geographic difference for respondents from schools outside the metropolitan area distinguishes it from the urban and suburban areas which closely resemble each other.

Course Topics and Computer Use

Several respondents indicated that their only use of the computer with respect to the course topics was as a word processor for generating worksheets, labs or tests. In view of such comments, the percentages reported should not be taken to indicate how many physics teachers have had their students using the computer in class. If the experience of other teachers matches my own, there is little time enough to teach the core topics let alone one of the optional topics. It is felt, therefore, that the findings for this question indicate, if nothing else, those course topics actually being taught. The optional topics show low computer usage because they are seldom taught, not because the computer has no application in that context.

The Physics 200 course topics A through F (see Table 15) are core topics and should be taught by all teachers. In the Physics 300 curriculum, topics A through F are the core topics. It should be noted that in Physics 300 the Optics unit, topic H, previously was a substantial portion of the Physics 200 course before curriculum revision made it an optional topic for the Physics 300 course.

Student use of the Computer

This study found that students were using the computer much more than other studies have found. The most common reported use of the computer by students was as a word

processor for the writing of laboratory reports. This was more than three times the rate reported by Lehman (1985) and almost nine times that reported by Becker (1983). Prelle and Hiatt (1989) mentioned student use of this computer application but did not quantify it. It is evident that teachers today see many more of their students using the computer. It should be noted that Lehman surveyed high school science teachers and Becker surveyed all teachers at all grades in all subjects. One would expect Becker to get a lower response rate on this item given his population.

Using the computer to create graphs was the next most frequently reported use of the computer. Making graphs with the computer was reported even less frequently.

Students appear to be using the computer despite the role model provided by their physics teacher. It seems that students will use the computer despite having a physics teacher who rarely uses the computer and so does not act as a strong role model in this regard. Perhaps these students have other teachers, adults, or other students as role models.

It could be that teachers who use the computer are more aware of their students using the computer. In every case reported, for every student use, the large majority of the respondents were either regular or intensive users. It was far less likely that the respondent was a non-user or an infrequent or occasional user.

Barriers to Computer Application

This study found the barrier most indicated was the lack of suitable software. This agrees with the findings of several others (Cuban, 1986, Aiken and Braun, 1980,). Lehman (1985) includes this barrier as one of the three he suggests as why very few teachers are using computers regularly in their science classes. Both the quality and the quantity of the software discouraged respondents from using the computer. This is a persistent problem mentioned by authors (Hawkridge, 1983, Bialo and Erickson, 1985, Tashner, 1984, Martin, 1980, Evans, 1986) since 1980 which does not appear to have been resolved.

The other barrier mentioned by more than half the respondents was the lack of readily available computers in the school. This is in agreement with the findings of the ETP (1987) study which found less than 50% of teachers happy with the access to computers in their school. Teachers need the technology in their classroom if they are to use it.

Lack of time was mentioned several times in response to this question. Given a piece of software a teacher must find time to evaluate it, and if it is suitable, learn how to use it and find an appropriate time and place for use in the classroom.

Prelle and Hiatt (1989) summarized their constraining factors of inadequate funding, preparation time, and numbers of computers as all really being a problem of funding.

These three barriers (software, access and time) were the most indicated and were very similar to those Cuban

(1986) found as the barriers to educational video use in schools. It would appear the lessons to be learned from the introduction of that educational technology were not obvious nor taken into account with the introduction of computers. The findings of this survey and others refute the myth presented by Nathan (1985) that the lessons to be learned from the past attempts to introduce technology in the classroom are clear and obvious. Lehman (1985) mentioned lack of access, training and software as the three main barriers to computer application.

It was found that the barrier mentioned with the fourth highest frequency was the matter of training. Training requires time, something educators are pressed to find more of. The technology is rapidly changing and keeping pace with that change also requires time. Four comments made at the end of the survey mentioned the problem of training. Sometimes this barrier was also linked to both lack of time and money.

Not being convinced of the benefit of computers was reported by the fifth highest number of respondents. It would appear these respondents have not seen enough evidence that the computer is an effective tool to be used in the classroom. If teachers are not convinced of the benefit of computers, it is unlikely they will try to overcome any of the other barriers they encounter.

The other barriers were chosen to lesser extents. Concerning the software - hardware mismatch one teacher

commented that a job transfer put him in a school where his software was no longer usable. If some of his programs where self-generated, his frustration is easily understandable. Given the budgetary restraint of most schools, teachers are forced to make decisions as to what they will purchase with their limited funds. It was found that some of the respondents would rather spend the money elsewhere than on computers. Either their budget is too small to afford any useful amount of equipment or they may not be convinced of the computer's benefit.

Given the number of barriers that a teacher could encounter in their attempts to use the computer, one can see the difficulty a teacher would have in deciding which barrier should be reduced first. In some cases the teacher has little control over their circumstances and so may be in no position to do anything about the barriers that confront them.

Barriers and Type of User

It would appear the barriers of concern to the regular or intensive user tends to be different than those of the non-user. While those who use the computer most are concerned with problems of computer availability, lack of software, and equipment mismatch, the non-user is primarily concerned with lack of training and time and isn't convinced the technology has benefit.

The problem of software is a barrier even experienced

computer users are still encountering. Of these respondents who reported this barrier, 60.4% were regular or intensive users. The software these respondents were using was meeting some of their needs but was still inadequate. This feeling was borne out by the large number of responses at the end of the survey that mentioned this barrier.

Teacher s may have adequate access to computer for instructional management purposes where only one computer is required, but inadequate numbers for computer use in the classroom. For such use, the teacher would need access to either a class set of computers or some projection system that would allow the entire class to see what was presented on one computer.

There must be an element of frustration for those respondents who indicated a problem with equipment mismatch. They know how to use the computer (and are doing so) but feel limited by the fact that they can not apply what they know because a computer is available and there is software available but they do not work together.

Teacher Opinion About Several Computer Related Issues

The first three opinion questions dealt with the present and future role of the computer in the teaching of physics. The present role of the computer was the point of the first question. The results strongly indicated that the respondents do not feel the computer is playing a very significant role at present. This corresponds with the

findings that the majority of respondents do not use the computer on a regular basis and that never more than half of the respondent group had used the computer in any fashion for any topic in the curriculum.

It would appear that teachers see the computer playing a more significant role in the future. The second and third opinion questions found that the respondents felt the next 10 years rather than the next 5 years would bring about significant change in the role the computer plays in their teaching of physics. Not surprisingly, the respondents indicate a greater anticipation of change with the passage of more time.

It would appear a small majority of teachers are confident about their level of training in computer application. More of the respondent group agreed strongly with the fourth opinion statement than any other in this section of the survey. Previously in the survey, 28.8% of the respondent group indicated they found their training a barrier to using the computer. In responding to this question, a similar proportion of respondents felt their training was inadequate enough to disagree or strongly disagree with the statement. This agreement tends to add to the validity of the survey . Whether these results are seen to contradict Prelle and Hiatt (1989) is unclear. Prelle and Hiatt concluded their respondents were experienced enough and sufficiently prepared to successfully use the computer. Given the large number of respondents who agreed

or strongly agreed with this statement, there were other barriers to their application of the computer to their teaching of physics that were more significant.

Most teachers see the computer as being a beneficial device. This is evident from the fact that the majority of the respondent group saw the computer as a device with more advantages than disadvantages. The fifth question of the ten in this section asked whether the computer had more disadvantages than advantages. The number of respondents that disagreed or strongly disagreed with this statement were far more than the number that agreed or strongly agreed. This is in agreement with the larger number of the respondents who reported frequent use of the computer.

The next three statements involved the physics students and the computer. The first of these was about whether physics students should have a minimum understanding of the computer. Many of the respondent group indicated their students should have some understanding about the computer and yet, if a large proportion of them do not provide any interaction between their students and the computer in their classes, where are their students going to develop that understanding? Once again, the barriers preventing teachers from using the computer more, especially in class, come to mind.

The middle of these three statements dealt with the students being able to write a simple program. This question had more respondents indicating a neutral opinion than any

other. On the whole, the opinion was for only a slight agreement. It would appear that programming ability is not a clear issue among the respondent group. Some teachers, like Tinker (1981), believe that the student should be able to calibrate their experience, get an intuitive feeling for the concept under study, using the computer and suitable software. One respondent mentioned that using the computer should be like driving a car. Many people can drive a car but know very little about how it works or how it operates. The same should be true for the computer. On the other hand, some would argue that knowing how to program teaches the student something about problem solving and thinking.

Beyond the computer having an impact and a role in physics, the respondent group indicated their students need to see the computer in a broader societal context, as well. The last statement concerning physics students was about their understanding the role of computers in today's society. This question had the highest agreement and the greatest consensus.

The final question of this section asked the respondents to compare the rate of computer application of physics teachers to that of their colleagues in other subject areas. This question had more respondents than any other who said they felt unable to answer. The overall opinion had teachers from other subject areas applying the computer to a greater extent than physics teachers. Either teachers do not communicate with each other about such matters or the levels

of computer use in the schools are so low that the trends are not clear to teachers in the school. With schools operating with departments that do not interact, one can see why physics teachers would not feel confident in responding about the degree that other subject teachers use the computer. Teachers from small schools who would not see many other teachers at work would have the same hesitancy.

Chapter VI

CONCLUSIONS AND IMPLICATIONS FOR FUTURE PRACTICE

CONCLUSIONS

Based on the findings of the study the following conclusions were drawn:

1. Teachers under 50 years old were most likely to regular of the computer, while those under 50 years were most likely to be non-users.

2. Teachers with less than 25 years teaching experience were most likely to be regular users while teachers with 25 or more years of teaching experience were most likely to be non-users.

3. A Master of Science degree was the degree most strongly associated with a teacher being a regular or intensive user of the computer.

4. Teachers with more university physics courses were more likely to teach in suburban or urban schools than rural schools.

5. Teachers with 5, 6, or more university physics courses were the most likely to be regular of intensive users and more likely to be teaching in a metropolitan school.

6. Teachers with a larger portion of physics teaching in their job description were more likely to be computer users.

7. Teachers were most likely to be self-taught in computer applications.

8. Teachers in schools with small science departments,

which tend to be in rural schools, were least likely to be taught informally by others.

9. Being self-taught and training through credit courses were the training methods most likely to be associated with a teacher being a regular or intensive user. In-service training was the least likely to be so.

10. On an average, one third of the computers in a school were considered to be available for physics classroom use.

11. Teachers outside the metropolitan area were most likely to personally own a computer.

12. Teacher owning a computer were more likely than non-owners to be users of the computer at school.

13. Teachers use the computer most frequently for instructional management purposes, namely, for word processing and handling of marks.

14. Physics teachers would most like to use the computer in the laboratory. Computer based laboratory applications were the ones the respondents said had the most personal value.

15. All computer applications were favorable evaluated.

16. Computers are most used in relation to the core areas of the curriculum.

17. Students were found to be using the computer to a greater degree than in any previous study.

18. Lack of satisfactory software, adequate access to computers in the schools, and sufficient time were the

barriers most mentioned.

19. Physics teachers do not feel the computer is playing a significant role in their teaching at present but see that role changing significantly in the next 10 years.

IMPLICATIONS FOR PRACTICE

Based on the findings of this study and the conclusions drawn, the following are implications for practice:

1. Computer based laboratory applications of the computer be given priority.

2. Computer applications should be directed to those course topics that belong to the core.

3. Priority should be given to increasing the amount of suitable software. Both the quality and quantity of the software should be addressed.

4. Teachers should be given the opportunity and the encouragement to train themselves as to how to apply the computer to their physics teaching.

5. Teachers be encouraged and given the opportunity to take credit courses in computer applications to physics teaching.

6. Physics teachers should be given more access to the computers already in the schools for class work. Failing this, they should be given better equipment for allowing the entire class to see what is being done on one computer with the aid of overhead projection or large screen display.

7. Physics teachers need to be given input into

decisions about what hardware and software is provided in the school.

8. Physics teachers from small schools or schools with small science departments be given more opportunity to meet with colleagues to share their knowledge about the computer.

9. Teachers newest to the profession and those who are older, if necessary, should be given greater opportunity and encouragement to learn how to implement the computer into their physics teaching.

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Appendix A

Jerry Friesen

216 Wildwood Park

Winnipeg, Manitoba R3T 0E3

Dear Colleague,

My name is Jerry Friesen. I teach at Fort Richmond Collegiate in Winnipeg. I am requesting your participation in a survey about the use of computers by the physics teachers of Manitoba. The survey is part of my thesis for my Master of Education.

Responding to the survey would take about 20 minutes to complete. Your answers will remain confidential. The identification number on the survey will only be used to send a second request to participate to those not responding to this initial invitation. If you do not wish to participate, simply return the survey in the stamped, self-addressed envelope provided.

A summary of survey findings will be made available at some later date. Those wishing to obtain further information may reach the researcher at the address given above.

Thank you for your valuable time and consideration.

Yours truly,

Jerry Friesen

Appendix B

A Survey of Computer Use by the Physics Teachers of Manitoba.

Instructions

Please answer each question following the instructions given. Feel free to make any comments or questions as you reply or use the last item as a free response opportunity. Thank you.

I Demographics

1. Sex. Circle the appropriate number.

   Male 1 Female 2

2. Age. Check one.

   20-29 ( ) 30-39 ( ) 40-49 ( ) 50-59 ( ) 60 or more ( )

3. State how many years of teaching experience you have. Write the number in the space provided.

   Years of teaching experience _____

4. Indicate which degree(s) you have. Check as many as apply. If possible, state your major and minor.

   B.A. ( ) Major_____ Minor_____
   B.Sc. ( ) Major_____ Minor_____
   B.Ed. ( ) Major_____ Minor_____
   M.Sc. ( ) Major_____ Minor_____
   Ph.D. ( ) Major_____ Minor_____
   Other (specify)_____

5. Indicate the number of full courses (or equivalent) in physics have you had at university? For example, one full course = two half courses = 6 credit hours = two semesters or terms.

   None ( ) 1 ( ) 2 ( ) 3 ( ) 4 ( ) 5 ( ) 6 or more ( )

6. Indicate the number of classes/sections of physics you are teaching this school year 1989-90. Write the number in the parentheses.

   Physics 200 ( ) Physics 300 ( )

7. Indicate what training in computers you have had. Check as many as apply.

A. In-service(s)..... ( )
B. Credit course(s) ..... ( )
C. Informally from others ( )
D. Self-taught ..... ( )
E. Other (specify)_____ ( )
_____
F. None..... ( )

8. Indicate where are you presently teaching. Check one.

A. Urban Winnipeg (Winnipeg No. 1) ( )
B. Suburban Winnipeg ..... ( )
C. Outside Winnipeg ..... ( )

9. State the number of students in your school. Write the number in the space provided.

Number of students _____

10. Indicate the number of teachers who teach science at the high school level in your school. Write in the number.

Number of teachers who teach science _____

11. State the number of physics students in your school. Write the number in the space provided.

Number of physics students _____

12. Record the number of computers presently in your school. Write the number in the space provided.

Number of computers _____

13. State the number of computers you could have at your disposal at one time when working with one of your classes. Write the number in the space provided.

Number of available computers _____

14. Indicate whether you personally own a computer. Check one. If Yes, skip the following question.

Yes ___ (skip no.15) No ___ (answer no.15)

15. Indicate your plans to acquire a computer. Check one.

Never.....( )
Within the next year.....( )
Within the next two years...( )
Within the next three years.( )
Not sure.....( )

II Computer Applications

1. With regard to physics teaching, indicate which of the following computer applications you have used, would like to use, would not use, or were not aware. Make only one response under the appropriate column for each application.

COMPUTER APPLICATION	HAVE USED	WOULD LIKE TO USE	WOULD NOT USE	WAS NOT AWARE
Computer Assisted Learning				
A. Drill and practice	____	____	____	____
B. Tutorial	____	____	____	____
C. Instructional games	____	____	____	____
Instructional Management				
D. Physics materials generation and word processing	____	____	____	____
E. Test scoring	____	____	____	____
F. Calculation and/or reporting of marks	____	____	____	____
Computer Based Laboratory				
G. Simulation/demonstration	____	____	____	____
H. Gathering data and data display	____	____	____	____
I. Analysis of data	____	____	____	____
Other				
J. Information retrieval from a database	____	____	____	____
K. Student problem solving or programming	____	____	____	____
L. Computer as calculator	____	____	____	____
M. Teach computer applications ...	____	____	____	____
N. Student papers/word processing	____	____	____	____
O. Electronics instruction	____	____	____	____
P. Communications	____	____	____	____
Q. Other (specify)_____	____	____	____	____

2. Indicate the four computer applications mentioned in the previous question that you feel are or would be the most valuable to you personaly in your physics teaching. Write the letter of the applications in the space provided. Put the most valuable application first.

1 ___ 2 ___ 3 ___ 4 ___

3. For each of the computer applications listed below that you have used, circle the scale value that best describes your evaluation of that teaching experience. Use the scale given below. If you have not used a certain application circle number 6 on the scale.

Excellent	Good	All right	Poor	Bad	Unable to answer
1	2	3	4	5	6

COMPUTER APPLICATION	EVALUATION					
Computer Assisted Learning						
A. Drill and practice	1	2	3	4	5	6
B. Tutorial	1	2	3	4	5	6
C. Instructional games	1	2	3	4	5	6
Instructional Management						
D. Physics materials generation and word processing	1	2	3	4	5	6
E. Test scoring	1	2	3	4	5	6
F. Calculation and/or reporting of marks	1	2	3	4	5	6
Computer Based Laboratory						
G. Simulation/demonstration	1	2	3	4	5	6
H. Gathering data and data display	1	2	3	4	5	6
I. Analysis of data	1	2	3	4	5	6
Other						
J. Information retrieval from a database	1	2	3	4	5	6
K. Student problem solving or programming	1	2	3	4	5	6
L. Computer as calculator	1	2	3	4	5	6
M. Teach computer applications ...	1	2	3	4	5	6
N. Student papers/word processing	1	2	3	4	5	6
O. Electronics instruction	1	2	3	4	5	6
P. Communications	1	2	3	4	5	6
Q. Other (specify)_____	1	2	3	4	5	6

_____

4. For each of the computer applications listed below, circle the scale value that best indicates the frequency with which you use each application. Use the scale below.

Daily	Weekly	Monthly	Yearly	Never
1	2	3	4	5

Computer Assisted Learning	Frequency of Use				
A. Drill and practice	1	2	3	4	5
B. Tutorial	1	2	3	4	5
C. Instructional games	1	2	3	4	5
Instructional Management					
D. Physics materials generation and word processing	1	2	3	4	5
E. Test scoring	1	2	3	4	5
F. Calculation and/or reporting of marks	1	2	3	4	5
Computer Based Laboratory					
G. Simulation/demonstration	1	2	3	4	5
H. Gathering data and data display	1	2	3	4	5
I. Analysis of data	1	2	3	4	5
Other					
J. Information retrieval from a database	1	2	3	4	5
K. Student problem solving or programming	1	2	3	4	5
L. Computer as calculator	1	2	3	4	5
M. Teach computer applications	1	2	3	4	5
N. Student papers/word processing .	1	2	3	4	5
O. Electronics instruction	1	2	3	4	5
P. Communications	1	2	3	4	5
Q. Other (specify)_____	1	2	3	4	5

_____

5. Indicate those course topics for which you have used the computer in some fashion. Check as many as apply.

Physics 200

A. Linear kinematics ..... ( )
B. Vectors ..... ( )
C. Newton's Laws of Motion ..... ( )
D. Circular motion ..... ( )
E. Momentum and Impulse ..... ( )
F. Work and Energy ..... ( )
G. Heat ..... ( )
H. Solar energy ..... ( )
I. Facts - nature of science ..... ( )
J. Motion: earth and sky ..... ( )
K. Fluids and hydraulic devices .... ( )
L. Local option (specify)
_____ ... ( )

Physics 300

A. Waves ..... ( )
B. Static electricity ..... ( )
C. Electric forces and fields ..... ( )
D. Basic electric circuits ..... ( )
E. Basic magnetism ..... ( )
F. Electromagnetic induction and alternating current ..... ( )
G. Sound ..... ( )
H. Optics ..... ( )
I. Sunburn ..... ( )
J. Earthquakes ..... ( )
K. Radiation and biological effects ( )
L. Special relativity ..... ( )
M. Nature of the atom ..... ( )
O. Energy futures ..... ( )
P. Alternatives to fossil fuels .... ( )
Q. Science, technology and society . ( )
R. Local option (specify)
_____ . ( )

6. Indicate which of the following are examples of <u>student</u> initiated uses of the computer that you have observed. Check as many as apply.

A. As a calculator ..... ( )
B. Making data tables ..... ( )
C. Generating graphs ..... ( )
D. Analysis of data ..... ( )
E. Writing lab reports ..... ( )
F. Problem solving ..... ( )
G. Other (specify) _____
_____ ( )
H. None ..... ( )

7. Indicate which of the following would describe why you have not used the computer or why you have not used the computer more. Check as many as apply.

A. None available in my school .... ( )
B. School computers not easily available ..... ( )
C. No suitable software ..... ( )
D. No or not enough training ..... ( )
E. Not enough time to learn ..... ( )
F. Not convinced of the benefit ... ( )
G. Negative previous experience ... ( )
H. Software-hardware mismatch ..... ( )
I. Can better spend money elsewhere ( )
J. Other (specify)_____ ( )
_____

8. For each of the following statements, circle a number on the scale that best corresponds to how you feel about that statement. Use the scale below.

Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Unable to answer
1	2	3	4	5	6

A. At present the computer is playing a significant role in my teaching of physics.

Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Unable to answer
1	2	3	4	5	6

B. The role that computers play in my physics teaching will significantly change in the next five years.

Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Unable to answer
1	2	3	4	5	6

C. The role that computers play in my physics teaching will change significantly in the next ten years.

Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Unable to answer
1	2	3	4	5	6

D. My training is adequate to permit me to integrate the computer into my teaching of physics.

Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Unable to answer
1	2	3	4	5	6

E. The effort to integrate the computer into my teaching of physics is not the best use of my time.

Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Unable to answer
1	2	3	4	5	6

F. The computer has more disadvantages than advantages.

Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Unable to answer
1	2	3	4	5	6

G. Physics students should have a minimum understanding of computer applications.

Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Unable to answer
1	2	3	4	5	6

H. Physics students should be able to write a simple program.

Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Unable to answer
1	2	3	4	5	6

I. The role of the computer in today's society should be understood by physics students.

Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Unable to answer
1	2	3	4	5	6

J. Physics teachers, when compared to colleagues in other subject areas, are implementing the computer into the classroom to a greater extent.

Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Unable to answer
1	2	3	4	5	6

9. If you have any questions or comments please feel free to include them here.

_____

_____

_____

_____

Thank you very much for your valuable time and cooperation.