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ABSTRACT

This paper describes an inservice project designed by The Johns Hopkins University and the Baltimore City Public School System to help teachers acquire the skills necessary to effectively integrate computer technology into science instruction. From 1986 to 1988 the project was implemented in the large urban Baltimore school system with 100 teachers who ranged in computer literacy from novice to experienced user. Components of the inservice design included teacher training, acquisition of hardware and software, development of model lessons, and the establishment of an extensive and diverse support system. The nature and extent of implementation of that training is currently being evaluated. Project staff are closely monitoring both personal and classroom use of the computer by those trained. Preliminary results indicate that 90% of trained teachers are using computers to manage instruction, and 75% are using computers in their science classrooms. Included are the classroom observation form and the computer usage questionnaire. (Author/MVL)

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COMPUTERS TO ENHANCE SCIENCE EDUCATION

An Inservice Designed to Foster Classroom Implementation

by

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This paper describes an inservice project designed by The Johns Hopkins University and the Baltimore City Public School System to help teachers acquire the skills necessary to effectively integrate computer technology into science instruction. From 1986 to 1988 the project was implemented in the large urban Baltimore school system with one hundred teachers who ranged in computer literacy from novice to experienced user. Components of the inservice design included teacher training, acquisition of hardware and software, development of model lessons, and the establishment of an extensive and diverse support system. The nature and extent of implementation of that training is currently being evaluated. Project staff are closely monitoring both personal and classroom use of the computer by those trained. Preliminary results indicate that 90% of trained teachers are using computers to manage instruction, and 75% are using computers in their science classrooms. The project is supported by funds from the National Science Foundation and the Maryland State Board for Higher Education; hardware for project participants was provided by the Apple Foundation and the National Cristina Foundation.

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INTRODUCTION

There is a critical need to introduce students to the use and power of computer technology. This is particularly true in science instruction where students are often confronted with large amounts of data to process. Aided by the computer which collects and organizes data, students are free to manipulate that data to search for relationships. Computer education effectively integrated into the science curriculum reveals to students the potential of the computer as a powerful tool to both process information and probe their environment.

There is considerable evidence which indicates that this need is not being met. Becker concluded from his 1985 National Survey (1987, p.1) that "apart from arithmetic drills, very little school computer use is for mathematics and science instruction." The 1986 National Assessment of Educational Progress (NAEP) report entitled Computer Competence: The First National Assessment concluded that "computers appear to be making little headway in subject-matter areas . . . about 85 percent of students have never used computers in science." (LaPointe & Martinez, 1988, p. 60).

Urban youngsters are the most likely to miss out on the excitement of computer learning. They make their way to poorer schools from neighborhoods that are typically at the lower end of the socioeconomic scale. In a recent report on the financial condition of the Baltimore City Public Schools (Abell Foundation, 1989) it was revealed that "Of [Maryland's] 24 subdivisions, Baltimore city ranks twenty-second in dollars spent per pupil...This gap in spending per pupil manifests itself in...the amount of computers and other educational aides a system is able to purchase." Not only are their schools sorely deficient in technology, but they are also much less likely to have access to computers at home. According to the NAEP report (LaPointe and Martinez, 1988, p. 60) "students who have access to computers in school and at home stand a better chance of developing computer skills than do their not-so-advantaged peers." Consequently, the need to integrate technology into urban classrooms is all the more imperative.

For technology to produce the kinds of changes in education that it is producing elsewhere, it must become a tool in the hands of teachers. In this area as well, urban school systems lag considerably behind their more affluent suburban neighbors. When this project was conceived in 1985, science teachers in Baltimore City had essentially no computers to use in their classrooms and little access to the limited number of computers in their schools (French & Smith, 1985). There had been no formal staff development in computer instruction that provided for the specific needs of science teachers, and the small number of science teachers who were computer literate and had access to machines often lacked the time and expertise to incorporate computer technology into lesson planning.

Project staff acknowledged from the start that "learning to use computers as educational tools was a very complex task, perhaps more complex than is normally associated with inservice training" (Educational Testing Service Report, 1987, p. 2). They recognized that classroom integration requires knowledge of the new technology, comfort with its management and use, models for its integration into science instruction, and continued support to sustain such integration. Appreciating the enormity of the task being undertaken, The Johns Hopkins University and the Baltimore City Public School System established a partnership to prepare teachers, acquire hardware and software, develop lessons, and facilitate effective computer use in science classrooms. This paper describes the Johns Hopkins/Baltimore City Schools inservice program for science teachers, identifies the components that we think contributed to its effectiveness, and reports on the progress of classroom implementation.

METHODS

During a three-year period, 100 teachers (40 high school, 40 middle school, and 20 elementary) were trained in groups of 20. Teachers were selected to participate based on the following criteria:

a. demonstrated competency rating of satisfactory to superior in content and methods of science teaching as evidenced by both informal observations and yearly evaluations,
b. demonstrated interest in professional growth by participation in inservice workshops, graduate courses, attendance, and/or presentations at local, state, and national science education conferences,
c. demonstrated effort to keep abreast of issues, opportunities, and ideas by reading professional science and educational journals (teacher conferences reveal the level of awareness),
d. potential for success in the program (level of interest, record of participation in other inservice offerings, support by school administrators),
e. female/minority composition when considered with other qualifications,
f. experience, when considered with other qualifications.

The instructional model was designed to foster maximum reinforcement of newly learned skills. Each training workshop consisted of twelve sessions which were held bimonthly during one semester of the school year. Session topics are found in Appendix A. Each full-day session coupled instruction with supervised practice and was followed up with homework assignments and a brief review at the start of the next meeting day. Teachers were released from their regular classroom responsibilities, and money to hire substitutes was provided. When possible, two teachers were selected from the same school to provide peer support during training and to act as the first level of support in subsequent integration of acquired skills into classroom instruction. An Apple computer was provided to each school so that between sessions teachers could complete assignments, practice skills, and begin to incorporate those skills into classroom instruction. Each teacher was required to develop two detailed lesson plans that demonstrated effective computer use in science instruction, one employing a data base or spreadsheet and the other using an interface device. They presented these lessons first to their peers and then to a statewide audience at a final conference.

Two private foundations were asked to provide hardware for project participants. The Cristina Foundation provided 70 Apple II+ computer systems (CPU, monitor, disk drives, printer), and the Apple Foundation donated 10 Apple IIe systems so that all of the participants could have exclusive use of a computer. Two teachers trained in the project later submitted a grant proposal to the Apple Foundation. The grant award received in August 1988 equipped the science department at their school with an Apple laboratory to support the department-wide integration of technology and to serve as a model for the school system. Teachers at two additional schools have submitted Apple Equipment grant applications which are pending.

Funds to purchase software were provided by grants from the National Science Foundation and the Maryland State Board for Higher Education. Each participating school received the Appleworks application software for word processing, data base, and spreadsheet use and a variety of probeware for interfacing. A circulating software collection was also purchased and is managed by a users' group that was organized through the project.

The availability of model lessons that are teacher-tested and proven to be successful is essential to the diffusion of computer-based instruction across the larger population of Baltimore city science teachers. The lessons developed by teachers during training were made available for use in classrooms. During summer curriculum development workshops, these lessons were reviewed, and some were tested, edited, and expanded. New lessons were produced to broaden the scope of curriculum applications available to teachers. During the summer of 1987, fifteen trained middle and high school teachers compiled over one hundred lessons; during the summer of 1988, six of the trained elementary and middle school teachers compiled over fifty lessons. These are available in draft form on diskettes as Appleworks files. In the fall of 1987, lessons were distributed with an evaluation form that solicited information which could be used to modify and further adapt the lessons for classroom use.

Project planners established mechanisms to support the lengthy process of integrating computer use into science instruction. They recognized from the start that without this support, the application of the computer training to the science curriculum was unlikely to occur. To assume that training would automatically be reflected in classroom practice would risk losing the potential benefits of the project. Support mechanisms were extensive and diverse:

- The training phase provided opportunities for practice with feedback, based on research that shows that adoption of school innovations increases by more than 50 percent when the inservice design includes both practice and coaching (Baker & Showers, 1984). Training two teachers from the same school provided peer support during training and encouraged the use of coaching techniques at their home school.

- Twenty out of the 100 trainees were chosen to participate in leadership training workshops. They were selected for this additional training based on their demonstrated competence with and enthusiasm for computers as well as the practical need to have leaders distributed among as many schools as possible. The workshops included using peer coaching, developing software evaluation techniques, developing exemplary lesson plans, and discussing ways to connect computer training to other innovations the school system advocates for science instruction. Leaders would then be equipped and positioned to assist the larger collection of trained teachers.

- A support coordinator, a Baltimore city science department head who was acknowledged to be both a master teacher and a computer expert, was released from teaching duties one day each week. This enabled him to visit classrooms of newly trained teachers to demonstrate and/ or assist with computer-based science lessons. His recent promotion to Baltimore City Science Specialist has enabled him to continue to provide this support.

- Science supervisors from the Baltimore City Office of Science and Health participated in training to assure their understanding not only of the power of computer technology but also of the complexities of integration. By completing the project assignments, science supervisors prepared themselves to assist teachers in their attempts to integrate computers into science. Moreover, supervisors already familiar with other school system innovations could demonstrate the link between computer training and other inservice topics. To this end, an instructional unit entitled "Low Birth Weight Babies" was developed. It modeled use of computer data bases, explicit teaching of thinking skills and elements of cooperative learning.

- The training schedule laid the foundation for the development of two courses so that other science teachers could receive instruction in computer use. One course, "Using Computers in the Secondary Science Curriculum," was offered for graduate credit in the Johns Hopkins 1987 and 1988 summer sessions and will again be offered in summer, 1989. To date 27 teachers have completed the course; 6 of them teach in Baltimore City Public Schools. A second course, offered for Maryland State Department of Education inservice credit, is available this spring to interested Maryland science teachers.

- A Maryland computers in science users' group (MUGS) was formed to disseminate computer-based lessons and to support the integration efforts of all trained teachers. The group publishes a quarterly newsletter that is distributed to over 200 members. Baltimore members plan and implement presentations at local, regional and national meetings.

Classroom application of computer training was initially investigated through direct observations and questionnaires. In the 1987-1988 school year, plans were made to observe lessons in the classrooms of the 16 public school teachers who had completed training. The form developed for these observations is found in Appendix B. Teachers had been familiarized with the form during the training workshop when lessons were presented. To underscore the intent of the observation as evaluation of computer use and not of the teacher, teachers chose the date and type of lesson to be presented for observation. Prior to the visit teachers reviewed the observation form, and following each observation teachers discussed the lesson evaluation with the observer. In April 1988 and again in January 1989, a questionnaire (Appendix C) was mailed to each trained teacher to examine the extent and nature of computer use and to survey school conditions which might encourage or discourage its use. The questionnaire inquired about the availability of hardware, software, and lesson plans. It asked participants to evaluate their training and several components of follow-up support. Finally, it sought information about the type and frequency of computer use by trained teachers both in classrooms and in the management of instruction. It differentiated between use for managing instruction (e.g. word processing, using spreadsheets to tabulate grades), and instructional use (e.g. using laboratory probeware or data base lessons in class).

RESULTS

Teachers Trained

Five training workshops were held between 1986-1988. Out of 100 teachers chosen to participate in training, 91 (74 secondary and 17 elementary) actually completed the training and presented projects. 71 out of the 91 currently teach in Baltimore City Public Schools; 12 teach in archdiocesan schools; 3 now teach in suburban public schools; 3 left teaching for other jobs or retirement; and 2 were promoted to administrative positions.

Data collected from the application forms indicated that public school participants were seasoned classroom teachers with little prior experience in the instructional use of computers. Nearly 90% had taught for 10 or more years and had earned a masters degree or the equivalent. All had earned a competency rating of satisfactory to superior during their past two years in the classroom. Two thirds of teachers trained were female, and nearly half were minorities. Between 50-60% of the secondary teachers belonged to professional science teacher organizations, although their level of participation varied from infrequently attending meetings to regularly attending and presenting. The lower (31%) participation of elementary teachers in professional science teacher associations may reflect the fact that they are responsible for teaching most subjects, not just science. Some of these elementary teachers listed participation in mathematics conferences. All teachers selected had applied to participate, indicating a high level of interest on their part as well as on the part of their building principal who had agreed to release them from twelve full days of class. Their prior experience with computers varied considerably with most reporting limited exposure via brief workshops using the Radio Shack TRS80 or with Basic Programming classes. Less than 10% had used Apple computers. The only reported instructional use of computers was with commercial drill and practice software.

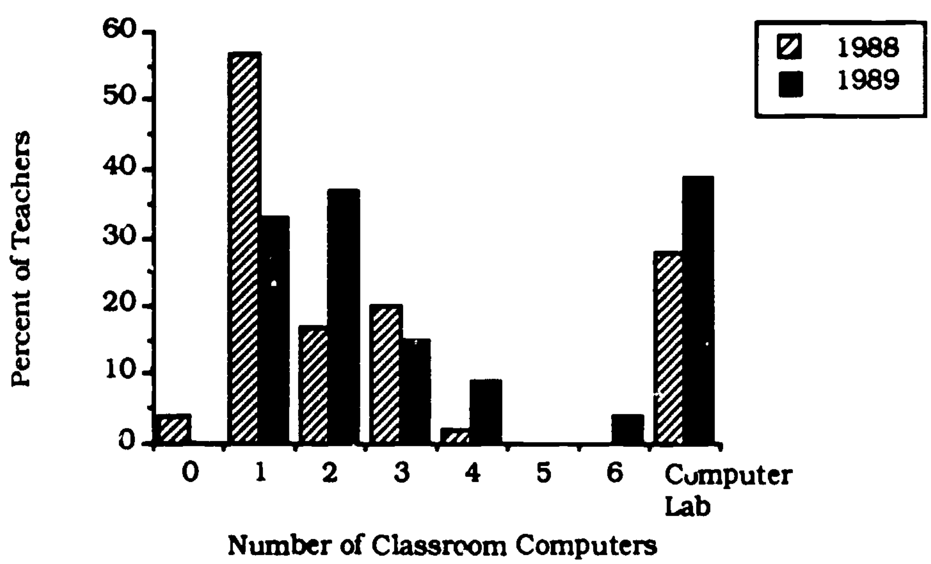
Leaders Trained

Twenty-one teachers (eight middle school and thirteen high school) participated in the additional leadership training workshops. As a consequence of reassignment of some teachers to other schools, these leaders are now distributed among seventeen secondary schools.

The eighty Apple II computers obtained from private foundations were distributed among secondary school participants. This guaranteed a computer in each participant's classroom. Elementary school participants already had access to school computers. The Apple Foundation donated ten Apple IIe computers, and the National Cristina Foundation donated seventy Apple II+ computers. This made it possible for each trainee to have the exclusive use of a computer for instructional planning and classroom use. Computer carts, constructed by a Baltimore city vocational school, increased the mobility of the computers. Thus, in the schools with two participants (and hence two computers) certain lessons could take advantage of two computers. Through a variety of sources such as PTA fundraising events, principal's discretionary funds, building renovation monies, and grants from local businesses, additional computers became available to some of the trainees. The Apple Foundation also awarded a computer laboratory to Baltimore City's Western High School for exclusive use in science instruction.

Results of the 1988 and preliminary results of the 1989 questionnaires are shown in Fig. 1. As shown, all teachers report having access to at least one computer, and 65% report having access to two or more computers. The percent of teachers reporting access to three or more computers has increased from 22 to 28%. As compared to 28% of teachers in 1988, 39% of teachers now report having access to an Apple computer laboratory. 60% of teachers indicate that they own a compatible computer at home, and about half of them purchased computers as a result of their participation in this project.

Figure 1. Access to Computers, 1988 - 1989



Software Acquired

Each participant received the Appleworks application package which includes software for word processing, data base and spreadsheet. They also were given two sets of laboratory probeware: one resembling the American Association for Physics Teachers probeware was constructed during training; the other, a commercial probeware package, was purchased. This "starter set" permitted teachers to use nearly all of the lessons developed during training as well as during the summer workshops. The Baltimore City Public Schools owns a site license for the Minnesota Educational Computer Consortium (MECC) software. Each participant was encouraged to copy relevant software. In addition, a circulating software collection was purchased with grant funds. The software collection, housed at Western High School's Apple Science Laboratory, contains over 100 items that are available to all teachers upon request. All software included in the collection was identified and evaluated by trained teachers.

Curriculum Developed

Over 200 lesson plans demonstrating computer use in science instruction were developed. Each lesson plan followed the existing lesson plan format developed by the Baltimore City Office of Science and Health, i.e. statement of lesson objectives, motivational activity, procedures, assessment, and assignments. Lessons encompassed all science curriculum areas for grades 3-12 with a predominance in secondary courses. These lessons were distributed to all project participants and have been made available to other interested teachers through the MUGS organization.

Use of Computers in Classroom Management and Instruction

During the fall of 1987, 8 lessons were observed in the classrooms of the high school teachers trained in 1986. Two of these will be described, because they represent the two ends of the spectrum of sophistication of computer application. The first lesson involved small groups of students taking turns using a mineral identification program to check the mineral identifications they had made using standard laboratory procedures. This was not one of the lessons which had been developed through the project. Students experienced some difficulty arriving at the same answer through the two different procedures, and the computer program did not help them to determine the source of their errors. The teacher did not help students to reconcile having obtained two different identifications for the same mineral. A second lesson observed involved the use of a light probe to monitor pulse rate. After pairs of students determined resting pulse rates using conventional means (using fingertips to measure and then counting the number of pulses between two time intervals), one student was chosen to demonstrate the effect of exercise on pulse rate as measured with the light probe. As other students watched, the volunteer first obtained a resting pulse rate, which the software graphed in real time for all to see. Then, he exercised vigorously and repeated the pulse measurement. The teacher then discussed with students not only the effect of exercise on pulse rate but also the advantages of using the computer for collecting data. Students commented that the use of technology allowed them to collect data immediately following exercise, whereas the traditional method required that they settle down, extend their wrist, find the pulse, and begin counting, all of which took a few seconds. When one student suggested that the computer would give more reproducible results, the teacher asked the class to figure out a way to test the suggestion. In all lessons observed, students were eager to use the computer. Attention to the lesson and actual time on task was high. A large percentage of students volunteered to answer teacher questions, raised questions of their own and conversed with peers about possible answers.

As the numbers of teachers who had completed training increased, it became impractical to assess classroom use by direct observation. The project staff and leaders developed the Usage Questionnaire. Of the 45 public school participants who were trained in 1986 and 1987 and still teach in Baltimore, 33 (74%) completed the 1988 questionnaire. This group included 10 teachers trained in 1986 and 23 teachers trained in 1987. Preliminary results of the 1989 questionnaire include responses from 46 out of the 59 (78%) of the secondary school teachers trained in 1986-1988. Results of the April 1988 and preliminary results of the 1989 Usage Questionnaires are given in Figs. 2 through 4. As shown in Fig. 2, more than 80% of the 1988 respondents reported using the computer one or more hours per week, and over 50% reported using it six or more hours per week for managing instruction (primarily word processing and keeping student records). Less than 20% reported no use of the computer to manage instruction. Preliminary results of the January 1989 questionnaire suggest that computer use for instructional management has increased; 90% now report using the computer for managing instruction.

Data collected about 1988 classroom computer use is shown in Fig. 3. As shown, about 35% of teachers reported using probeware in one to five lessons, and another 35% reported using probeware in six or more lessons, totaling nearly 75% who reported using probeware in classroom instruction. Similarly, 75% reported using at least one data base lesson with students, but only 17% reported using data bases six or more times. As with probeware, about 25% reported not using data base lessons with students. Also shown is the reported use of commercial software. Commercial software includes MECC software, simulations and games, and software accompanying textbooks. Generally, no lesson plans were specifically written

Figure 2. Computer Usage: Instructional Management 1988-1989

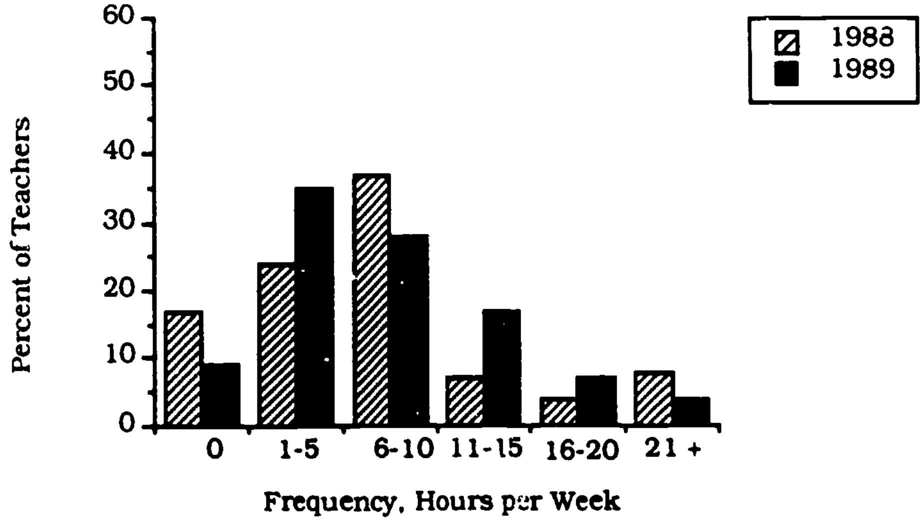
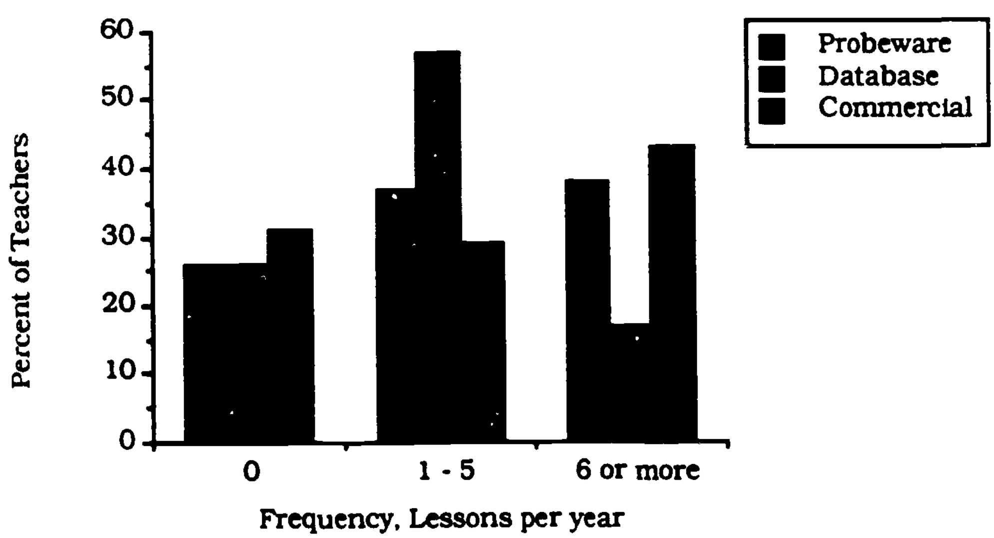


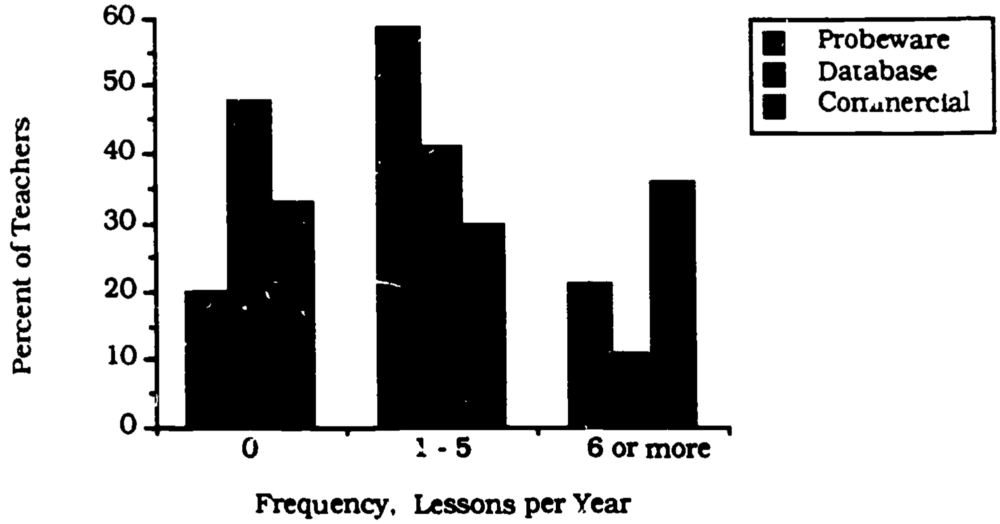
Figure 3. Classroom Computer Use, 1988



which incorporate this software. As shown in Fig. 3, 70% reported using commercial software at least once, and 40% reported using it six or more times.

Preliminary results of the January 1989 questionnaire are shown in Fig. 4. As shown, about 20% of teachers report no use of laboratory probeware; and about 50% report no classroom use of data bases. It should be emphasized that the 1989 data reflect classroom computer use in a 5 month period, while

Figure 4. Classroom Computer Use, 1989



the 1988 data reflect use over 8 months. Hence, any attempt to compare the two graphs should keep that difference in mind.

Data was also collected about efforts of project participants to disseminate outcomes of the project, particularly through demonstration of computer-based lessons. It is noteworthy that 80 percent of those teachers trained in 1986 and 1987 reported making presentations of computer lessons either at local, regional or national meetings and/or to groups of teachers at their own schools. This presence of trained teachers and accessibility of computers at their own school so sparked the interest of other science teachers in the participants' schools, that several of them have independently taken computer classes. Six took the Johns Hopkins course which was modeled after this project.

DISCUSSION

Trained Teachers

The "Computers to Enhance Science Education" project was designed to bring learning technologies to an entire system by training as many of the best teachers as possible from as many different schools as possible. It did not limit selection to those teachers who already had computer expertise or to those who had access to computers. While this resulted in selection of participants with a wide range of computer skills, few had any experience in the instructional applications of computers. The project actively recruited and succeeded in attracting a significant number of women and minorities. The fact that the majority of teachers chosen clustered around 10-15 years of teaching experience increased the chances that the impact of their training on the Baltimore City science program would continue. Where possible, project staff sought to exclude from participation those teachers who were too close to retirement and those who had less than 5 years of teaching experience. Members of the former group could leave teaching without having shared their computer training with students or colleagues; members of the latter group were more likely to be hired away to better paying suburban school systems. It appears to have been a wise decision: only 4% have left Baltimore for other systems or through retirement. Throughout training and developing of lessons for conference presentations, the groups of trainees met and in many cases surpassed the expectations of the project selection committee. These teachers were highly motivated, effective classroom teachers who willingly accepted the challenge of learning a new technology.

A second intent of the project was training a cadre of teachers capable of both using the hardware and appreciating the value of its use in science. The training program always reinforced this purpose by focusing on instructional uses as much as on the personal and managerial benefits of computer use. The project attempted to involve as many schools as possible within the constraints of the inservice design (selecting two teachers from each school). The extent to which training was shared seems to be influenced by two factors: the number of computers available to science teachers and the confidence and enthusiasm of the trained staff assigned to that school. In schools where both of these conditions were met, additional staff sought training and made use of computers. In some schools, as many as three additional staff members have been trained.

Leaders

The decision to train a subset of project teachers as leaders was based on two perceived needs. First, the school system had limited staff available to respond to teachers' requests for help with areas ranging from hardware problems to homework assignments. Leaders with knowledge and experience in these areas could provide more immediate service to teachers experiencing difficulty both during and subsequent to training. Second, a need existed to relate computer training to other school system innovations. To that end, a group of leaders who had already been exposed to other instructional strategies that could be complemented and strengthened by effective computer use would assist the larger group of teachers in making these connections. For example, the potential power of data base lessons to enhance students' awareness of the processing of information connected very naturally with the school system's emphasis on students' reflection and articulation of their own information processing strategies. Leaders trained in the explicit teaching of thinking skills were better able to use the computer to enhance students' awareness of themselves as questioners and problem solvers. Leaders trained in the use of cooperative learning strategies could more creatively incorporate the one or two computers available for use with large classes. In short, leaders would be able to help teachers appreciate and take advantage of the synergistic effects of computer use and other instructional innovations.

Hardware and Software Acquired

Hardware and software acquisition was a critical prerequisite to the training project. The expectation that teachers would complete homework assignments on computers obviously required that they have easy access to machines. Ideally, this would entail having a computer both at school and at home. The purchase of computers by so many of the project participants supports this view. The project provided school computers and arranged for teachers who did not own their own to at least take the school computers home during the summer. This was particularly important for the curriculum developers, but other teachers reported that they used summers to try out ideas.

Software was chosen for its versatility and ease of use by both teachers and students. The Appleworks package was selected for its ability to integrate data bases and spreadsheets with word processed documents. Probeware packages containing heat and light probes were chosen over packages with more specialized probes to give teachers tools to develop the widest possible range of laboratory applications. Science Tool Kit (Broderbund) was the choice for elementary and middle school teachers due to its ease of use and relative indestructibility. Teachers subsequently purchased additional modules developed to accompany this package. High school teachers were given more sophisticated packages such as Experiments in Science (Human Relations Media).

Lessons

The reason for requiring trainees to develop both an interface and a data base lesson was twofold. First, it would force the trainees to consider a range of possible curriculum applications for their training and second, it would provide them firsthand experience with working through the obstacles to such applications. The training sessions included time for teachers to work cooperatively in all phases of lesson development. This time was used differently by teachers according to their learning and planning styles, but opportunity existed for receiving as much support from others as desired.

There is a vast difference between demonstrating acquisition of new skills in written lesson plans and in actual classroom performance. Project staff, acknowledging the need for trainees to practice new skills in low risk settings, allotted time for each pair of trainees to present one lesson to the peer group. In the company of the group with whom they had shared training, teachers "tried out" their lessons, accepted praise and constructive criticism. Usually this resulted in some editing of the lessons prior to their presentation to the larger audience attending the state-wide conference.

Lessons produced during each of the training programs were made available to all trainees. As project staff reviewed these lessons for quality, the need to organize a team to analyze and edit existing lessons became clear. In addition, this team would supplement the lesson file with data base and interface lessons that addressed a broader range of science topics and learning levels. This task was undertaken by summer writing teams composed of trainees who demonstrated either creative approaches to instructional planning, mastery of the array of computer skills taught, or both. These teams reviewed and edited all of the lessons prepared by trainees and developed new lessons to produce the final lesson disks available to teachers upon request. By January of 1989, 90% of trained teachers reported having these lessons. Despite the widespread distribution of the lesson disks, no evaluation forms were returned. Failure to receive necessary feedback on the lessons was one of several factors that motivated the experimental study described below.

Support Systems

Perhaps the strongest component of this extended inservice training effort is the elaborate support network woven into every phase of the program. As a result of the team approach to training, the home schools became extensions of the training process. Supervisors from the Office of Science, now comfortable and enthusiastic about the potential of computers, continue to provide leadership in its curricular integration. The Maryland Users Group is a firmly established network of teachers who are experienced in efforts to incorporate the computer into science instruction. This group is frequently called upon statewide to demonstrate instructional models that have been developed.

Computer Use

Project staff are encouraged by the large numbers of trainees using computers. The result that 90% of trained teachers report using computers to manage instruction indicates that they are comfortable with the technology and convinced that it is a valuable aid to instructional planning. This conclusion is also supported by the fact that so many teachers purchased computers for home use. Certainly teachers' willingness to use computers in instructional planning is an important step in the complex process of integrating computers into classroom instruction.

That so many of the trainees are attempting to use computers with students is also promising. Teachers are beginning to deal with the organizational challenges imposed by having access to a small number of computers. Use of laboratory probeware seems to be preferred to use of data bases. This is interesting given how much extra preparation its use requires. It may be that the lessons which employ probeware fit more naturally into the curriculum than the data base lessons. Teachers have a degree of comfort with certain traditional laboratory activities that easily accommodate use of the computer as a data collecting instrument. Also, we observed a high level of student enthusiasm and involvement when probeware was used. This provides sufficient incentive for the teacher to spend the extra time. Since we observed no data base lessons presented during site visits to classrooms, we cannot comment on the level of student interest generated by this computer application. We must confess that the data base lessons generated during training do not match the quality of lessons employing probeware. These data base lessons represent more artificial additions to the curriculum and hence may be more cumbersome to use. While teachers were enthusiastic about the creative application of data bases demonstrated by the science supervisors' lesson, few of the developed data base lessons effectively enhanced instruction. In addition, the use of data base lessons required more in the way of altered instructional strategies than did the probeware use. We cannot comment on the significance of classroom use of commercial software, since teachers failed to specify the name of the software being used. The circulating software collection contains several award winning simulations and games, but teachers also have access to commercial software that may not be of as high quality.

It was troubling that in filling out the questionnaire, teachers frequently left blank the question that asked them to give the titles of computer lessons used. Only two included specific computer-based lesson plans as was requested. If teachers were using the lessons on disk, it would not have required much effort to print them out. We suspected that teachers were not taking advantage of the many lessons developed through the project. Our expectation that these lessons would become a significant support for teachers who were attempting to integrate the computer into science instruction appeared not to occur. One reason for the slow integration of already developed lessons became obvious in the implementation study currently being conducted. Teachers were initially unaware of the wealth of lessons available to them even though they reported that they "had the disks." We underestimated the amount of time an individual teacher has to spend in identifying, reviewing, and adapting a given lesson to a particular set of circumstances. The adage that one teacher's lesson plan cannot be lifted intact for another teacher's class is proving to be true.

Results of the questionnaire raised new questions that are currently being investigated. An experimental study that examines the effect of lesson practice sessions on the extent of lesson use is in progress. From October 1988 through March 1989, fifteen to twenty of the trained teachers practice the model lessons that are appropriate to their teaching assignment and discuss strategies to effectively use the lessons in large classes with one or two computers. An additional fifteen to twenty teachers who do not participate in the lesson practice sessions serve as the control group. Teachers in both groups keep track of both their classroom and out-of-class computer use. Forms were developed for teachers to record the time they spend out of class using the computer (e.g. for word processing lessons, tabulating student grades, previewing software, or testing lessons) and for the time students spend out of class using the computer. Another form was developed for teachers to record information about classroom computer use. One of these forms is completed for each computer-based lesson the teacher uses in class. A Johns Hopkins graduate student visits each teacher monthly to collect and tabulate this data as well as to discuss questions or concerns. Results of this study will establish a baseline (control group) of reasonable expectations of computer use in the initial years following training, and they will also show (experimental group) the increase, if any, that can be effected by this added practice and planning.

CONCLUSION

This project began with a highly successful training program that gave teachers the computer skills they needed to use technology comfortably. More important, it provided settings and experiences that encouraged teachers to explore the range of instructional opportunities available when technology and science become allies in the classroom. Teachers' initial high level of implementation reflects both their conviction that computers can enhance science instruction and their willingness to make instructional changes when provided the necessary support. The process of integrating educational innovations is developmental. This training program has moved teachers along the continuum from tentative computer users to tentative innovators in the era of computer integration into content areas.

The project has resulted in more than teachers trained to integrate technology in their science classrooms. It has provided direction for future explorations of the use of technology in instruction. First, it has identified the need for on-going involvement of teachers in the planning, production, testing, and editing of exemplary computer-based science lessons. Second, it has indicated possibilities for collaborations between trained teachers and researchers to collect data on the effectiveness of specific types of computer uses in science. Finally, it has underscored the importance of involving science teachers in effecting change in science classrooms by harnessing the power of technology-based instruction.

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APPENDIX A
SESSION TOPICS

Schedule of Science Workshop

Middle School (NSF Sponsored)

1987-88

Each day will begin promptly at 8:30 A.M. and end at 3:30 P.M. and be divided into morning and afternoon sessions. Each session will have lecture and demonstration on a particular topic and time for laboratory practice using the computer. If there is a snow day the class will be held on the following Saturday, and you (teachers) will receive a stipend of $40.00.

November 13	Computer Awareness/Delivery, Assembly, Setup
December 4	Word Processing
January 8	Database
January 29	Spreadsheet
February 12	Integration of Applications
March 4	Interface Presentation/Construction
March 18	Interface Use
April 8	Programming
April 22	Trouble Shooting/Software Evaluation
May 6	Design/Presentation of Projects
May 13	Project Presentation and Discussion
June 4	Conference

The final sessions will be held on two Saturdays in the Fall, 1988; dates to be determined. Teachers will receive a $40.00 stipend for each session. The two sessions will cover Integration of Computers into Science Instruction and Coaching.

APPENDIX B
OBSERVATION FORM

COMPUTERS TO ENHANCE SCIENCE EDUCATION

OBSERVATION FORM

Observation Date:____________________________

Title of Lesson:____

Objective: ____

I. Organization of Computer Use

- ☐ Teacher demonstration/whole class
- ☐ Learning station/student small group

II. Type of Computer Application

- ☐ Commercial software ☐ Interface
- ☐ Teacher Generated ☐ Teacher Written

Title/publisher: ____

Source:____

Type (if applicable)____

III. Integration of the Computer into Instruction

Yes	No	
☐	☐	Use of the computer is effectively incorporated into the presentation of the lesson.
☐	☐	A relationship between the instructional objectives and computer use is demonstrated in concept development and/or in skill development.
☐	☐	Instruction explains rationale for computer use.
☐	☐	Computer application selected is appropriate.
☐	☐	Computer application is extended through teacher-produced guide sheets, questioning techniques, student data sheets, etc.
☐	☐	Computer application provides an instructional presentation that could not be accomplished as effectively in another way.

Comments: ____

____

____

IV. Development of Instruction (Concept Formation and Development of Science Process Skills)

Use of the Computer Helps Students to:

- ☐ collect information
- ☐ organize/manipulate information
- ☐ formulate hypotheses
- ☐ visualize relationships between variables and describe the nature of these relationships
- ☐ generate questions or alternatives
- ☐ analyze information
- ☐ draw conclusions
- ☐ comprehend a concept (e.g., visual presentation reinforces verbal or textual explanation)
- ☐ other (specify) ______________________________

V. Impact on Instruction

- ☐ permits students to determine rate of learning
- ☐ level of student interest
- ☐ level of student participation in lesson
- ☐ number of student initiated questions during observation
- ☐ number of student responses to teacher/program generated questions
- ☐ number of student-to-student interactions
- ☐ evidence that students comprehend the advantages of using the computer (specify) ______________________________
- ☐ evidence of on-task behavior (specify) ______________________________

APPENDIX C
QUESTIONNAIRE

COMPUTERS TO ENHANCE SCIENCE EDUCATION USAGE QUESTIONNAIRE

Name______________________________

Date______________________________

School______________________________

Subjects taught (indicate number of classes of each per day)

____

____

____

Please indicate the training session you attended

☐ 1986 HS ☐ 1987 MS ☐ 1987 HS

☐ 1988 MS ☐ 1988 ES

I. Accessibility of Equipment and Lessons

A. Hardware—Estimate the following (do not count any computer more than once!)

_____ 1. Number of computers you share with faculty in other curricular areas

_____ 2. Number of computers you share with other members of your science department

_____ 3. Number of computers you have <u>exclusive</u> use of during any instructional period

_____ 4. Do you have a compatible computer at home?

_____ 5. Did you buy a computer as a result of your participation in this program?

_____ 6. Do you foresee the availability of any additional sources of funding for computers, or anticipate any purchases?
If yes, please explain briefly. ____________________

____

____

B. Software and Interfacing Materials

1. Indicate the number of each type of interfacing device in your science department.

	Number
Materials from Charles Toth	_____
Experiments in Science (HRM)	_____
Experiments in Physiology (HRM)	_____
Science Toolkit, Mas r Module (Broderbund)	_____
Other (specify)	_____

2. What is the **total** number of science software packages in your science department?

Of these, approximately what percentage are from each of the following:

MECC ______% Conduit _____%

Sunburst _____% Seraphim ____%

HRM ______ % Textbook publisher ______%

Other ______ % (specify)______________________________

3. Do you have access to specific lesson plans which integrate computers into the science curriculum?

Lessons produced during your training ______________________

Lessons written during the Summer, 1987 ______________________

Other (indicate source) ______________________

C. Needs

1. What hardware and software items to be provided during training have you still not received?______________________

____

____

2. What additional hardware and/or software would make the most significant impact on your use of computers? List as specifically as possible)

____

____

II. Support

A. The following questions attempt to assess the level of support available to you in your attempt to integrate computers into your science instruction. For each category indicate whether you feel support has been adequate (A) or inadequate (I), then suggest what is needed to make it adequate or optimal.

1.	Quality of computer training in the JHU classroom	A	I
2.	Assistance with solving hardware problems after completion of training	A	I
3.	Assistance using software and interfacing devices after completion of training	A	I
4.	Assistance using lessons after completion of training	A	I
5.	Assistance in developing lessons after completion of training	A	I
6.	Other teachers with whom to share successes and failures in your attempts to integrate the computer into your science instruction	A	I

7. Supportive administrators at your school site A I

8. Other (specify) ______________________________ A I

III. Frequency of Use

A. Personal use to enhance lessons, lesson planning or lesson management

	# times per week	# hours per week
1. Word processing		
2. Student records		
3. Other		

B. Classroom use (total number of times this year)

	Class demonstration	Small group	Individual
1. Interface lessons			
2. Database lessons			
3. Spreadsheet lessons			
4. Commercial software			
5. Other			

C. Use with clubs and after-school groups (describe)

____

____

____

____

IV. Effectiveness of Use

A. List the topics, the software, and the group type of the three **most** effective computer lessons you taught (use a separate sheet if necessary, and **attach lesson plans** if available).

	Topic	Software	Group Type
Examples:			
	Drugs	Appleworks Data Base	Small groups
	Investigating a Phase change	Probeware	Class Demonstration
1.			
2.			
3.			

B. List the topics, the software, and the group type of any computer related lessons that were **not** effective.

	Topic	Software	Group Type
1.	____________	____________	____________
2.	____________		
3.	____________		

V. Dissemination Efforts

A. Indicate the dates when you have made presentations to each of the following and give the topic (you may approximate date if it is not exactly known).

Audience	Date	Topic
Science teachers within own school ____________		
Non-science teachers within own school ____________		
Science teachers at other schools ____________		
Science teachers at system-wide meetings ____________		
MAST presentations ____________		
National presentations (NABT, NSTA, etc.) ____________		
Other (Specify) ____________		

____