MICROCOMPUTER INTERFACING

IN MONTANA SECONDARY SCIENCE CLASSROOMS

by

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ABSTRACT

The purpose of this study was to evaluate the use of microcomputer-based and calculator-based laboratory (MBL/CBL) systems in Montana science classrooms. A questionnaire was developed which asked secondary science teachers to either identify where in their curriculum they use MBL/CBL technology or reasons they have not used this technology. A list of science teachers was obtained from the Office of Public Instruction in Helena. A response rate of 79 % was achieved after two mailings from a randomly selected sample of 242 secondary science teachers.

The major conclusions from the study were that: 1) there was limited availability to MBL/CBL technology for full classroom use; 2) more teachers in the physical sciences were implementing MBL/CBL technology; 3) almost half of the teachers with 4 or more years teaching experience were using MBL/CBL technology to some degree; 4) the major limiting factors are monetary constraints; 5) additional factors inhibiting usage of MBL/CBL technology were lack of both professional development opportunities and insufficient time to incorporate the technology into existing curriculum.

CHAPTER 1

INTRODUCTION

Microcomputers are an indispensable part of our information-based society because they are used regularly in homes, offices, businesses, universities, and public and private school classrooms (Berger, Lu, Belzer, & Voss, 1994). In the field of education, microcomputers are being incorporated into classroom pedagogy and science teachers must implement this technology. The integration of microcomputers into United States' secondary science classrooms has occurred in a variety of ways. Traditionally, computer-based education has taken the form of computer-assisted instruction for drill and practice, computer-managed instruction for assessment, and microcomputer-based laboratories (MBL) (Berger, et. al., 1994). Within the laboratory context, microcomputers are used as an interfacing device to control an experiment, collect data, and to perform graphing and statistical analysis (Prosser & Tamir, 1990). In addition, Prosser and Tamir (1990) stated:

> "It seems clear that both secondary and tertiary students need to develop an awareness and more skills in the use of microcomputers in the science laboratories as part of the laboratory programme. Such skills need to be one of our aims for laboratories." (p. 270)

The increase in microcomputer performance and the decrease in their cost leads to the possibility of expansion in the quality of learning and more efficient use of time within the secondary science laboratory environment (Amend, Furstenau, Howald, Ivey, & Tucker, 1990).

The rapid miniaturization of electronic components has made it possible for graphing calculators to function on a comparable level as a microcomputer. Within the secondary science classroom a Calculator Based Laboratory (CBL, trademark of Texas Instruments) system can function on a level similar to a microcomputer-based system. The use of microcomputer-based and calculator-based technology is an integral part of the secondary science curriculum. The implementation of MBL and CBL (TM) is an element of educational reform within secondary science programs.

Statement of the Problem

Inquiry based learning through microcomputer-based and calculator-based laboratories allow students in secondary school science classes to participate in all phases of the scientific method. However, implementation of this technology (MBL and CBL) in the science classrooms of Montana is sporadic and inconsistent.

Purpose of Study

The purpose of this study is to evaluate the use of microcomputer-based and calculator-based laboratory systems in Montana science classrooms.

Need for the Study

The rapid integration of technology in the workplace has lead to a severe shortage of technically trained employees (Mageau, 1990). Scientific officers of large industrial corporations have concluded that "...education in science and technology does not measure up to the demands of the 1990's and beyond" (Mageau, 1990, p. 16). Students are taught computer literacy skills but not how to use computers creatively, flexibly, and purposefully (Eisenberg & Johnson, 1996). The use of MBL or CBL in secondary science classrooms provides a solution to this problem. The learning environment provided by the combination of a MBL and appropriate curricular materials places students in a situation in which they simulate the scientific workplace (Thornton & Sokoloff, 1990). MBLs provide an excellent, highly interactive learning experience within a secondary science laboratory and improves students' science intuition (Tinker, 1996). Characteristics of the MBL environment that cause the development of better understanding of science concepts and improved employee skills include immediate feedback of real time data, collaborative learning and working situations, reduction of the unnecessary drudgery of data acquisition, and the smooth transition from concrete to abstract topics (Thorton & Sokoloff, 1990).

The MBL causes a change in the amount of time that students spend in data acquisition. More time can be spent in the design of the experiment and the analysis and interpretation of results. "The tedium is taken out; the thinking is put in" (Amend, Tucker, Larsen, & Furstenau, 1990, p. 102).

Research supports the fact that seeing the data graphed in real time increases the students learning, retention, and abstract visualization (Brassell, 1987; Ivey, 1992; Mokros & Tinker, 1987; Nakhleh & Krajcik, 1993). Both the MBL and CBL have the capability of graphing data in real time. The use of technology for the collection, analysis, and display of data has been recommended by the committee which developed the National Science Education Standards (National Research Council, 1996). Montana science educators must consider using MBL and CBL technology to increase both student understanding of science concepts and to develop workplace skills so that students can meet the challenges of the 1990's and beyond.

A substantial amount (approximately $200,000) of grant money (Eisenhower Grant) was spent by the state of Montana Office of Public Instruction (OPI) to support workshops for secondary science teachers in computer interfacing and implementation of MBL in their classrooms (Amend, personal conversation, 1995). This funding began in 1988 and has continued until the present time. These workshops differed from those in other states because they were presented by university faculty and secondary teachers, not private companies. Approximately 500 secondary science teachers attended these workshops, many attended more than once (Amend, personal conversation, 1995).

Workshop members included teachers of all science disciplines ranging from seventh to twelfth grades.

Methodology

A short questionnaire was constructed and tested for validity. A list of names and addresses of all secondary science teachers in Montana from the Montana Office of Public Instruction (OPI) provided the population for the survey. Questionnaires were mailed with a cover letter and a follow-up letter was sent after three weeks to nonrespondents of the initial questionnaire. A seventy percent response rate was considered adequate for the population. An analysis of responses was conducted. Results include the percentage of responders who selected an item within a question and the response rate for each question.

Specific Objectives

The following objectives were identified for this study:

1. Determine the type of MBL and CBL usage in Montana secondary science classrooms.
2. Determine where in the curriculum teachers find MBL and CBL usage to be pedagogically useful.
3. Determine budgetary, professional development, and technological constraints on the implementation of MBL and CBL technology.

Assumptions

This study was based on the following assumptions:

1. Montana secondary science teachers have equal access to workshops for professional development.
2. The traditional method of science education is not fulfilling the needs of both students and their future employers.
3. The use of MBL and CBL is not hindered by lack of software and hardware.
4. Adequate professional time is available for Montana secondary teachers to integrate MBL and CBL technology into their curricula.

Limitations

The following limitations were identified for this study:

1. The study was directed at secondary science teachers in Montana public schools.
2. Some secondary science teachers may be teaching a science discipline in which they are not well prepared.
3. Some secondary science teachers teach more than one science discipline.

Definitions

The following terms are defined in alphabetical order:

1. Calculator-based laboratory, CBL(TM, Texas Instruments) - electronic device that facilitates data collection between probes and a graphing calculator.
2. Collaborative learning - method in which students work together to achieve a specific goal (National Research Council, 1996).
3. Data acquisition - information gathered during an experiment.
4. Integrated science - curriculum in secondary schools that combines specific disciplines (*e.g.*, biology, chemistry, physics) into thematic units (MMASS, 1996).
5. Interface device - an electronic device that collects data from an experiment and relays it to a microcomputer(Amend, Furstenau, Howald, Ivey, & Tucker, 1990).
6. Microcomputer-based laboratory - use of a microcomputer and an interface device to collect, display, store, and analyze data generated during an experiment (Lehman & Campbell, 1991).
7. Real time - the display of experimental results as the data is being collected (Lehman & Campbell, 1991).
8. Secondary science curricula - includes integrated science curriculum and the basic science disciplines of biology, chemistry, physics, and earth science in addition to variations of these disciplines (*e.g.*, ecology, consumer chemistry).

9. Secondary schools - schools which serve students in grades 7 - 12.

10. Traditional method of science education - based primarily on lecture format with laboratory activities having specific steps that deal mainly with data acquisition (National Science Education Standards, 1996).

CHAPTER 2

REVIEW OF RELATED LITERATURE

Introduction

Technology has infiltrated every aspect of educating today's youth. Microcomputers are found in the libraries, offices, and classrooms of most schools. The availability of technology coincides with the National Science Education Standards which emphasize a new way of teaching and learning science that is both inquiry-based and directly related to how science is done (Klausner & Alberts, 1996). In addition, the American Association for the Advancement of Science (AAAS) advocated reform of the American education system so that all high school graduates are science literate (Project 2061, 1996). The definition of science literacy proposed by AAAS in its Project 2061 (1996) included the fact that today's technology provides the tools and techniques for inquiry and to pursue new avenues of investigation. One of the general premises of Project 2061 (1996) stated that "Literacy in science, mathematics, and technology is important in helping people live interesting, responsible, and productive lives." (p. 4)

Four goals of teaching science through laboratory work as summarized by Lazarowitz & Tamir (1994) include providing concrete experiences to confront misconceptions, opportunities for data manipulation, developing skills in logical thinking and building values related to the nature of science. These goals and objectives, along with those proposed by Project 2061 (1996) and the National Science Education Standards, are met by the use of MBL and CBL technology in science laboratory experiments. This chapter focuses on the literature dealing with how microcomputers (MBL) are used in the secondary science classroom. The effectiveness of these technologies on student learning, levels of understanding, and attitudes toward science laboratory experiences will also be discussed.

Use of MBL

The two major uses of computers in the science laboratory are for interfacing experiments to control and collect data and to perform graphical or statistical analysis on data from experiments (Prosser & Tamir, 1990). In addition, some MBL systems provide software to allow the student to enter into the scientific process by designing an experiment (Amend, Briggs, Furstenau, Tucker, Howald & Ivey, 1989). The techniques of MBLs give students immediate feedback on the results of their experiments and allows them to modify and expand ideas while exploring alternatives to their original experiment (Heck, 1990). Some advantages of using MBLs include real-time graphing capability, data manipulation, ease-of-use, sturdiness, and accuracy (Lehman & Campbell, 1991). The abilities and advantages listed above for MBL technology indicate that its use should be widespread in secondary schools. A nation-wide research project by Jeffrey Lehman (1994) analyzed the use of microcomputers in science instruction by sending questionnaires to science department chairs. Although there was only a response rate of

38 %, the data indicated that the use of microcomputers is widespread. Seventy-six percent of those that responded indicated that microcomputers have had an impact on science laboratory activities. Use included graphing packages (63%) and interfacing with MBL (56%). The use of MBLs by teachers and students in six Indiana high schools was studied by Lehman & Campbell (1991). The research project included training for teachers on the basics of the microcomputer and interfacing devices and a description of MBL use in a "normal" classroom. The information gathered indicated a somewhat positive rating of student and teacher attitudes toward MBL activities. The authors indicated that effectiveness of MBL use is related to ample opportunity for hands-on work. Another study on the use of MBL technology was conducted by Heck (1990) in Hawaii. It also included MBL training for teachers and an assessment of the use of MBL in the classrooms of these teachers. Eighty-four percent of the teachers trained indicated they used MBL techniques in the classroom. The majority (95%) used the MBL technology 24% or less of the total laboratory time. However, most teachers believed that the MBL may have important implications for learning. A high percentage (about 80%) of teachers desired to use the MBL more frequently but were inhibited by lack of hardware and professional development time. These factors of insufficient amount of computer hardware and software and the demands of incorporating new technology into the curriculum for the teachers were documented in numerous articles (Morse, 1991; Lehman & Campbell, 1991; Lehman, 1994; Stringfield, 1994).

Effectiveness of MBL and CBL

The effectiveness of MBL and CBL systems on student learning at the secondary level is divided into two realms. One area deals with student learning and attitudes toward science concepts. The other realm is the understanding of data analysis and graphing. Because CBL systems were introduced only recently there is limited literature specifically related to its effectiveness, but because it functions as a smaller version of a MBL, it can be assumed to provide the same benefits as a MBL system.

The majority of the research on student learning in conjunction with an MBL system was done with students at the college and university level. A research project by Thorton & Sokoloff (1990) at the university level indicated strong evidence for improved learning and retention by students using MBL material compared to those taught in lectures. They also found that collected data for a large sample of secondary students correlated with that for university students. Reasons given for increased learning were that students did real science and could experience the excitement of the science process and that the physical phenomena were more accessible to all students. The MBL environment provided a direct link from concrete actions to useful abstractions, immediate feed back, and a reduction in drudgery of data collection.

Using a MBL system during an acid-base titration laboratory by secondary students allowed Nakhleh & Krajcik (1993) to document the effectiveness of this technology. They found that the large quantity of information available from the technology influenced the understanding of this laboratory experiment. Conceptual development was also enhanced because the students were forced to narrow their focus to the graph evolving on the computer screen and the memory support the graph provided. In addition, the fact that the MBL system was simultaneously gathering and graphing data "freed students to reflect upon, predict about, and speculate upon the phenomena they were observing (Nakhleh & Krajcik, 1993, p.1167)."

Eighth-grade students' abilities to increase their observation or prediction skills by using a MBL system was investigated by Friedler, Nachmias & Linn (1990). It was believed that using a MBL as a tool for data gathering would allow students to focus their short term memory on information observed during the experiment and increase their ability to predict more accurately. The study documented the successful instruction of prediction and observation skills in an MBL environment. It was noted that these skills do need to be taught, and not assumed to be inherent in student abilities.

Robert Tinker (1996) stated that the importance of MBL is in its effectiveness in providing a highly interactive learning environment that allowed students to focus on the underlying science of the experiment and to improve science intuition. He also mentioned that good teaching and curricular materials are essential to providing a good MBL learning environment. Tinker sited research that indicated improved learning with students ranging from third grade to college level with an MBL system. The realm of student learning and attitudes toward science appeared to be greatly influenced by the use of MBL systems in the science laboratory.

Graphing, data manipulation, and logical thinking were the other areas in which the effectiveness of MBL systems were documented. As early as 1987, Mokros & Tinker

(1987) provided evidence that graph interpretation skills improved through the use of MBLs. Adams and Shrum (1990) found that MBL appeared to lead to higher levels of graph interpretation. They studied tenth-grade biology students and found that the students who constructed their own graphs did better on graph construction tasks while those that used a MBL system had a educationally significant increase in the interpretation of graphs. The students also began to use the MBL system more as a tool and could monitor the real-time data and complete other tasks at the same time. A study by Huetinck (1992) identified two reasons that students have difficulty with graphing, they do not connect the physical reality with the abstract graph and the tedium of graphing detracted from its overall effect. MBLs overcome both of these difficulties. Real-time graphing provided a connection between a result in an experiment and the graph. In addition, manipulation and changing the data was easily done with a spreadsheet and graphing program. Huetinck (1992) listed additional advantages of MBL systems. These included acquiring more data quickly and gaining an appreciation of graphing as a useful tool to manipulate and organize data. Huetinck (1992) also mentioned an increase in enthusiasm and student interaction with the computer as the students produced various graphs. It allowed students to go beyond and ask the "what if" questions.

Summary

The availability of both MBL and CBL technology is causing a major shift in the science laboratory experience at the secondary level. This change is further augmented by the publishing of National Science Education Standards that call for a new way of teaching and learning science as opposed to the traditional methods of lecture and "cookbook" labs. The pedagogical advantages of using MBL and CBL technology that correspond to the National Science Education Standards led to attempts to incorporate these technologies into the secondary science laboratory curriculum. Implementation of this change is hindered by lack of hardware and software and teacher training. In 1992 there were only a few science teacher training courses on applications of microcomputers within the science curriculum (Lehman, 1994). Teacher inservice programs that allowed "hands on" experience with MBL technology led to increased use within the classroom. While most science educators understand the effectiveness of using MBL and CBL technology in the science laboratory, finding the time to develop or incorporate new curriculum is difficult. Student response to using the technology during a laboratory activity is overwhelmingly favorable (Huetinck, 1992) as is the research pointing to the effectiveness in increasing student understanding of not only the science concept being addressed but also the student's ability to interpret the results.

CHAPTER 3

METHODOLOGY

Introduction

The descriptive research method was selected for the study of the implementation of MBL and CBL technology in science classrooms of Montana. The population for the study was determined to be all secondary science teachers in Montana. The sample of the population used for the research was randomly selected. A self-report study using a survey as the instrument to collect information from the sample was utilized for evaluating the use of the MBL and CBL laboratory systems. Data collection was accomplished by mail with phone inquiries to nonresponders if necessary. The analysis of the data was by percentage of responses. The information from the research was submitted to the Montana Science Teachers Association newsletter for dissemination to state educators.

Descriptive Research

Descriptive research methods are useful for educational purposes because they measure the existing patterns in a population. As a type of quantitative research, the descriptive approach to data collection is used to describe present conditions and investigate relationships that exist (Gay, 1996). The objectives of this study were to determine the type of MBL and CBL usage, where teachers found this technology to be useful in their curriculum, and hindrances to the implementation of these laboratory systems. These objectives correlate with the typical concerns of descriptive research which are to assess attitudes, procedures , conditions, and opinions and collect demographic information (Gay, 1996). Collection of data regarding the usage patterns of teachers was attained through the self-reporting survey method. The population was then assessed to determine the practices of secondary teachers in implementing MBL and CBL technology.

Population and Sample

The population for this study was all secondary science teachers in Montana. Secondary science teachers are those teachers who teach any science subject in grades 7 - 12. This includes both junior high school and high school teachers. A list of the population names and school addresses was downloaded from an Office of Public Instruction computer file located on MET NET, a state-wide educational network. The file was for the 1995 school year. The file contained 796 names. Of the 796 names in the list, 155 were middle school teachers. A middle school normally contains students in grades 6-8. The population for this study was defined as teachers of grades 7-12 so these 155 middle school teachers were excluded from the study. This left a population of 641. An adequate sample of a population of 650 is 242 randomly selected names. This was determined from a table of sample sizes for a given population size (Gay, 1996, p.125).

Since the most recent file was for the 1995-96 school year and the study was done during the 1996-1997 school year it was determined to include 300 names in the sample to compensate for teachers who were reassigned or no longer in the school district. To acquire an adequate representative sample of the population random sampling techniques were used. All members of the population were assigned a number from 0 to 640 (641 total numbers). A table of random numbers was used to determine the 300 names to be included in the study (Gay, 1996).

Instrument Development

The self-report type of descriptive research was selected for this study. This involved a survey mailed to individuals who responded according to their own usage patterns and opinions. They also provided personal demographic information. Using a survey that the selected sample of the population responds to independently can yield precise and quantifiable data that can be extrapolated to the population (Gay, 1996).

Formulation of an instrument such as a survey that gathers the appropriate information was critical to the research. A variety of factors were considered during the creation of the survey. Items were structured so that responders had a list of alternatives for each question. Questions were clearly worded and dealt with a single concept. The survey was constructed so that it was brief and easy to respond to. Demographics gathered by the survey were years of teaching experience, school size, and specific science classes taught (Appendix D). Information regarding teaching experience was used to determine if more experienced teachers were more or less likely to integrate technology into the curriculum. School size information illustrated whether teachers in rural or urban areas used technology more. By relating classes taught and the use or nonuse of MBL or CBL technology determined in which disciplines science teachers incorporated this technology into the curriculum. In addition, specific topics within the physical sciences and biological sciences were listed to determine where in a discipline teachers were likely to use this technology.

The instrument (Appendix D) elicited responses from teachers on constraints which limit the use of MBL and CBL technology. Information on types of MBL and CBL hardware and software and commonly used sensors and probes was gathered to further evaluate how and where this technology was used in the curriculum.

Considerations during the overall development of the survey included making the instrument brief and neat, and using closed-form or structured items. This type of item poses a single question and provides a list of alternative responses. The advantages of structured items include facilitating response and data analysis (Gay, 1996). Once the survey was developed it was evaluated for validity by other teachers, professors, and a business person (Appendix C) for comment and revision. A cover letter was written which specifically addressed the purpose for the survey, directions for completing the survey, stated a deadline of two weeks for responding, and where the information from the survey might be published. A stamped self-addressed envelope was included to encourage a response. To identify which members of the sample responded, the surveys were numbered.

A response rate of 70% (170 responses from the 242 sample size) was considered adequate. Validity of the conclusions drawn from a survey are weak without at least 70 % response rate (Gay, 1996). For a response rate less than 70% on the first mailing, a second cover letter, survey, and stamped self-addressed envelope was sent to nonrespondents. If a sufficient percentage of the sample did not respond, then a phone call was made to those who had not responded to the second mailing. Their responses will be compared to the responders of the first two mailings to evaluate any differences.

Analysis of Results

The number of respondents divided by the sample size (242 for a population of 641) determined the response rate for the instrument. The response rate for each item was calculated by dividing the number of respondents that item had by total number of respondents to the item. This provided a percentage of responders who selected a particular alternative for a response. The alternative answers for each item were rated by percentage choosing that alternative compared to total number answering that particular item (Gay, 1996). In addition, other statistical methods such as the mean and mode were employed to investigate relationships. The mean was used to display the average number provided by all respondents. The mean provided a measure of the central tendency of the data (Gay, 1996). The mode was used to display the most common response given when analyzing courses taught and number of MBL/CBL available (Tables 4 & 5). The percent of teachers responding with the mode compared to overall response rate provided information on how often the mode occurred within the total number of respondents. Although the mean provided the average number for the data in Tables 4 & 5, the mode and percentage with the mode displayed a high percentage of respondents with a different response than the mean. Because the objectives of the study were to determine the type of MBL and CBL usage, where teachers found this technology useful and hindrances to the implementation of these laboratory systems, these simple statistical calculations were considered adequate.

Summary

The methodology chosen for this study was the descriptive survey method because it most closely aligned with the objectives of the study. The population for the study was secondary science teachers in Montana. Three hundred names were randomly selected from a computer file from the Office of Public Instruction for the sample population. A self-report type of survey was developed to elicit information germane to this study. The survey and a cover letter were mailed to the selected sample population. A second cover letter and survey were sent to nonrespondents to the first mailing. Phone call inquiries to nonrespondents of the second mailing were to be made if the 70% response rate was not achieved. Analysis of the results were accomplished with statistical methods of mean, median, and mode.

CHAPTER 4

PRESENTATION AND INTERPRETATION OF DATA

Introduction

The population surveyed in this study was secondary science teachers in the state of Montana. This included those teaching any of the science disciplines in grades 7 through 12. Names were randomly selected from the list of science teachers provided by the Office of Public Instruction for the 1995-1996 school year. The results of the survey were organized and presented in the following sections: survey returns, demographic information, and availability and use of MBL/CBL.

Survey Returns

The population size was 641 and an adequate sample for this population was 242. The initial mailing consisted of 300 names since the most recent list available was for the previous school year from when the surveys were mailed. A return rate of 70% of the sample size of 242 indicated a sufficient response. As Table 1 indicates after two mailings a useable return rate of 79% (190 surveys returned for sample size of 242) was achieved. Surveys were considered not useable for two reasons, either the survey was returned because the teacher was no longer there or the back side of the survey was inadvertently not copied so that there was no opportunity for the teacher to respond to the information on the back of the survey. Because an adequate return rate was achieved after two mailings, no phone call inquiries were made nor was an analysis of the difference between responses and forced responses necessary.

TABLE 1. RESPONSE RATE

Population = 641 Sample Size = 242

	Mailed	Returned	Useable	Percent of Sample (242)
First Mailing	300	153	140	58%
Second Mailing	150	55	50	21%
Total			190	79%

Demographics

Demographic information gathered in the survey included number of years teaching experience, school classification and courses taught. Table 2 shows that the majority of teachers (51%) responding to the survey had more than 15 years experience teaching at the secondary level. Teachers with 4 - 15 years experience constituted 44% of the respondents. Only 3% had three or less years teaching experience. The data indicated that there were very few new teachers in the field of science and almost half of those currently teaching will be nearing retirement within 10 years.

TABLE 2. NUMBER OF YEARS OF SECONDARY TEACHING EXPERIENCE

	1 - 3 Years	4 - 6 Years	7 - 10 Years	10 - 15 Years	More than 15 Years	No Response
Total Responses	6	26	31	27	97	3
% of Response	3%	14%	16%	14%	51%	2%

Data in Table 3 indicated that respondents represented all Montana school classifications. Montana schools are classified by various criteria with school size predominating the classification scheme. Class AA schools have a student population of 1198 - 2359, class A population ranges from 164 - 866, class B from 124 - 411 and class C student population ranges from 14 - 178 (Montana High School Association, 1996). Those respondents from junior high schools who did not respond to the classification question were classified by the size of the high school that those students will eventually attend. The percent responses from each classification of school was fairly evenly distributed. The category of "number of schools responding" was determined by one or more teachers from a school responding to the survey. Since the number of science teachers at a class AA school is substantially larger than the number of science teachers at a class C school, it was important to determine if each class of school was adequately represented by at least one teacher from that school responding. Each class of school had representation of at least 40%.

TABLE 3. SCHOOL CLASSIFICATION

	AA	A	B	C
Responses	63	39	45	43
% Responses	33%	20%	24%	23%
# Schools Responding	13	15	27	42
Total # Schools in Class	13	22	43	104
% Total in Class in MT	100%	68%	63%	40%

A list of the basic science courses taught in Montana schools is found in Table 4. For all courses except 7-8 Integrated Science, the mode was one. This means that for all these courses, 40% or more of the teachers responding have only one section of that course. Teachers in Montana typically teach 5 , 6, or 7 classes daily with one class period as a preparation period. The data in Table 4 showed that most teachers in Montana have two or more different science courses that they must prepare for on a daily basis. The data also indicated that only a small fraction of a science teacher's preparation time can be devoted to a particular science subject and a teacher must be knowledgeable in a wide range of science disciplines. The largest number of sections of a particular science course was found in Biology. This is due to state graduation requirements which require one year of Biology along with any other laboratory science.

TABLE 4. COURSES TAUGHT

Course Title	Teachers Responding	# Sections Taught	Mean # Sections Taught	Mode of Sections Taught	% Mode to Teachers Responding
7-8 Life Science	51	96	1.9	1	59%
7-8 Earth Science	7	11	1.6	1	71%
7-8 Physical Science	50	105	2.1	1	52%
7-8 Integrated Science	3	18	6	6	100%
Earth Science	61	143	2.3	1	44%
Biology	90	229	2.5	1	40%
Chemistry	61	126	2.1	1	54%
Physics	50	76	1.5	1	76%
9-12 Integrated Science	8	16	2	1	50%

In addition to the courses mentioned in Table 4 there were a large variety of other courses taught by respondents. These included advanced courses in Biology, Chemistry and Physics, and specialty courses in Geology, Astronomy, Applied Science, Paleontology, and a variety of courses involving science projects or individual research by students.

Availability and Use of MBL and CBL Technology

The data included in Table 5 indicated that the availability of MBL or CBL technology varied widely. Of the 190 surveys in the study, 91 respondents (48%) had access to either MBL technology, CBL technology or both during class time. There is more CBL equipment in secondary schools statewide than MBL equipment. The percentage of teachers with only a limited number of either MBL/CBL hardware units available during a class period was greater than the percentage of those who had enough hardware units to allow a class of twenty students to use an individual unit in pairs.

TABLE 5. NUMBER OF MBL/CBL AVAILABLE

	Total Available	Responses	Mean	Mode	% with Mode	% with >=10 Units
MBL	257	48	5.4	1	38%	19%
CBL	509	64	8	1,3,6	47%	36%

The actual use of MBL or CBL technology for specific topics within the physical sciences or biological sciences are catalogued in Tables 6 and 7. The courses included in the physical science category were Chemistry, Physics, Earth Science, and Integrated Science. The biological sciences include Biology, Integrated Science, and Life Science. The total number of teachers that teach in each category was determined by counting the number of surveys that were checked for any course under the physical sciences category or the biological sciences category. Many teachers teach in both categories so each may have responded to both sections. The topics under each category were chosen for the survey because they were listed in science supply catalogs (Appendix E) and by those people who reviewed the survey (Appendix C) as possible topics for MBL or CBL usage.

The data indicated that more topics in the physical sciences were being taught with the use of MBL and/or CBL technology although no one topic had a rating above 45%.

TABLE 6. PHYSICAL SCIENCES

Total Number Teaching Physical Science Courses = 139

Topic	MBL	CBL	Total	% of Total
Motion	21	33	54	39%
Heat, Temperature	25	37	62	45%
pH	22	23	45	32%
Sound	8	16	24	17%
Radiation	9	4	13	9%
Machines	6	9	15	11%
Colorimetry	16	5	21	15%
Light	14	22	36	26%
Forces	11	15	26	19%
Electricity	10	15	25	18%
Magnetism	6	6	12	9%

TABLE 7. BIOLOGICAL SCIENCES

Total Number Teaching Biological Science Courses = 123

Topic	MBL	CBL	Total	% of Total
Heat, Temperature	12	11	23	19%
Colorimetry	7	1	8	7%
pH	17	17	34	28%
Respiration	9	7	16	13%
Heart Rate	11	8	19	15%
Light, Photosynthesis	9	8	17	14%
Humidity	3	1	4	3%
Conductivity	4	3	7	6%
Gas Pressure	1	3	4	3%
Dissolved Oxygen	5	6	11	9%

There were numerous topics other than those listed in Tables 6 & 7 in which respondents indicated they used MBL/CBL technology. These include pressure, relative humidity, gas laws, energy, conductivity, gas chromatography and dissolved oxygen for the physical science category and EKG, reaction rates, genetics and gycolysis for the biological sciences.

Table 8 displays the reasons respondents gave for either a limited use or no use of MBL/CBL technology. The two main reasons were budget limitations and lack of equipment. Not enough time and lack of professional development opportunities also hindered implementation of MBL/CBL technology. Hindrance occurred to a lesser degree due to lack of curriculum, technological problems and being unaware of the technology at all.

TABLE 8. REASONS LIMITED OR NON USE OF MBL/CBL

Reason	# Responses
Budget Limitations	108
Lack of Equipment	105
Lack of Professional Development Opportunities	57
Not Enough Time	51
Lack of Curriculum	34
Unaware of MBL/CBL	26
Technological Problems	23

Other information provided by respondents on why they have not used MBL and/or CBL technology was varied and interesting. One respondent felt as if "somebody's gotta balance the techies to keep common sense in a world of budget-robbing technology." Others indicated that the technology was not user friendly or poor data was gathered during experiments. The largest number of other reasons centered on the fact that teachers were choosing not to use the technology because they feel it was not necessary or that students must learn the "basics" first. There were a few teachers who stated that only advanced classes were allowed to use MBL/CBL technology or that other teachers of science or math would not share the equipment. Some respondents mentioned that they were purchasing equipment this year and hoped to implement the technology into their curriculums during the coming school year.

The MBL hardware most frequently listed by respondents was IBM compatible microcomputers with Vernier or SCI interfaces and the corresponding software to run the interfaces and spreadsheets. The CBL technology was exclusively by Texas Instruments, usually with Vernier software and the TI-Graphs Link (TM) program to connect the graphing calculators to a microcomputer. Probes listed most frequently were thermistors, pH probes, light probes, accelerometers, motion detector, pressure, colorimeter, and photogates.

A demographic comparison between use of MBL/CBL technology and the numbers of years teaching experience is presented in Table 9. Use of MBL/CBL technology was between 42% to 50% for all teachers with 4 or more years of teaching experience. The low percentage in the 1 - 3 years of teaching experience category (33%) could have occurred because of several reasons. The low number of actual responses in this category could skew the data since one more positive response to MBL/CBL use would have changed the percentage to 50%. Another reason for the low percentage of use in beginning teachers could be inadequate preparation in the use of MBL/CBL technology during pre-service training.

TABLE 9. USE OF MBL/CBL COMPARED TO YEARS TEACHING EXPERIENCE

Years Experience	1-3	4-6	7-10	10-15	>15
# Using MBL/CBL	2	13	13	13	46
Total # Responses	6	26	31	27	97
% Using MBL/CBL to Total Responses	33%	50%	42%	48%	47%

Table 10 compares the use of MBL/CBL technology with the school classification of the respondent. The largest schools (AA) and the smallest schools (C) had an equal percentage (51%) of teachers that indicated that they use MBL/CBL technology in the classroom. The other two classifications (Class A & Class B) had approximately the same use rate (41% & 38%, respectively). None of the percentages indicated that a particular school classification is lacking in the implementation of MBL/CBL technology.

TABLE 10. USE OF MBL/CBL COMPARED TO SCHOOL CLASSIFICATION

School Classification	**AA**	**A**	**B**	**C**
# Teachers Using MBL/CBL	32	16	17	22
Total # Teachers Responding	63	39	45	43
Percentage Using MBL/CBL to Total Responding	51%	41%	38%	51%

Summary

An adequate response rate of 79% was achieved after two mailings eliminating the need for phone inquiries and an analysis of nonrespondents. The majority of the respondents had more than fifteen years teaching experience at the secondary level. Each classification of Montana schools had 40% or more representation. Most teachers in Montana teach a variety of different science courses and individual courses were well represented except for the Integrated Science courses at both the 7 - 8 and 9 - 12 level. This is due to the fact that these are new courses being implemented at the state level. Access to either MBL or CBL technology is limited. Teachers responded that they have an inadequate number of MBL/CBL units available for a class of twenty or more during a class period since most have only between 1 to 6 available. This allows only for demonstrations with the technology by the teacher and eliminates direct student use. A lesser amount of teachers have an adequate amount of MBL/CBL units (19%/36%) available for class wide use. Topics that were most frequently covered by using MBL/CBL were motion, heat and temperature, pH and light. Less than 20% of the teachers used MBL/CBL technology for any of the other topics. Budget limitations and consequently the lack of equipment were the main reasons given for teachers not using MBL/CBL technology.

An analysis of demographic data compared to use of MBL/CBL indicated that the number of years a teacher has been teaching did not directly influence their use of MBL/CBL technology. The percentages of teachers with 4 or more years teaching experience that indicated use of MBL/CBL technology ranged from 42% to 50%. The only exception to this was in the 1 to 3 years teaching experience category. Only 33% of these teachers indicated use of MBL/CBL technology. This result may be skewed due to the low response rate in for this category. The most use of MBL/CBL technology occurred in the largest and smallest Montana schools (Class AA & Class C). Fifty-one percent of the responding teachers from each class indicated some use of MBL/CBL technology. The percentages for Class A and Class B schools were not significantly lower (41% & 38%, respectively). This data suggested that MBL/CBL technology is being incorporated into secondary schools in Montana.

CHAPTER 5

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

Summary

The rapid change in size and cost of microcomputer technology in the last ten years has made access to this technology feasible for school classrooms. The increased demand for computer literate employees and the need for students trained in inquiry-based learning along with the scientific method demands that teachers implement interfacing laboratory activities that are microcomputer-based or calculator-based (MBL/CBL) into their curriculum. The purpose of this study was to evaluate the use of this technology in the state of Montana. Objectives included determining the type and amount of MBL/CBL usage, where in the curriculum teachers find the technology useful and the hindrances to usage of MBL/CBL technology.

A review of current literature focused on how MBL were used in the secondary science classrooms across the nation in addition to its effectiveness on student learning, levels of understanding and student's attitudes toward science laboratory experiences. Nationwide, teachers of secondary science are using MBL technology in their classrooms and most researchers felt that implementation of MBL occurs after teachers have had sufficient inservice with the technology. The majority of teachers feel that the technology was effective in increasing student learning by providing a link between the scientific phenomena being observed and the simultaneous analysis of the data collected by the interface device. As cited in the literature review, student attitudes towards MBL technology were overwhelmingly favorable. The literature review also revealed that the majority of teachers mentioned the hindrances to using technology were lack of time to incorporate the technology into the curriculum and lack of hardware and software.

A survey was developed and sent to a randomly selected sample of secondary science teachers throughout Montana. The survey was responded to by 190 teachers. This represented a 79% response rate based on a sample size of 242. All classes of Montana secondary schools were adequately represented. The majority of the teachers responding had more than 15 years teaching experience. Only three percent were new teachers with 1 - 3 years teaching experience. This implies an aging population with the majority having approximately 10 years until retirement. Courses taught by the respondents covered the full range of the basic science classes so each science discipline was represented by the data. Most teachers had limited access to MBL/CBL technology. The numbers of teachers with adequate supplies of MBL/CBL technology for a class of twenty students was meager, 19%/36%, respectively. The lower percentage for availability of MBL technology may be due to its higher cost than CBL technology. Those teachers with only one MBL or CBL unit in a class are limited to using it for demonstration purposes. This eliminated the necessary hands-on and inquiry modes of teaching that were encouraged by current literature. Of those that did use the technology, most primarily used it for laboratory activities dealing with motion, heat and temperature, light, and pH. These topics were predominately from the physical sciences. This implied that the technology was not being used as much in the biological sciences although Biology is the only specific laboratory class required for Montana graduation requirements. Therefore, many students may not have any access to either technology. The main reasons for nonuse or limited use were budget limitations and consequently lack of equipment. The cost of a MBL unit including a microcomputer, interface device, software and probes varied widely mainly because of the type of microcomputer. The MBL interface device, probes and software alone can cost between $250 - $1300. CBL units with graphing calculator, interface device, probes and software average around $250. With the current state of school financing, most science budgets are under constraints that disallow major purchases. School budgets must also provide for professional development opportunities and this was also listed as a important reason for limited or nonuse of MBL/CBL technology. Although the majority of teachers have to prepare for a variety of different science classes every day, not enough time was only listed as the fourth reason for not implementing MBL/CBL technology. This implied that teachers are willing to incorporate the technology if the budget constraints were not inhibiting. Very few teachers were totally unaware of MBL/CBL technology or discouraged by technological problems or lack of curriculum.

Conclusions

The following conclusions may be drawn from the study:

1. The data showed that there was limited availability to MBL/CBL technology for full classroom use.
2. More teachers of the physical sciences were implementing MBL/CBL technology than those in the biological sciences.
3. Close to half the teachers with 4 or more years teaching experience were using MBL/CBL technology to some degree.
4. The major limiting factors were budgetary constraints which limit access to MBL/CBL technology.
5. Other factors inhibiting usage of MBL/CBL technology include not enough professional development opportunities and lack of sufficient time to incorporate MBL/CBL technology into existing curriculum.

Recommendations

The following recommendations are based on the conclusions of this study:

1. There should be increased monetary support for the purchasing of MBL/CBL technology so that there are enough hardware units available for full class use.

2. Teachers of biological science classes should be encouraged to implement MBL/CBL technology.
3. More curriculum materials that incorporate MBL/CBL technology should be published in statewide science teacher media.
4. Sufficient time and monetary support should be made available to science teachers so that they can attend related professional development activities and have the time to incorporate the technology into their curriculum.

REFERENCES

Adams, D.Daryl & Shrum, John W. (1990). The effects of microcomputer-based laboratory exercises on the acquisition of line graph construction and interpretation skills by high school biology students. *Journal of Research in Science Teaching,* 27, 777-787.

Amend, John R., Briggs, Robert D., Furstenau, Ronald P., Tucker, Kathleen A., Howald, Reed A., & Ivey, Bruce E. (1989). Laboratory interfacing for science courses in Montana schools: A project at Montana State University. *Journal of Computer in Mathematics and Science Teaching,* 9, 95-105.

Amend, John R., Furstenau, Ronald P., Howald, Reed A., Ivey, Bruce E., & Tucker, Kathleen A. (1990). An integrated workstation for the freshman laboratory. *Journal of Chemical Education,* 67, 333-336.

Amend, John R., Tucker, Kathleen A., & Larsen, Ray. (1990). Drawing relationships from experimental data: Computers can change the way we teach science. *Journal of Computers in Mathematics and Science Teaching,* 10, 101-111.

Berger, Carl F., Lu Casey R., Blezer, Sharolyn J., & Voss, Burton E. (1994). *Research on the uses of technology in science education.* In Dorothy L. Gabel (Ed.), Handbook of Research on Science Teaching and Learning (pp. 466-490). New York:Macmillian Publishing Co.

Brassell, H. (1987). The effect of real-time laboratory graphing on learning graphic representations of distance and velocity. *Journal of Research in Science Teaching,* 24, 385-395.

Eisenberg, Michael B., & Johnson, Doug. (1996). *Computer skills for information problem-solving: Learning and teaching technology in context.* ERIC Digest EDO-IR-96-04.

Friedler, Yael, Nachmias, Rafi, & Linn, Marcia C. (1990). Learning scientific reasoning skills in microcomputer-based laboratories. *Journal of Research in Science Teaching,* 27, 173-191.

Gay, L. R. (1996). *Educational Research: Competencies for analysis and application (5th ed.).* New Jersey: Prentice-Hall, Inc.

Heck, Ronald H. (1990). Secondary science teachers' attitudes about microcomputer-based laboratory techniques: Instructional uses and needed improvements. *Computers in the Schools,* 7, 71-85.

Huetinck, Linda. (1992). Understanding graphing through microcomputer-based Laboraotries. *Journal of Computers in Mathematics and Science Teaching,* 11, 95-100.

Ivey, Bruce Earl. (1992). *A case study of student learning in a microcomputer-based chemistry laboratory.* Unpublished doctoral dissertation, Montana State University, Bozeman.

Klausner, Richard & Alberts, Bruce. (1996). *Call to action. National Science Education Standards.* Washington, D.C.: National Academy Press.

Lazarowitz, Reuven & Tamir, Pinchas. (1994). *Research on using laboratory instruction in science.* In Dorothy L. Gabel (Ed.), Handbook of Research on Science Teaching and Learning (pp. 94-128). New York:Macmillian Publishing Co.

Lehman, Jeffrey R. (1994). Secondary science teachers' use of microcomputers during instruction. *School Science and Mathematics,* 94, 413-420.

Lehman, James D. & Campbell, John P. (1991). *Microcomputer-based laboratories and computer networking in high school science classrooms.* ERIC Document, ED338492.

Mageau, Therese. (1990). Reforming science education. *Electronic Learning,* 9, 16.

Mokros, J.R. & Tinker, R.F. (1987). The impact of microcomputer-based labs on children's ability to interpret graphs. *Journal of Research in Science Teaching,* 24, 369-383.

Montana High School Association. (1996). *Montana High School Association Official Handbook.* Helena: Board of Control.

MMASS, Montana Mathematics and Science Society. (1996). *Montana's framework for improving Mathematics and Science Education.* Helena, MT:Office of Public Instruction.

Morse, Ronald H. (1991). *Computer uses in secondary science education.* ERIC Digest, ED331489.

Nakhleh, Mary B. & Krajcik, Joseph S. (1993). A protocol analysis of the influence of technology on students' actions, verbal commentary, and thought processes during the performance of acid-base titrations. *Journal of Research in Science Teaching,* 30, 1149-1168.

National Research Council. (1996). *National Science Education Standards.* Washington, D.C., National Academy Press.

Project 2061. (1996). *A perspective on reform in Mathematics and Science Education.* Monographs of the Eisenhower National Clearinghouse for Mathematics and Science Education, #2.

Prosser Michael T. & Tamir, Pinchas. (1990). *Developing and improving the role of computers in student laboratories.* In Elizabeth Hegarty-Hazel (Ed.), The Student Laboratory and the Science Curriculum, London and New York: Routledge.

Tinker, Robert. (1996). *Evidence for the long term impact of one AAT project.* [On-line]. Available:gopher://gopher.hub.terc.edu...ief scientist/mbl impact.txt.

Stringfield, James. (1994). Using commercially available microcomputer-based labs in the biology classroom. *The American Biology Teacher*, 56, 106-108.

Thorton, Ronald K. & Sokoloff, David R. (1990). Learning motion concepts using real-time microcomputer-based laboratory tools. *American Journal of Physics* 58, 858-866.

APPENDICES

APPENDIX A

COVER LETTER TO ACCOMPANY QUESTIONNAIRE

(FIRST MAILING)

March , 1997

1225 Indian Creek Rd.
Eureka, MT 59917

Dear «FIRSTNAME»,

It's everywhere!! "Technology in the classroom" is the wave of the future and the future is now!! How many times have you heard this in the last few years? Have you ever wondered what your colleagues are doing in their classrooms with technology? The purpose of the enclosed questionnaire is to determine what technology is being used by science teachers across Montana in their laboratory activities. With a stressful and busy occupation like teaching, it is difficult to keep up with new teaching techniques and to effectively integrate new methods into an already full curriculum. Wouldn't it be helpful to know what your colleagues are doing with technology in the science laboratory? Where in their curriculum do they use technology effectively?

As part of a masters program in Technology Education at Montana State University, I am trying to discern how teachers are using technology in their science labs. The focus of the survey is the use of microcomputer based labs (MBL) and calculator based labs (CBL). Both MBL and CBL use interface devices to collect and analyze data. The difference lies in what processes the data, a microcomputer or a graphing calculator. They are very effective in collecting and analyzing data. But do you find them helpful in your teaching? Do you use them frequently, occasionally or not at all?

Of the approximately 800 science teachers in Montana, you have been randomly selected to be part of this study. It is important that all science teachers within the state have an idea of what and how their colleagues are using this technology in their classrooms. Your response is very important to complete the study. I intend to submit the results to the MSTA newsletter for publication and will send a copy of the results directly to you if you check the box on the survey.

Please complete the enclosed survey by March 14, 1997 and return it in the enclosed stamped envelope. Thank you for your cooperation.

Sincerely,

Darlene B. Ruble
Science Teacher
Lincoln County High School

APPENDIX B

COVER LETTER TO ACCOMPANY QUESTIONNAIRE

(SECOND MAILING)

April 8, 1997

Dear «FIRSTNAME»,

Spring and spring fever has blossomed all around Montana. It's the time of year when a busy schedule gets busier and the end of the school year approaches quickly.

A few weeks ago I sent you a survey about your use of microcomputer and calculator based laboratories in your science curriculum. I know you are very busy and the original survey is probably buried under piles of papers to grade. But your input is very important to other teachers around the state. It is also important for me to receive this information soon so that I can evaluate it and be able to publish it for everyone at the beginning of the next school year.

Please take a few minutes and fill out the survey and return it by April 20 in the stamped self-addressed envelope. Your cooperation is greatly appreciated.

Sincerely,

Darlene B. Ruble
Science Teacher
Lincoln County High School
Eureka, MT 59917

APPENDIX C

INDIVIDUALS WHO TESTED VALIDITY OF SURVEY INSTRUMENT

John Amend, PhD., Chemistry Department, Montana State University, Bozeman, MT.

Scott Davis, PhD., Education Department, Montana State University, Bozeman, MT.

Marie Dorsey, SCI Technologies, Bozeman, MT.

Robert Henderson, Biology Teacher, Lincoln County High School, Eureka, MT.

Larry Kirkpatrick, PhD., Physics Department, Montana State University, Bozeman, MT.

Kevin Ruble, Technology Education Teacher, Lincoln County High School, Eureka, MT.

APPENDIX D

SURVEY INSTRUMENT

USING TECHNOLOGY IN THE SCIENCE CLASSROOM

1. Please indicate the science courses that you teach: (Indicate the # of sections of each different science class)

Course Title	# of sections	Course Title	# of sections
_____ 7-8 Life Science	_____	_____ 7-8 Physical Science	_____
_____ 7-8 Earth Science	_____	_____ 7-8 Integrated Science	_____
_____ Biology	_____	_____ Earth Science	_____
_____ Chemistry	_____	_____ Physics	_____
_____ 9-12 Integrated Science	_____		

_____ OTHER (LIST NAME OF COURSE(S)) ______________________________

____

2. Within each general science discipline, check the topics in which MBL AND/OR CBL technology is used:

A. PHYSICAL SCIENCES (Chemistry, Physics, Earth Science, Integrated Science)

MBL	CBL	
_____	_____	MOTION
_____	_____	HEAT, TEMPERATURE
_____	_____	pH
_____	_____	SOUND
_____	_____	RADIATION
_____	_____	MACHINES (PULLEYS)
_____	_____	COLORIMETRY
_____	_____	LIGHT
_____	_____	FORCES
_____	_____	ELECTRICITY
_____	_____	MAGNETICISM
_____	_____	OTHER (PLEASE LIST)____________________
_____	_____	______________________________________
_____	_____	______________________________________

B. LIFE SCIENCES (Biology, Integrated Science)

MBL	CBL	
_____	_____	HEAT, TEMPERATURE
_____	_____	COLORIMETRY
_____	_____	pH
_____	_____	RESPIRATION
_____	_____	HEART RATES
_____	_____	LIGHT (PHOTOSYNTHESIS)
_____	_____	HUMIDITY
_____	_____	CONDUCTIVITY
_____	_____	GAS PRESSURE
_____	_____	DISSOLVED OXYGEN
_____	_____	OTHER (PLEASE LIST)____________________
_____	_____	______________________________________

3. Indicate the number of MBL AND/OR CBL units available during class time:

___ MBL _____ CBL

4. Please list the types of hardware, software and probes (include brand names, if available) that you find most useful in your laboratory classes.

A. HARDWARE:

B. SOFTWARE:

C. PROBES:

5. Please indicate your reasons for not using either MBL or CBL technology. (CHECK ALL THAT APPLY)

_____ Unaware of MBL &/or CBL _____ Budget limitations

_____ Lack of curriculum _____ Not enough time

_____ Lack of professional development opportunities

_____ Too many technological problems _____ Lack of equipment

_____ Other (PLEASE LIST)____

____

DEMOGRAPHIC INFORMATION

6. Please indicate your number of years of secondary teaching experience:

_____ 1-3 ______ 4-6 ______ 7-10 _______ 10-15 ______ >15

7. Based on the student population, what is the school's rank:

_____ AA _____ A _____ B _____ C

☐ CHECK HERE TO RECEIVE RESULTS OF SURVEY

APPENDIX E

SCIENCE CATALOGS

SCI Technologies, Inc. 1716 West Main St, Suite 4, Bozeman, MT 59715

Pasco Scientific, 10101 Foothills Blvd., P.O. Box 619011, Roseville, CA 95678-9011.

Vernier Software, 8565 S.W. Beaverton-Hillsdale Hwy, Portland, OR 97225-2429.