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ABSTRACT

Microcomputer-based laboratories (MBLs) are believed to have significant potential for improving laboratory experiences in science classrooms. A study funded through a grant project called STEPS to Better Science sought to broaden the knowledge base by examining MBL use by teachers and students in a variety of science classrooms in six high schools in Indiana. The use of MBLs in "real-world" science classrooms was being examined through triangulation of several data sources. Data collected include the following: student and teacher attitudes toward the use of MBLs, classroom observations of the use of MBLs, and student graphing performance. Of additional interest is the use of a large-scale computer network for project data sharing, resource acquisition, and communications. The study was being conducted during the 1990-91 school year. Preliminary data indicate that the large-scale network has primarily been used for communication purposes thus far, although a number of classroom uses of the MBL have been initiated. Quantitative results from one classroom studied show no evidence of an impact of the use of MBLs on either student graphing skills or student attitudes toward computers. However, these results were obtained after only very limited student exposure to the MBL. Student attitudes toward the MBL were positive, and the attitudes of the 24 participating teachers were overwhelmingly positive. The greatest assets of the MBL appear to include real-time graphing, data manipulation, ease-of-use, sturdiness, and accuracy. Implementation is seen as a key to effective use of the MBL. Techniques for classroom use have included small groups in rotation, whole class problem solving, and demonstration. Those techniques that most directly involve student use of the MBL appear to have the greatest potential for effectiveness. (15 references) (Author/KR)

Microcomputer-Based Laboratories and Computer Networking in High School Science Classrooms

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Abstract

Microcomputer-based laboratories (MBLs) are believed to have significant potential for improving laboratory experiences in science classrooms. Previous research, conducted mostly with junior high school and middle school students, indicates that MBLs are a valuable addition to the science classroom and can result in significant improvement in students' graphing skills.

This study, funded through a grant project called STEPS to Better Science, seeks to broaden the knowledge base by examining MBL use by teachers and students in a variety of science classrooms in six high schools in Indiana. The use of MBLs in "real-world" science classrooms is being examined through triangulation of several data sources. Data collected include: student and teacher attitudes toward the use of MBLs, classroom observations of the use of MBLs, and student graphing performance. Of additional interest is the use of a large-scale computer network for project data sharing, resource acquisition, and communications. The study is being conducted during the 1990-91 school year, and the data reported herein are very preliminary only.

The large-scale network has primarily been used for communication purposes thus far, while a number of classroom uses of the MBL have been initiated. Quantitative results from one classroom studied show no evidence of an impact of the use of MBLs on either student graphing skills or student attitudes towards computers. However, these results were obtained after only very limited student exposure to the MBL. Student attitudes towards the MBL were positive, and the attitudes of the 24 participating teachers have been overwhelmingly positive.

The greatest assets of the MBL appear to include: real-time graphing, data manipulation, ease-of-use, sturdiness, and accuracy. Implementation is seen as a key to effective use of the MBL. Techniques for classroom utilization have included small groups in rotation, whole class problem-solving, and demonstration. Those

techniques that most directly involve student use of the MBL appear to have the greatest potential for effectiveness.

Introduction

The term microcomputer based laboratory (MBL) refers to the acquisition of data through probes directly interfaced to the computer, an educational application pioneered by the Technical Education Research Center (Tinker, 1987). The term MBL first appeared in the literature in the mid-1980's and has been borrowed from Bross (1986), Tinker (1987) and many others. It has been accepted as an appropriate label for this educational application of the microcomputer.

Most of the studies of the impact of microcomputer-based laboratories have been conducted with middle/junior high school children (Linn, Layman, & Nachmias, 1987; Mokros & Tinker, 1987; Nachmias & Linn, 1987). Fewer have been conducted with high school students (Brasell, 1987; Stuessy & Rowland, 1989).

In this study, the base of knowledge will be expanded to include high school students in a variety of science classrooms. Twenty-four teachers and over 1000 students are participating from 6 school districts throughout Indiana. The purpose of the study is to examine the use of microcomputer-based laboratories in high school science classrooms. Students' and teachers' attitudes towards microcomputer-based laboratories are being examined. Students' graphing performance is being assessed. Observations of classroom use of MBLs are being conducted. It is expected that this study will result in a descriptive analysis of the use of MBLs in the science classroom.

Of additional interest is the use of a large-scale computer network for data sharing, resource acquisition, and school-to-school communications during the project. In Indiana, a large-scale computer network called STEPS, Student and Teachers Electronic Productivity System, has been established as part of a joint study effort called the Electronic School District project. Computer networking has the potential to support interactive and cooperative learning over distances. Indeed, the value of computer networking for scientific problem solving has been demonstrated by the success of National Geographic's Kidsnet project and by the work of Levin et al. (1985, 1987). The use of Indiana's STEPS network in support of this project is also being examined.

Literature Review and Background

Early literature about microcomputer-based laboratories can frequently be found under topics such as laboratory interfacing or microcomputer interfacing. In 1986 Bross examined the emergence of microcomputer-based science laboratories (MBLs). The author saw MBLs as one of the newest and most exciting applications of microcomputers. Bross cited advantages such as student interest, consistency of data collection, instantaneous display of data, computer processing of the data, and ease of data storage. Though some disadvantages were also noted, Bross concluded that the advantages outweighed the disadvantages and the use of MBLs in science classrooms should be promoted.

Mokros and Tinker (1987) reported the status of the Technical Education Research Center's microcomputer-based lab project. This project, a five-year effort, was intended to improve science education by developing curriculum materials that used the computer in the laboratory for real-time data gathering and analysis. The project included two preliminary studies and one longitudinal study. The preliminary studies identified graph-related misconceptions and provided evidence of improved graph interpretation skills through the use of MBLs. A quasi-experimental study was designed to provide more evidence about the impact of MBL on children's graphing skills. The study found that, after three months, scores on the 16 graphing items indicated a significant improvement in students' ability to interpret and use graphs between pre- and post-tests.

Brasell (1987) studied the effect of real-time laboratory graphing on learning graphic representations of distance and velocity in high school physics classes. After controlling for significant covariates, factorial analysis of covariance indicated that overall post-test scores from the standard MBL treatment were significantly higher than scores from all other treatments. Mean scores of treatments indicated that real-time graphing accounted for nearly all (90%) of the improvement within the standard-MBL treatment relative to the control.

Stuessy and Rowland (1989) examined the advantages of microcomputer-based laboratories to determine whether the improvements were due to the electronic data acquisition, computerized graphing or both. The authors used a total of 75 tenth grade students randomly assigned into five treatment groups. The treatment groups varied in the method of measuring temperature and the method of graphing. The students who used the real-time MBL scored significantly higher that students who used non-computer data acquisition techniques.

Linn, Layman, and Nachmias (1987) examined the chain of cognitive accomplishments of microcomputer-based laboratories in graphing skills development. Based on the results, the authors concluded that the microcomputer-based laboratory is effective in teaching students about graphing. The MBL improved students' ability to identify graph trends and extract meaning of the information presented.

Researchers have indicated that microcomputer-based laboratories are effective tools for teaching students to understand and interpret graphs. Much of the initial work has concentrated on middle school students, with relatively little done in high school or college. This project seeks to broaden the knowledge base on MBLs by examining their use by high school teachers and students in a variety of science classrooms.

Computer networking has also shown promise in encouraging scientific problem-solving over distances. In a discussion of technology-mediated interactive learning, Dede (1990) pointed out that computer-supported cooperative distance learning can transcend barriers of time and space, foster the development of shared mental models, build social interactions, and promote emotional and maturational shifts in students.

Cohen and Riel (1989) found that students who wrote compositions for peer communication over a computer network wrote better and more complete compositions than students who wrote for teacher evaluation. Apparently, the genuine social context of writing for peers induced better performance than the incentive of writing for a grade. Levin, Riel, Miyake, and Cohen (1987) also pointed out the benefits of social and cultural context that accrue from electronic networks. They found that students in different cultural settings learned and solved problems via an apprenticeship model by interacting electronically with other students, teachers, and other adults.

The notion of providing students with a context for their efforts fits well with the growing Science Technology Society (STS) movement in the science education community. The primary thrust of this movement is to emphasize rigorous study of social problems and the development of students' critical thinking skills for effective participation in society (Hart and Robottom, 1990). Levin and Cohen (1985) have argued that electronic networking provides an excellent vehicle for scientific problem-solving. Indeed, the success of National Geographic's Kidsnet project demonstrates that electronic networking can promote real scientific inquiry in a social context.

The project reported herein makes use of a large-scale computer network called STEPS that was established as part of the Electronic School District project in Indiana. The schools involved in the project all have direct connections to the STEPS computer system. In addition to the use of MBLs, this project is examining the use of the STEPS network for communications, resource acquisition, and data sharing.

Method and Materials

This study uses six sites participating in the STEPS for Better Science grant. Each site was selected on the basis of previous participation in the Electronic School District project, a joint study of large-scale computer networking supported by Purdue and Indiana Universities, the Indiana Department of Education, and IBM Corporation. The Electronic School District project led to the development of a large-scale computer network in Indiana linking K-12 schools and universities. The STEPS (Student and Teachers Electronic Productivity System) network supports electronic messaging (both inside and outside of the STEPS system) and computer conferences on a variety of topics. At present, science related conferences on the STEPS network include physics, biology, chemistry, earth science, and weather. In addition, via electronic messaging, students and teachers can contact resources such as the Indianapolis Zoo, Indiana Geologic Survey, NASA, and scientists in area firms.

Each school site is equipped with a laboratory of IBM PS/2 microcomputers and is connected via dedicated telephone lines to the STEPS computer network. The sites are geographically diverse and include large and small high schools in both urban and rural settings. As such, they represent a sufficiently representative sample of the state to serve as a rich source for exploratory data analysis.

A total of twenty four teachers, an average of four per site, are participating in the project. The participating teachers include 13 men and 6 women; they have an average of 13 years of teaching experience. Twenty-one of the teachers are science teachers representing subject areas including physics, chemistry, biology, earth/space science, and physical science. The remaining three teachers are computer or media specialists. The student population, those students enrolled in the classes of the participating teachers, number over 1000 ninth through twelfth graders.

During the preliminary phase of the project, summer of 1990, the participating teachers were given training in: (1) basics of the use of IBM's PS/2 microcomputer system, (2) use of the STEPS computer network, and (3) use of IBM's Personal Science Laboratory, a microcomputer-based laboratory system. Participating teacher evaluations of the training sessions, using a 10 item questionnaire of Likert-type construction, had a mean rating of 47.8 out of a possible 50. This suggests the training was appropriate to the needs of the teachers.

Primary emphasis in the training was placed on the STEPS computer network and the Personal Science Laboratory (PSL). The PSL is one of the newest MBLs available to schools. Each site was provided with one PSL unit equipped with temperature, pH, light, and motion probes. The software provided with the PSL, originally developed by the Technical Education Research Center, provides sophisticated data handling and real-time graphing capability (Campbell & Lehman, 1991).

Subsequent to the training, each team of teachers developed units of instruction incorporating MBL data acquisition and/or the use of the STEPS network for data sharing among school sites. The units deal with the following topics: weather prediction, kinematic graphs, Galileo's inclined ramp experiment, angle of the sun's rays, pH of potable water, pH and plant growth, and acid rain. These instructional units are being implemented and their use evaluated during the 1990-91 school year. The instructional units are available upon request from the authors.

Due to the nature of the study, the environmental conditions and interactions cannot be held constant. Rather, the environments and interactions are being taken into account while attempting to assess the use of microcomputer based laboratories and networking in the science classrooms. The intent of this study is to provide a description of the use of MBL's and computer networking in "normal" classroom settings. Conclusions are derived from a triangulation of numeric data, attitude surveys, and classroom observations.

The study is examining four areas: the school, the teacher, the student, and the use of the MBL and/or computer network. Information collected includes basic demographic school data, teacher attitudes, student attitudes, student performance on graphing, and classroom observations of MBL use.

Teachers attitudes toward project are being assessed via a 20 item Likert-style questionnaire developed by the authors as well as by personal interviews. Student attitudes toward computer are being assessed via a 20 item Likert-style questionnaire adapted from the work of Anderson, Hansen, Johnson, and Klassen (1979). Individual items are scored from one to five points, and item scores are summed to yield an overall attitudes score of 20 (negative attitudes) to 100 (positive attitudes). Previous work with the measure has yielded a reliability of 0.82 for the instrument. Student attitudes towards the instructional activities are being assessed using a 10 item Likert-style questionnaire developed by the authors. Means for individual items will be examined; in addition, items are being scored and summed as with the computer instrument t- yield an overall student activity rating of 10 (negative) to 50 (positive).

Students' graphing skills are being assessed using the Test of Graphing in Science (McKenzie & Padilla, 1986). This instrument, designed for students in grades 7-12, measures students' abilities to construct and interpret line graphs. Scores on the Test of Graphing in Science (TOGS) can range from 0 to 26. The developers have reported a reliability of 0.83 for the test.

Classroom observations of the instructional activities are also being conducted. The observations serve to provide a qualitative description of the use of the project activities in the classroom. The project is continuing through May of 1991; therefore, data reported herein must be considered very preliminary only.

Results and Discussion

As of this writing, only a very small portion of the project activities have been completed. Project activities are on-going in all of the cooperating schools and will not be completed until May of 1991. Observations have been conducted in several classrooms, and cooperating teachers have reported on additional activities involving the use of the MBLs. However, complete pre- and post-test data from the quantitative instruments have been obtained from only a single classroom thus far. These data are reported in Table 1 below.

Table 1. Summary of Quantitative Measures

Measure	n	Mean	S.D.	df	t	Prob
Graphing						
TOGS Pretest	18	23.28	1.81			
TOGS Posttest	18	23.17	2.46	17	0.23	0.819
Computer Attitudes						
Pretest	18	75.11	8.88			
Posttest	18	72.61	8.35	17	1.84	0.083
Activity Attitudes						
Posttest	20	34.65	4.61			

Mean scores on the Test of Graphing in Science (TOGS) pretest were over 23 out of a possible 26. Mean posttest scores were nearly identical to the pretest. Mean attitudes towards computers were 75.11 for the pretest and 72.61 for the posttest. Paired samples t-tests were used to compare pre- and posttest means for the TOGS instrument and the computer attitude scale. No significant differences were observed at the 0.05 alpha level.

In the case of the particular class involved, the lack of any discernable impact of project activities is not surprising. The class in question was a high school physics class. Students entered with relatively high graphing skills and high attitudes towards computers. In addition, for this class, the period of project activities was limited to only a few weeks because the way the school schedules its classes. During that period, only a single complete activity with the MBL was conducted. Therefore, these data are neither unexpected nor particularly useful in examining the impact of the project's activities.

Student and teacher reactions to the MBL, as well as observations of classes to date, have provided information of greater utility. The mean rating of attitudes towards the activity from the one class reporting thus far was 34.65, somewhat positive. In observations of classes, many of the students that have commented about the use of the MBL to date have been very positive. Those students who have been less positive, for the most part, seem to be those students who have had relatively little exposure to the MBL, either through lack of opportunity or lack of interest.

The participating teachers have been universal in their interest in and enthusiasm for the MBL. Each of the teachers has been anxious to incorporate use of the MBL into science laboratory activities. As of this writing, two of the project schools have committed to acquiring additional MBLs for the science department. Several obvious advantages to the MBL have emerged from discussions with the participating teachers. These include:

- real-time graphing capability
- data manipulation capability
- ease-of-use
- sturdiness
- accuracy

To a considerable degree, these advantages seem to accrue from the construction of the Personal Science Laboratory MBL and the software associated with it, although other systems may function as well. The PSL software provides a relatively simple, menu-driven system with considerable capability. Velocity data from a physics experiment, for example, can easily be transformed to yield acceleration. Several of the teachers have remarked about the high degree of accuracy possible with the MBL. One class of students, puzzled by a persistent dip in a velocity graph, discovered that the ramp being used for the experiment was warped. In another, the accuracy of measurements permitted straightforward derivation of frictional forces.

The primary difficulties that have been encountered thus far relate to the implementation of the MBL activities in the classroom. Each school received only a single PSL unit for a team of science teachers. Therefore, utilization of a scarce resource has been a concern from the outset. In at least one instance, friction developed among teachers within the school about who would have access to a computer to operate the PSL.

Several different models of use have been employed by the participating teachers. The most commonly used technique is to divide classes of students into small groups and to permit access to the MBL on a rotation basis. Other teachers have adopted a whole-class approach in which the MBL becomes the focus of a cooperative laboratory investigation. Still other teachers have used the MBL as a demonstration tool. In some classes, the students appear to be quite comfortable with the MBL and its operation. In others, it is clear that only a select group of students is actually familiar with unit.

Although the information obtained thus far is very preliminary, it is already becoming clear that the manner of implementation may have a major impact on the effectiveness of the MBL. Unlike the carefully controlled studies that have established the utility of MBLs, this project has taken the approach of examining "real-world" use of the tool complete with the sorts of limitations often found in actual classrooms. It seems likely that use of the MBL will have little if any impact in situations where few students are actually able to work with the equipment. Rather, it is our expectation from our observations thus far, that the MBL will only prove to be effective when the students, through rotation or a similar mechanism, get ample opportunity for hands-on work with the unit.

The use of the STEPS computer network to date has been very limited. The primary use of the network has been for electronic mail communication among the participating teachers and the project's staff. Student use of the network as part of this project has been very limited, although there has been considerable student traffic on the network associated with other projects. Although shared data experiments are planned for the future, none has yet been conducted. The primary obstacle to the use of the network appears to be access. While each school has dedicated connections to the network, only one school has a computer capable of network access in the science office. So, it has proven problematic for the participating teachers to incorporate network usage into their classes.

New technologies offer a great deal of promise for science education. MBLs have been shown to be effective in promoting students' graphing skills. Early experiments with computer networking in science have shown considerable promise. However, classroom reality often inhibits potential. Effective implementation is a key to the successful infusion of any new innovation in the classroom. We must better understand the implementation of innovation if we are to successfully realize the promise inherent in these new technologies.

Bibliography

Anderson, R. E., Hansen, T. P., Johnson, D. C., & Klassen, D. L. (1979). Minnesota computer literacy and awareness assessment. St. Paul, Minnesota: Minnesota Educational Computing Consortium.

Brasell, H. (1987). The effect of real-time laboratory graphing on learning graphic representations of distance and velocity. Journal of Research in Science Teaching, 24(4), 385-395.

Bross, T. R. (1986). The microcomputer-based science laboratory. Journal of Computers in Mathematics and Science Teaching, 5(3), 16-18.

Campbell, J. P. & Lehman, J. D. (1991). Detecting data with the personal science lab. Science Scope, 14(6), S19-S20.

Cohen, M. & Riel, M. (1989). The effect of distant audiences on students' writing. American Educational Research Journal, 26(2), 143-159.

Dede, C. J. (1990). The evolution of distance learning: Technology-mediated interactive learning. Journal of Research on Computing in Education, 22(3), 247-264.

Hart, E. P. & Robottom, I. M. (1990). The science-technology-society movement: A critique of the reform process. Journal of Research in Science Teaching, 27(6), 575-588.

Levin, J. A. & Cohen, M. (1985). The world as an international science laboratory: Electronic networks for science instruction and problem solving. The Journal of Computers in Mathematics and Science Teaching, 4(4), 33-35.

Levin, J. A., Riel, M., Miyake, N., & Cohen, M. (1987). Education on the electronic frontier: Teleapprentices in globally distributed educational contexts. Contemporary Educational Psychology, 12, 254-260.

Linn, M. C., Layman J. W., & Nachmias R. (1987). Cognitive consequences of microcomputer based laboratories: Graphing skills development. Contemporary Educational Psychology, 12, 244-253.

McKenzie, D. L. & Padilla, M. J. (1986). The construction and validation of the test of graphing in science (TOGS). Journal of Research in Science Teaching, 23, 571-579.

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.

Nachmias, R. & Linn, M. C. (1987). Evaluations of science laboratory data: The role of computer presented information. Journal of Research in Science Teaching, 24, 491-506.

Stuessy, C. L. & Rowland, P. M. (1989). Advantages of micro-based labs: Electronic data acquisition, computerized graphing, or both? Journal of Computers in Mathematics and Science Teaching, 8(3), 18-21.

. ıker, R. F. (1987). Educational technology and the future of science education. School Science and Mathematics, 87, 466-476.