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ABSTRACT

The Biological Sciences Curriculum Study (BSCS), with support from the National Science Foundation, is conducting a three-year project to develop a model for implementing educational computing in school science. This paper explains the tentative model in detail and presents the results of a pilot test of the model, which project staff conducted during the first year of the project. The goals for the project are: (1) to develop and test a model of implementing educational computing in school science; (2) to train 260 science teachers and administrators in the Pikes Peak region of Colorado to use microcomputers to enhance science learning and teaching; (3) to establish a network in the Pikes Peak region to implement educational computing in school science; and (4) to disseminate a model of implementation for educational computing in school science. The project met its first year objectives and was successful at increasing science teachers' use of microcomputers. Project staff defined and measured implementation according to the Concerns Based Adoption Model (CBAM). Results from pre- and posttests using the Stages of Concern Questionnaire from CBAM indicated that the participants changed from a profile typical of non-users of an innovation toward one typical of users. Project staff developed an Innovation Configuration checklist to describe participants' use of microcomputers. Most of the participants were using microcomputers in several ways by the end of the year. Appendixes include the Microcomputer Use in Science Teaching checklist and the Stages of Concern Questionnaire. A 41-item reference list is also provided. (TW)

A MODEL FOR IMPLEMENTING MICROCOMPUTERS IN SCIENCE TEACHING

by

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TABLE OF CONTENTS

A Model for Implementing Microcomputers in Science Teaching

For several years, science education has been bombarded with messages about using microcomputers in science teaching. Numerous national reports call for a reform in education, in science education in particular. A central theme of the call for reform is to increase the use of information technologies. Science teachers cannot pick up an issue of *The Science Teacher*, *Science and Children*, or *School Science and Mathematics* without finding one or more articles extolling the virtues of microcomputers, several advertisements for microcomputer software, and reviews of microcomputer courseware. Research articles on microcomputer use in science education receive special attention in the annual review of research in science education in *Science Education*. Furthermore, programs for science educators at regional and national conferences highlight applications of microcomputers in science teaching. The exhibits at the conferences are resplendent with microcomputer products; even the book publishers showcase their microcomputer software.

Most science teachers, however, apparently live in educational bomb shelters; they have been impervious to the message—"use microcomputers in science teaching." A variety of studies have found only a small percentage of science classes where students use microcomputers regularly as one of the main methods of learning science. Is the call for reform in science education mere rhetoric? What are the reasons for the slow response by schools?

As indicated by numerous journal articles and sessions at educational conferences, science teachers do not seem to lack interest in the educational applications of microcomputers. Indeed, science teachers often overflow the sessions on microcomputers at conferences. Furthermore, science teachers indicate on surveys a willingness to attend workshops on educational computing.

Consequently, the Biological Sciences Curriculum Study (BSCS) believes that the most important action it can take to increase the use of microcomputers in science education is to develop quality teacher-training materials and approaches for helping science teachers implement educational computing. Science teachers need training programs that introduce them to applications of educational computing and to strategies for integrating those applications into science instruction, that model effective uses of microcomputers, that provide them opportunities to practice those effective uses, and that provide them follow-up support over a period of several years.

With *ENLIST Micros*, the BSCS is responding to the need for training teachers to use microcomputers in science instruction. *ENLIST Micros* is a BSCS project to help teachers implement microcomputers in school science. *ENLIST Micros* consists of a curriculum for preparing science teachers to use microcomputers and an implementation model. This paper is a report of a BSCS project to develop and test an implementation model to overcome barriers to increased use of microcomputers in science teaching.

PROJECT GOALS AND OBJECTIVES

The Biological Sciences Curriculum Study (BSCS)—with support from the National Science Foundation (NSF), Colorado Springs School District 11, Pikes Peak Board of Cooperative Services, and software publishers—is conducting a three-year project to develop a model for implementing educational computing in school science. In the proposal to the National Science Foundation, the BSCS established the following goals for the project:

- to develop and test a model of implementing educational computing in school science;
- to train 260 science teachers and administrators in the Pikes Peak region of Colorado to use microcomputers to enhance science learning and teaching;
- to establish a network in the Pikes Peak region to implement educational computing in school science; and,
- to disseminate a model of implementation for educational computing in school science.

The project began with an advisory committee meeting in June 1986. The advisory committee agreed the project would focus on designing, developing, testing, and disseminating a model for implementing educational computing in school science. Consequently, they recommended the following major objectives for the first year of the project:

- Engender enthusiasm for educational computing among the participants;
- Encourage participants' use of microcomputers;
- Establish a network for educational computing in science within the region;
- Determine how the participants use microcomputers;
- Determine barriers to educational computing in science;
- Develop effective implementation strategies; and
- Develop evaluation procedures and instruments.

This paper presents the activities and results of the first year of the project, which focused on the objectives recommended by the advisory committee.

RATIONALE

The rationale for this study is that science teachers are not responding to the call for the increased use of microcomputers. Science teachers see the need to improve, however, they are not receiving the support they need to implement those improvements. To implement reform in science education, science teachers need programs that teach them the nature of the reform and that help them adopt the new practices. The following sections outline the reform movement and its status and present the need for projects to train teachers to use microcomputers in school science.

Call for Reform

During the past decade, numerous national studies and reports have called for a reform in education; one emphasis is on including information technologies in the educational process. The National Science Foundation has been in the forefront of the reform movement by recognizing that "as the computer becomes part of the home, school, and business landscape, people will need to know how to make intelligent, productive, and creative use of it" (NSF, 1979, p. 23). In addition, Paul DeHart Hurd, who has been one of the architects of the reform, emphasized that "quite likely, the disadvantaged learners of the near future will be those who lack the skills to exploit the microelectronic information resource and synthesize the findings" (Hurd, NSB, 1982, p. 11). Consequently, a number of agencies have included goals for computer literacy in their guidelines for improving education (Association for the Education of Teachers in Science, 1985; U.S. Department of Education, 1983; National Science Board Commission of Precollege Education in Mathematics, Science, and Technology, 1983; Education Commission of the States, 1983; National Task Force on Educational Technology, 1986; and, the National Governor's Association, 1986). Information technologies, therefore, should be part of science education.

In a recent report, the National Science Board (NSB) summarized the major issues in the following recommendations supporting the use of microcomputers in science teaching:

- An important role is seen for technology in enriching the educational experiences of all children.
- The most critical need is to train teachers, administrators, and parents in the uses of technology in the education of children.
- The nation must find ways to provide to all children equality of access to the advantages of technology.
- The federal government has a crucial role in establishing educational technology. This includes investing venture capital in development, coordination among the states, and establishing long-term evaluation programs.
- Business and the military benefit from the products of our educational system, but must invest in overcoming its deficiencies when they exist. Ways must be found to bring these two groups into the development program along with the federal and state governments, and the educational system. (NSB, 1983, p. 3)

Consequently, the NSB Commission on Precollege Education in Mathematics, Science, and Technology recommended a massive federal responsibility ($1.5 billion for the first year) in upgrading mathematics, science, and technology education.

Status of Use

In spite of the call to increase the use of information technologies in science education, research studies prior to and since the beginning of this project have found that science teachers use information technologies only occasionally. Lehman (1985) found that in 41 percent of 193 high schools not one science faculty member used microcomputers for instruction and that only six percent used microcomputers at least one hour per week per class. In a study in South Carolina (where small, rural school districts predominate), Kherlopian and Dickey (1985) found that only 40 percent of the K-12 science teachers were using microcomputers.

To learn about microcomputer use in elementary schools, the BSCS (1987) conducted a national survey of elementary teachers and principals that examined educational technologies for elementary school science, health, and technology. The study found the following: computers for student use were available permanently in 22.7 percent of the classrooms, on an as needed basis in 40.9 percent of the classrooms, and in computer laboratories for use by 44.9 percent of science students. The most predominate use of computers by science students was for drill and practice, games, tutorials, and word processing; furthermore, students actually use computers in only 17 percent of the classrooms.

Iris Weiss included several questions on educational computing in her recent national survey on science and mathematics education. Weiss found that "in science, overall computer usage tends to increase with increasing grade level, with 25 percent of K-6 science classes and 36 percent of 10-12 science classes using computers....Particular uses that increase with grade level are using computers as a laboratory tool and using computers for simulations" (Weiss, 1987, p. 57). For all grade levels in those classes where students used computers, she found that typical students spent fewer than 15 minutes per week working with computers. Ninety percent or more of the schools had computers available to students; however, in roughly half of the classes, the computers were either not available for use or were quite difficult to access.

Becker completed the most in-depth analysis of instructional uses of computers in science with his 1985 national survey (Becker, 1987). Becker found that use of computers in science has constituted a small part of school computer use, at both the elementary and secondary levels. "In science classes, computer use occupied about six percent of the instructional time on computers in high schools, roughly three percent in the middle grades, and only one percent in the elementary grades" (Becker, 1987, p. 2). Nevertheless, Becker found that roughly one-sixth of the science teachers used computers. There is a discrepancy between the small amount of time science teachers reported they used computers for instruction and the higher percentage of science teachers reporting that they used computers. The discrepancy is because nearly one-fourth of courses taught by science teachers involved teaching computer programming or computer literacy. Becker concludes that "the primary involvement of math and science teachers with computers (at least as of Spring 1985) has been to use them as the object of instruction rather than as a means of providing traditional instruction in mathematics and science" (Becker, 1987, p. 3).

In addition, Becker found that science teachers used computers less intensively than did teachers in other subjects. Science classes in secondary schools overwhelmingly used computers in their own rooms rather than in a separate computer lab; working at computers in pairs or small groups was common. Students in the middle grades used computers in science primarily for enrichment, and in 85 percent of these classes, students used computers no more than one day per week. High school classes used computers primarily for drill, and they used them most often for enrichment. As in the middle grades, high school students most commonly worked in pairs or groups at the computer.

These studies of the status of use of microcomputers in science teaching indicate that science teachers are falling far short of implementing the recommendations for integrating information technologies into science education. None of the studies found that the majority of science teachers are using educational computing as a significant part of their instruction. Many of the findings indicate that when science teachers use microcomputers to provide instruction they use the least powerful modes of delivery, such as drill and practice and games, and that science teachers often use the computer more as an object of instruction rather than to improve instruction. Nearly all science teachers have access to microcomputers; the proximity of the computer to the classroom, however, seems to be a very important factor in how much science teachers use microcomputers for instructional purposes.

The Need for Teacher Training

Teacher training seems to be the key factor in implementing microcomputers in science teaching. Weiss included in her study an assessment of needs related to training science teachers in educational computing. Roughly one-third of science teachers she surveyed had completed one or more college courses in instructional computing; she also found, however, that half or more of science teachers at each grade level felt totally or somewhat unprepared to use computers as an instructional tool. Perhaps those teachers who felt unprepared had little training. Or, perhaps the content of courses in instructional computing is not aligned with the needs of the teachers or the courses are of insufficient duration for the teachers to master the skills and content required to use computers effectively.

Lamon (1988) found that the majority of computer-using teachers had more than 20 hours of formal training in educational computing. A report by the Office of Technology Assessment (OTA) (1987) expressed similar concerns about teacher training. OTA found the following:

- Less than one-third of U.S. teachers, but more than one-half of computer-using teachers, have had at least 10 hours of training.
- Although teachers traditionally receive in-service training on site, more than one-half of teachers who received training learned about computers in other ways: taking courses for college credit, attending training sessions offered by vendors, or in some other ways.
- The majority of state coordinators indicated that teacher training must be a part of any further investment in computer technology.
- Researchers and state and local policy makers emphasized the need for training in the application of programs to meet students' needs.

Several other studies also have concluded that the lack of teacher training might be closely related to the low level of use of microcomputers by science teachers. The BSCS study found that summer training workshops and after school inservice were among factors that teachers indicated would increase use. Lehman (1985) proposed that because 75 percent of the teachers using microcomputers had completed formal training in educational computing, the lack of inservice or preservice courses on educational computing for science education might be a significant barrier to increased implementation. Kherlopian and Dickey (1985) made a similar claim when they discovered that more than 80 percent of the science teachers using computers had completed formal course work in educational computing; few teachers started using computers without formal training.

A few studies have listed barriers that education must overcome to increase the instructional use of microcomputers. Lamon (1988) found in a survey of Oregon teachers that 94 percent felt "there is not enough time to fit computers in" and 81 percent felt "the school has too few computers for students to get enough time to learn," but that only seven percent had "heard any reservations about computers at their school." A Rand study (Winkler, 1986) made four recommendations to school districts for overcoming barriers to increased use of microcomputers in subject matter instruction: continue to acquire microcomputers and educational courseware; provide centralized, routine assistance (subject-specific computer advisers) in integrating computers into instruction; provide inservice training on how to integrate computers into subject areas; and compensate computer-using teachers to encourage use of computers for subject matter instruction.

THEORETICAL BASIS

This project based its procedures and strategies on a large volume of research on educational change and staff development and on previous BSCS studies. Research on educational change led us to understand some of the underlying reasons that teachers have been slow to respond to the call for increased use of microcomputers and helped us develop a model for implementing microcomputers in science teaching. Research on staff development helped us to understand teachers as learners and to design procedures for the teacher training. In addition, previous BSCS research formed the basis for this study. The following sections present a review of the literature on educational change and staff development, and a summary of previous BSCS research on training science teachers to use microcomputers.

Educational Change Theory

In spite of the rhetoric and recommendations about the need to use microcomputers in schools, there has been little change. Goodlad (1983) found that only rarely did a curriculum in the schools he examined have an integrated-technology component. Bill Honig (1987, p. 9), superintendent of the California public school system, contrasts the realities of today's classroom and today's world as follows: "While the world around them has changed dramatically, children are still tediously working on page after page of arithmetic problems, filling in answers in the same way as their grandparents did."

In response to this lack of change, Hall and Hord (1987) emphasize that change is a process, not an event. Educational change is a long and tedious process that does not end with the adoption of a new curriculum or approach to teaching. The decision to change is only the beginning; Hord and Huling-Austin found that it takes three or more years for teachers to make a substantial change in teaching. They identified three key factors in implementing an innovation that are often overlooked: "A realization that various types of actions that support teachers will be required; identification of who is responsible for facilitating the changes that teachers will make; and an understanding on the part of facilitators that change takes a great deal of time and that, even under the best of circumstances, implementation takes several years" (Hord and Huling-Austin, 1986, p. 97).

Hord and Huling-Austin state that successfully implemented programs require leadership, often from the principal. Successful leadership is expressed in the following ways: providing supportive organizational arrangements—such as equipment, materials, logistics, and facilities—that encourage the use of the innovation; providing for teacher training; providing weekly consultation and feedback during the process of implementing the innovation; and, monitoring and evaluating the implementation of the innovation.

Hall and Hord (1987) recommend that a change facilitation team is needed to promote change in schools. The team should consist of the school principal, a second change facilitator (usually an expert teacher or curriculum supervisor) and perhaps a third change facilitator (usually another teacher), and, when possible, external change facilitators (curriculum developers, university professors, or outside experts). Table 1 lists the roles of the members of the change facilitation team.

Table 1

The Importance of Who Does What for Successful Change

	Change Facilitating Team Members			
FUNCTIONS	First CF (principal)	Second CF	Third CF	External CFs
Sanctioning/ continued back up	xxxx	xx		xx
Providing resources	xxx	xx		x
Technical coaching	x	xx	x	x
Monitoring/ follow up	xx	xx	x	
Training	x	x		xx
Reinforcing	xx	xxx	x	x
Pushing	xx	xx	x	x
Telling others	xx	x		x
Approving adaptations	xx	x		x

Legend:

x, xx, xxx, xxxx = Degree of importance

From: Hall, G.E. & Hord, S.M. Change in Schools: Facilitating the Process. Albany, New York: State University of New York Press; 1987.

Staff Development

When designing the teacher training and implementation activities, project staff carefully considered the literature on staff development. Showers (1985) emphasizes that with thorough training—which includes theory, demonstration, and opportunities for practice and feedback (peer teaching and with students)—most teachers can acquire new skills and teaching strategies. Most training falls short by offering a one-shot workshop that may improve the teachers' concepts and attitudes. Follow-up in the classroom (coaching), however, is needed to change teaching behaviors. Consequently, Showers recommends these follow-up activities that fellow teachers might provide on a weekly basis: observing the teacher practice the behavior in the classroom, followed by a post-observation conference; providing support and encouragement; assisting in planning future lessons; and helping with the location and production of materials. Leggett and Hoyle (1987) also recommend that as part of staff development the change facilitators should provide training sessions, sharing sessions, teacher-to-teacher interaction, one-to-one assistance, and small-group meetings.

Wu (1987) found that teachers prefer other teachers as consultants. Teachers serving as consultants help create a comfortable atmosphere (which facilitates the exchange of ideas), usually place the participants in an active role, discuss ideas that are practical and immediately applicable to the classroom, and understand the resources and time available to other teachers. Wu cautions, however, that teachers who are consultants need to be familiar with the concepts of adult learning, to have time to plan and deliver the activities, to be familiar with current research, and to make use of resource personnel outside of the school district.

Several researchers point out that peer coaching is a cost-effective way to improve teacher training (Leggett and Hoyle, 1987; Joyce and Showers, 1987; Showers, 1985; Munro and Elliott, 1987; Brandt, 1987; Neubert and Bratton, 1987). Garmston (1987) points out that collegial coaching refines teaching practices, deepens collegiality, increases professional dialogue, and helps teachers think more deeply about their work. The coaching should be conducted by pairs of teachers; focus on the priority set by the observed teacher; gather data about the teaching strategy, student behaviors and outcomes, and teacher behavior; and help analyze and interpret the data from the observation. It is important that the teachers practice the new strategies in a series of several follow-up sessions.

The research described above provides general guidelines for training teachers that are not tied to specific teaching skills or strategies or to a particular educational innovation. In designing the teacher training and implementation activities for this project, we also reviewed literature that recommended strategies for computer-inservice programs. Stecher and Solorzano (1987) listed the following 15 important factors for the successful training of teachers to use microcomputers:

1. Extensive practice with computers,
2. Comfortable and relaxed atmosphere,
3. Appropriate balance between lecture and guided practice,
4. Individualized attention,

5. Knowledgeable trainers,
6. Detailed curriculum guides and lesson plans,
7. Clear and relevant objectives,
8. Lesson-related materials and handouts,
9. Inservice lessons linked to instruction,
10. Peer interaction,
11. Voluntary participation,
12. Use of strategies for teaching heterogeneous groups,
13. Follow-up support,
14. Recognition that computer use is a very complex task, and
15. Assistance for teachers in making the transition from theory into practice.

In addition to the specific strategies Stecher and Solorzano found effective, Allen (1984) listed the following important conditions for training adults to use computers:

1. Capitalize on the natural motivation of adults by using an instructor who is a facilitator and leader of learning;
2. Ensure that adult learners will have a feeling of efficacy;
3. Recognize, expose as normal, and channel anxiety as a positive enabling influence;
4. Inform the learner of expected outcomes;
5. Stimulate recall of relevant prior experiences and information previously covered;
6. Evaluate their performance against an external standard during and after the learning period;
7. Make provisions for retention and transfer of concepts and skills;
8. Provide group learning activities;
9. Provide practical, meaningful material;
10. Provide for active rather than passive participation;
11. Provide for cooperative learning experiences, relying on peers to support the learning through constructive feedback in a non-competitive environment;
12. Center attention on personal involvement of the learner;
13. Emphasize choice, creativity, and self-realization in selection of activities;
14. Provide constant support for change of teaching behaviors; and
15. Aim at cognitive and social goals.

Previous BSCS Studies

Several BSCS studies have informed this current project. Prior to this project, the National Science Foundation provided support for a BSCS project to develop the *ENLIST Micros* curriculum. BSCS staff used the *ENLIST Micros* curriculum in this project to train teachers to use microcomputers to enhance science learning and teaching. BSCS designed the materials for preservice and inservice courses for science teachers. The curriculum requires 16-hours of instructional time.

In accordance with the established BSCS approach to curriculum development (Mayer, 1976), project staff conducted several research studies as part of the development process. In 1984, educators did not agree on a definition of computer literacy for teachers. Consequently, the first task of *ENLIST Micros* was to identify and validate computer-literacy competencies for science teachers. We defined a science teacher who is computer literate as one who is able to use a microcomputer effectively for the purpose of improving the quality and efficiency of learning science. Ellis and Kuerbis (1986) followed a five-step procedure to determine the 22 essential competencies for a science teacher, which are the basis of the curriculum.

Eighteen groups of teachers (K-12) in 15 sites (inservice and preservice) around the nation field tested the curriculum materials. Ellis and Kuerbis (1987) found the field-test teachers' knowledge and attitudes about educational computing significantly increased as a result of using the curriculum.

As we developed the curriculum, we were aware that the literature on educational change and staff development emphasizes that changing teachers' behaviors takes more than a one-shot workshop and happens over a period of three or more years. Consequently, Baird, Ellis, and Kuerbis (1987) conducted an implementation study to look at the effects of the 16-hour workshop on educational computing. The outcome measures for these teachers indicated they had mastered the knowledge and attitudes for computer literacy; few of them, however, were using microcomputers during the year following the training. Despite this, 76 percent felt that the training had positively affected their use of computers and 42 percent said they had trained other teachers in computer skills. The degree of implementation was disappointing. We used this, however, as a basis for beginning the current project to develop an implementation model for educational computing in school science.

METHODS

Participants

During the first year of the project, the project staff trained 61 science teachers and administrators from 16 school districts to be leaders of educational computing in the Pikes Peak region of Colorado. Appendix A lists the school districts participating in the project. Superintendents and instructional supervisors from the districts in the region nominated the participants. We asked that the participants be teachers or administrators who could serve as change facilitators in their school districts for educational computing with science teachers.

The participants were evenly distributed among grade levels with approximately a third each from elementary schools, middle/junior high schools, and high schools. Most of the participants were classroom teachers; ten were building or district administrators and five were part-time computer coordinators or department chairs. The participants were evenly distributed between male and female; most of the females, however, came from elementary schools. Nearly three-fourths were 30-49 years of age; nearly half had master's degrees. They had a mean of 11.9 years of teaching experience and taught a variety of science subjects, with multiple disciplines being the most common assignment (36.8 percent). They were from 16 school districts, ranging from a rural school district with 36 students to an urban school district with more than

30,000 students. The districts, however, were predominately rural; all but five had fewer than 2,500 students. Participants' experience with microcomputers included 39.5 percent who had never been involved in educational computing; 69.2 percent had no formal training. Of those who had experience with computers, 67.5 percent considered themselves to be novice or nonusers.

Teachers, particularly those in elementary schools, often are overwhelmed by multiple educational innovations. When teachers are involved with multiple innovations, one or more of those innovations may suffer. In this study, however, we found only 28.9 percent of the teachers indicated they were currently involved in implementing other innovations in addition to educational computing.

Project Activities

The project has eight tasks: planning, curriculum development, teacher preparation, leader preparation, networking, dissemination, a software resource center, and evaluation. The project staff and the advisory committee, who hold a meeting during the first month of each project year, plan the project. The advisory committee consists of four science educators who have expertise in implementation theory and the process of educational change, rural education, educational computing, staff development, and the education of science teachers. Appendix B lists the members of the advisory committee. In addition, administrators and a science teacher from the participating districts were guests at the first day of the two-day meeting of the advisory committee. At that meeting, the advisory committee reviewed the project goals and a tentative implementation model and recommended objectives and strategies for the first year of the project.

Curriculum development. *ENLIST Micros* is the core curriculum for the preparation of the teachers. The BSCS developed the curriculum as part of an NSF materials development project during 1984-86. The curriculum consists of a text, four videotape programs, and tutorial software. We recommend that instructors also use commercial software and catalogs from software vendors to supplement the curriculum. BSCS staff completed a thorough field test and evaluation of the *ENLIST Micros* materials (Ellis and Kuerbis, 1987; Baird, Ellis, and Kuerbis, 1987).

As part of the current project, project staff are using the evaluation results to revise and expand the experimental curriculum materials. Project staff will also produce an implementation guide for instructors who want to use the curriculum for inservice or preservice preparation of science teachers and for leaders who want to use the implementation model to facilitate the use of educational computing by science teachers in a school district or region.

Teacher preparation. The implementation activities for this three-year project interrelate. Figure 1 presents the implementation model the BSCS designed for year one of this project. During the first year, we worked with science teachers and administrators who would be district leaders in educational computing in school science. We trained these participants to use educational computing in science teaching, provided support to help them implement educational computing, and prepared them to be leaders in their districts. We designed three activities for teacher preparation—teacher preparation workshops, teacher practicums, and teacher seminars. We parcelled the participants into two groups for the initial 16-hour workshop. *ENLIST Micros* (1985a-c) was the core curriculum for the workshop.

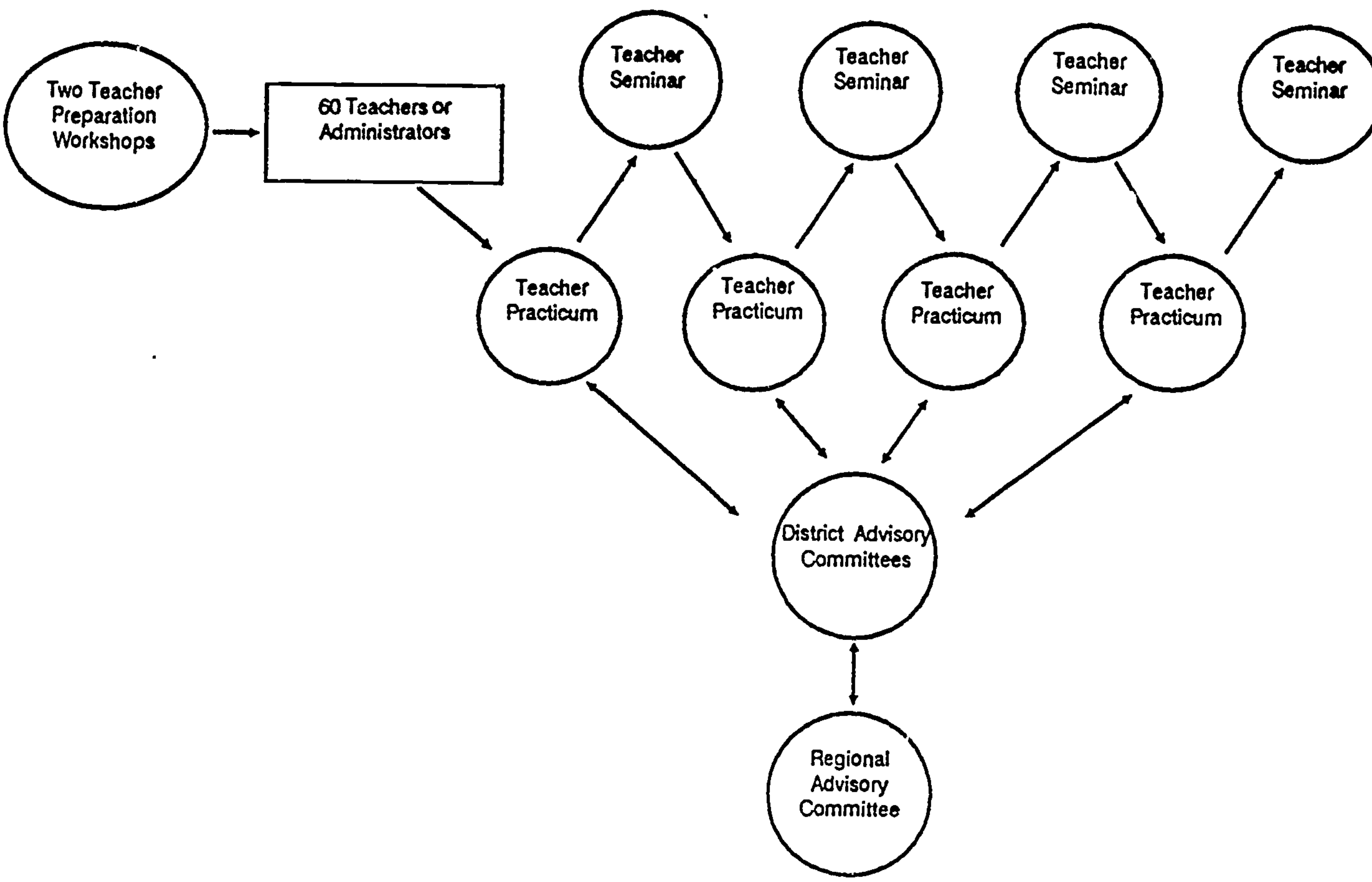

Figure 1: Implementation Model for Year One

The participants attended four follow-up seminars, which were held after school hours throughout the school year. At these seminars, participants previewed science software, observed science lessons that integrated educational computing, shared ideas and resources, and formed special-interest groups to make reports on topics and issues in educational computing in school science. At the seminars, we also introduced the first-year participants to leadership skills and worked with them to solicit participants and to plan the activities for year two. The participants received two credits toward recertification and $160 for participation in the training activities; we also provided snacks or meals at the meetings.

We expected participants to implement educational computing in their science teaching during the teacher practicum. As assignments, we asked them to read the text and run the software from *ENLIST Micros*, to determine the status of educational computing in their building and district, to review five science software packages and write a memo recommending some of these for purchase, to order and review software programs for a science unit, to develop and teach a lesson involving science software, and to keep a journal on the use of microcomputers. Several times during the year, project staff visited the participants and observed them teaching lessons, held conferences with them to analyze their lessons and to discuss problems with implementation, and interviewed them to assess the process of implementation.

Leader preparation. The science teachers and administrators had to be implementors before they could be leaders of educational computing in school science; therefore, they participated in teacher preparation activities during year one. Even though we began training leaders during year one, we will focus on leadership training during years two and three (figure 2).

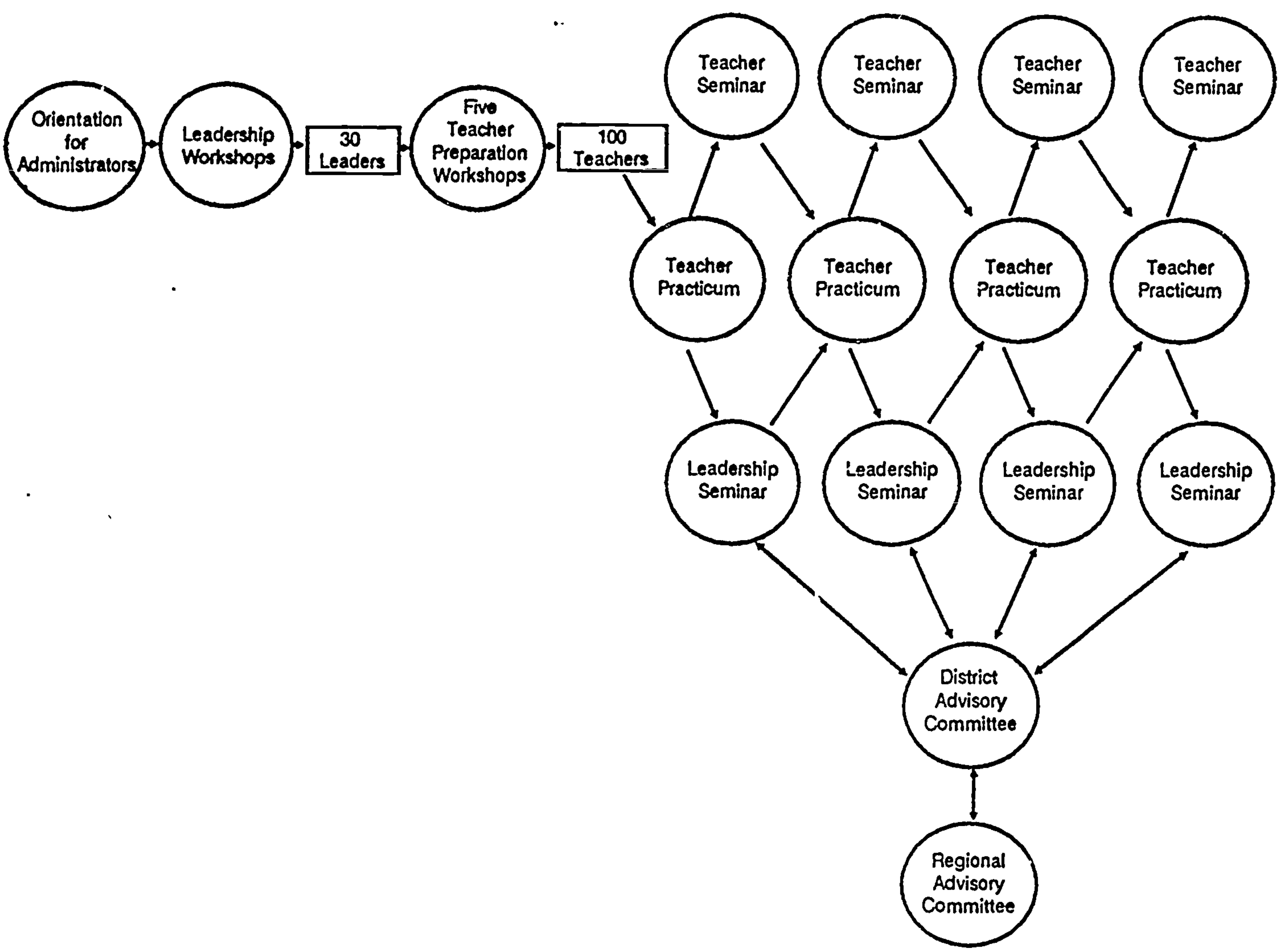

Figure 2: Implementation Model for Years Two and Three

Networking. To build a communication network, we established advisory committees in each district and one for the Pikes Peak region. These advisory committees study and make recommendations for using microcomputers in science education and facilitate the exchange of ideas and services among and within the cooperating districts. During years two and three, we will establish teams of participants as support networks within buildings and form special-interest groups with members from several districts to build a support network across districts.

Software resource center. We established a software resource center for the project. Software publishers and the BSCS donated more than 350 pieces of science software for use with the project. Science teachers in the Pikes Peak region may borrow the software for one week for review to make purchasing decisions. The software resource center is an important component of the project. It contains a wide selection of good science software. Consequently, the software center helps overcome teachers' perception that there is a lack of quality software in science. We ask that teachers observe the copyright restrictions when using the software and that they not use the software with students in lieu of purchase. Colorado Springs School District 11 donated space and personnel to manage the software collection. In addition, District 11 made its collection of science and math software available to participants in the project.

Dissemination. A major purpose of the project is to disseminate information about how to implement educational computing in school science. The goal of the dissemination effort is to provide information to help science educators, administrators, and supervisors establish the implementation model in school districts throughout the United States. Therefore, project staff present the *ENLIST Micros* curriculum and the implementation model to science educators at regional and national meetings of the National Association of Biology Teachers, the Association for the Education of Teachers in Science (AETS), the National Association for Research in Science Teaching, and the National Science Teachers Association, and at the National Educational Computing Conference. In addition, Ellis is writing articles for journals in science education and submitting news releases to journals and newsletters of science education, science, and computer education. Ellis also is the editor of the 1988 AETS yearbook on information technologies and science education, in which he will elaborate on *ENLIST Micros* and the implementation model.

Evaluation. Evaluation is a central activity of the project. The general purpose of the evaluation activities during year one was to measure the attainment of the objectives the advisory committee set for year one. More specifically, we evaluated the success of the training activities and the implementation of microcomputers and developed instruments and procedures for use during the three years of the project. The following section describes the evaluation instruments in detail.

Evaluation Procedures

We gathered information to describe the participants, to evaluate the training activities, to describe the implementation of microcomputers by the participants, to measure implementation success, and to determine the barriers to implementing educational computing in school science. We used questionnaires to obtain descriptive information from the participants—including teaching assignment, age, gender, experience with microcomputers, educational background, and teaching experience. The previous section on participants presented the descriptive data.

We used two separate instructional questionnaires to evaluate the training workshops and the follow-up seminars. The questionnaires contained positive and negative statements about the respective training activities, and the participants indicated their level of agreement with the statements on a scale from "strongly agree" to "strongly disagree." A typical item from a questionnaire is "Course goals and objectives were well stated."

We gathered descriptive information about how the participants were using microcomputers by observing in classrooms, conducting informal interviews, requiring participants to keep journals, and administering a questionnaire to determine how the participants used microcomputers in science teaching. The participants kept a journal of use of microcomputers in which they recorded the different ways they used the microcomputer in teaching science and in performing management duties and the feelings they had as they implemented educational computing in school science. Project staff documented the use of microcomputers throughout the school year (following the initial training workshops) by observing the participants in their classrooms and interviewing them during informal conferences.

We also used a checklist to determine how the participants were implementing educational computing in school science. We followed the procedures described in *Measuring Innovation Configurations: Procedures and Applications* (Heck, Stiegelbauer, Hall, and Loucks, 1981) to develop the checklist of Microcomputer Use in Science Teaching (MUST). The MUST checklist is in Appendix C. It consists of 20 items about the use of microcomputers in science teaching. One section of the MUST contains items about the availability of microcomputers and the frequency of their use in science teaching. Another section contains items about how a teacher uses the microcomputer in science teaching, and the last section assesses the level of school support for educational computing and the barriers to implementation. We administered the MUST in April 1987, at the end of the first year of training.

We are using the Concerns-Based Adoption Model (CBAM) to measure the success the participants had with implementing educational computing in school science. We are using the results of the first administration of the MUST to refine the checklist and to develop an innovation configuration. Innovation configurations are an important dimension of the CBAM model for defining implementation success. The innovation configuration defines the components of the innovation and provides indicators of the successful implementation of those components. The first and second sections of the MUST contain items to measure innovation configurations.

The Stages of Concern About the Innovation Questionnaire (SOC) (Hall, George, and Rutherford, 1979) measures stages of concern (figure 3), which are a primary dimension of the CBAM model. The SOC, which is in Appendix D, is a 35-item questionnaire where an adopter of an innovation marks on a scale of zero (irrelevant) to seven (very true of me now) the degree to which the items accurately describe his or her concerns. The SOC items measure the personal concerns of an innovation adopter. We administered the SOC as a pretest and posttest. Time restrictions prohibited use of the Levels of Use interview, the third component of the CBAM model.

0 Awareness

Little concern about or involvement with the innovation is indicated.

1 Informational

A general awareness of the innovation and interest in learning more detail about it is indicated. The person seems to be unworried about herself/himself in relation to the innovation. She/he is interested in substantive aspects of the innovation in a selfless manner such as general characteristics, effects, and requirements for use.

2 Personal

Individual is uncertain about the demands of the innovation, and her/his inadequacy to meet those demands and her/his role with the innovation. This includes analysis of her/his role in relation to the reward structure of the organization, decision making, and consideration of potential conflicts with existing structures or personal commitment. Financial or status implications of the program for self and colleagues may also be reflected.

3 Management

Attention is focused on the processes and tasks of using the innovation and the best use of information and resources. Issues related to efficiency, organizing, managing, scheduling, and time demands are utmost.

4 Consequence

Attention focuses on impact of the innovation on students in her/his immediate sphere of influence. The focus is on relevance of the innovation for students, evaluation of student outcomes, including performance and competencies, and changes needed to increase student outcomes.

5 Collaboration

The focus is on coordination and cooperation with others regarding use of the innovation.

6 Refocusing

The focus is on exploration of more universal benefits from the innovation, including the possibility of major changes or replacement with a more powerful alternative. Individual has definite ideas about alternatives to the proposed or existing form of the innovation.

Figure 3: Stages of Concern About the Innovation

As a final component of the evaluation, we used the MUST, observations, interviews, and the journal to identify possible barriers to implementing educational computing in school science. The MUST, which we administered as a posttest, contained items about perceived barriers. We developed those items by analyzing the results of the observations and interviews and by reviewing the literature; project staff discussed issues about implementing educational computing in school science with the participants during training meetings and as part of interviews and observations.

RESULTS

Teacher Training

We used questionnaires to evaluate the participants' satisfaction with the teacher preparation workshops and the teacher preparation seminars. For the 12 items on the evaluation questionnaire for the two-day workshop, the average participant rating was 3.48 (about halfway between strongly agree and agree). Table 2 lists the items and average responses. The highest ratings were for "Instructor responsive to student input and needs" (3.72) and "Food and beverages were adequate" (3.72). The lowest rating (3.04) was for "Stated goals and objectives were met." A rating of 3.04 where a rating of three means agree, however, is not low.

Table 2
Evaluation of Teacher Preparation Workshops

Strongly Agree	Agree	Disagree	Strongly Disagree
4	3	2	1

Course goals and objectives were well stated	3.32
Stated goals and objectives were well met	3.04
Written and/or learning materials good and organized	3.64
Registration procedures efficient and planned	3.48
Instructor well prepared	3.56
Subject matter was relevant	3.68
Material presented logically and sequentially	3.28
Instructor expressed ideas clearly	3.44
Instructor responsive to student input and needs	3.72
Physical arrangements were conducive to learning	3.48
Ventilation and lighting were adequate	3.40
Food and beverages were adequate	3.72

We used another questionnaire to evaluate the four seminars. The average participant rating of the 12 items on the evaluation questionnaire for the seminars was 3.82, where 5.0 was the highest possible rating. Table 3 presents the items and average responses.

Table 3
Evaluation of Teacher Preparation Seminars

Low				High
1	2	3	4	5

Were the objectives, goals and requirements of this course well defined and specified?	4.15
To what extent do you feel the course objectives were attained?	3.92
To what extent do you feel that the content of this course was well organized and sequentially developed in order to assure optimum learning?	3.85
To what extent do you feel this course has contributed to your professional development?	4.23
To what degree do you feel that you will be able to incorporate what you have learned in this inservice into your own assignment?	4.19
With respect to your professional development how does this inservice compare with similar college courses you have taken?	4.00
Was the subject matter presented effectively by the instructor?	4.08
Did the instructor exhibit broad background and knowledge of subject matter?	4.54
Rate the materials used in this inservice (text, films, handouts, etc.).	4.23
How would you rate this course in recommending it to another teacher/administrator?	4.23
Should this inservice be offered again?	4.46

In general, the responses were uniformly positive, as were those for the workshop. The last item—"Should this inservice be offered again?"—received an average rating of 4.46; a strong indication of the success of the training. Interviews and informal discussions with the participants and the participants' journals confirmed the results of the survey. In addition, 90.0 percent of the participants indicated that their participation in *ENLIST Micros* positively affected their use of computers.

Success of Implementation

To determine participants' success at implementing educational computing, we followed CBAM procedures to develop an innovation configuration checklist to determine how the participants were using educational computing in science teaching and used the Stages of Concern Questionnaire (SOC) from the Concerns-Based Adoption Model (CBAM). Figure 4 presents a graph of the pretest and posttest results from the SOC. The pretest results exhibit the typical pattern of mean scores for the stages of concern for nonusers or beginning users of an innovation; this is the pattern we expected for our participants. The decrease from pretest to posttest in mean scores for lower concerns (awareness and information) and increase in mean scores for higher concerns (consequence and collaboration) indicates that the participants were progressing to higher stages of concern, which we expected to happen as they became users of educational computing.

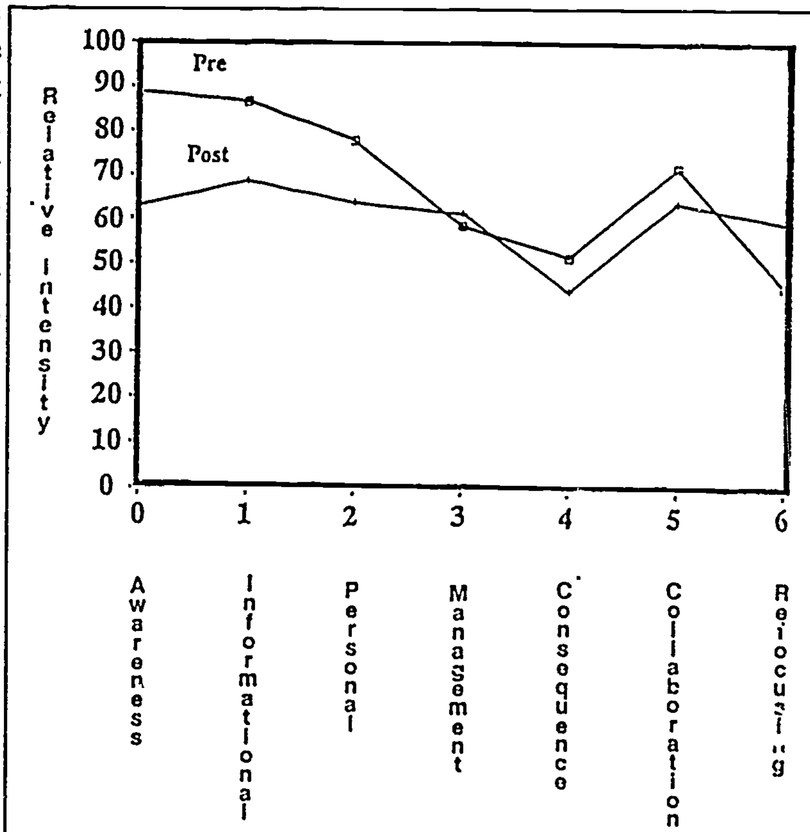

Figure 4: Mean Scores for Stages of Concern Pretest and Posttest

Tables 4a and 4b presents the results from the checklist for Microcomputer Use in Science Teaching (MUST). We found that nearly all teachers indicated they had microcomputers available for use in science teaching. Apple computers were the predominant machines in use and teachers in grades K-6 seemed to have computers available to them more than did other teachers. The amount of software available and the amount of money available to purchase software for science teaching, however, increased from elementary school to high school.

Table 4a

Microcomputer Use in Science Teaching Checklist by Grade Assignment

Percentages for Categorical Variables

Item	K-6	7-9	9-12	7-12	Admin	Total
Micros are available	91.7	88.9	92.9	50.0	100.0	90.0
Whe.e micros located						
one in room	54.5	25.0	38.5	0.0	66.7	41.7
two or more in room	0.0	0.0	15.4	0.0	0.0	5.6
temporarily in room	54.5	62.5	53.8	0.0	66.7	55.6
one or more outside rm.	36.4	25.0	46.2	0.0	66.7	38.9
computer lab	54.5	75.0	53.8	100.0	100.0	63.9
other	0.0	12.5	7.7	0.0	66.7	11.1
Use Micros in science	75.0	87.5	100.0	50.0	0.0	83.8
Frequency of use sci.						
100 %	0.0	0.0	7.1	0.0	0.0	3.1
75 %	10.0	0.0	0.0	0.0	0.0	13.1
50 %	10.0	12.5	21.4	0.0	0.0	15.6
25 %	50.0	25.0	14.3	0.0	0.0	28.1
less than 25 %	30.0	62.5	57.1	0.0	0.0	50.0
Use in other subjects	91.7	66.7	85.7	100.0	100.0	84.2
Management uses						
Testing	33.3	57.1	60.2	100.0	0.0	53.1
Grade recording	33.3	85.7	92.3	100.0	0.0	68.0
Developing print mat.	66.7	85.7	100.0	100.0	100.0	87.5
Developing software	44.4	14.3	30.8	0.0	0.0	28.1
Inventory	22.2	57.1	61.5	100.0	0.0	46.9
Prescribing learning	44.4	14.3	30.8	0.0	0.0	28.1
Data analysis	22.2	28.6	30.8	100.0	0.0	28.1
Administration	33.3	71.4	53.8	100.0	0.0	56.3
Other	11.1	0.0	0.0	0.0	0.0	3.1
Science tool uses						
Lab instrument	33.3	57.1	58.3	0.0	0.0	48.3
Data recording	33.3	42.9	50.0	0.0	0.0	41.4
Statistics	0.0	14.3	50.0	0.0	0.0	24.1
Data base	0.0	42.9	50.0	100.0	0.0	34.5
Telecommunications	0.0	0.0	0.0	0.0	0.0	0.0
Building models	0.0	42.9	50.0	0.0	0.0	31.0
Printing reports	66.7	28.6	75.0	100.0	0.0	62.1
Other	55.6	14.3	8.3	100.0	0.0	27.6

(Continued)

Table 4a
(Continued)

Item	K-6	7-9	9-12	7-12	Admin	Total
Instructional uses						
Drill and Practice	77.8	85.7	76.9	100.0	100.0	81.3
Simulations	66.7	100.0	69.2	100.0	100.0	78.1
Games	100.0	14.3	23.1	100.0	0.0	43.8
Tutorials	77.8	57.1	92.3	100.0	100.0	81.3
Interactive video	0.0	0.0	0.0	0.0	0.0	0.0
Remediation	44.4	0.0	46.2	0.0	0.0	31.3
Core instruction	33.3	14.3	30.8	0.0	0.0	25.0
Enrichment	100.0	14.3	76.9	100.0	100.0	71.9
Other	0.0	0.0	0.0	0.0	100.0	6.3
Grouping						
Demonstration	66.7	57.1	57.1	0.0	100.0	60.6
Individuals	77.8	57.1	92.9	100.0	100.0	81.8
Small groups	77.8	57.1	64.3	100.0	100.0	69.7
Whole groups	11.1	28.6	57.1	100.0	100.0	42.4
Other	0.0	0.0	0.0	0.0	100.0	6.1
Do teach about micros	66.7	50.0	35.7	0.0	100.0	50.0
Computer topics						
History of computing	16.7	0.0	16.7	0.0	0.0	11.8
Awareness	50.0	0.0	33.3	0.0	100.0	41.2
Operation	100.0	66.7	100.0	0.0	100.0	94.1
How computers work	50.0	0.0	33.3	0.0	0.0	29.4
How used in science	66.7	100.0	50.0	0.0	0.0	58.8
Other	0.0	33.3	16.7	0.0	0.0	11.8
Do teach programming	11.1	14.3	28.6	0.0	0.0	18.2
If yes for the previous item, purpose of student programs						
Students write programs	100.0	0.0	50.0	0.0	0.0	50.0
To solve science problems	0.0	100.0	75.0	0.0	0.0	66.7
To develop instruc. soft.	0.0	0.0	25.0	0.0	0.0	16.7
To develop manage. soft.	0.0	0.0	50.0	0.0	0.0	33.3
Other	0.0	0.0	0.0	0.0	0.0	0.0
ENLIST Micros good	100.0	100.0	71.4	100.0	100.0	90.0
Trained others	66.7	55.6	53.8	50.0	66.7	59.0

Table 4b

Microcomputer Use in Science Teaching Checklist by Grade Assignment

Means for Continuous Variables

Item	K-6	7-9	9-12	7-12	Admin	Total
Computer availability						
Number of Apple II	9.8	13.5	6.2	7.0	8.0	9.6
Number of IBM pc	0.0	0.1	0.2	0.0	0.0	0.1
Number of Mac	0.1	0.0	0.0	0.0	0.0	0.0
Number of Radio Shack	0.0	0.0	0.0	0.0	0.0	0.0
Number of Commodore	3.2	1.9	0.0	0.0	0.0	1.6
Number of Others	0.2	0.0	0.3	0.0	0.0	0.2
Software availability						
Number of science soft.	6.5	7.1	8.7	6.0	0.0	6.9
Number of manage. soft.	0.3	1.7	1.7	0.5	0.0	1.1
Software $ for you	21	61	54	400	0	62
Software $ for district	67	356	2505	1000	833	1089
No. of teachers helped	3.5	5.3	3.6	6.0	3.0	4.0

We found after training that 83.8 percent of the participants indicated they were using microcomputers in science teaching; the percent of use increased from elementary school to high school. Remember that participants involved in the first year of the project were to be leaders of educational computing for science in their buildings. Prior to training 61.5 percent had used microcomputers in teaching science; the most dramatic increase in use, however, was among elementary teachers who increased from 27.2 percent to 75.0 percent users of microcomputers in science teaching. Contrast this with the lack of any increase in use found in the previous study (Baird, Ellis, and Kuerbis, 1987), where no follow-up training occurred. When we asked the participants to indicate the percentage of units in which they used microcomputers, we found that the majority used educational computing in less than half of the units. We believe this is because the participants gradually implemented educational computing during the year, as they learned more during the follow-up seminars. An interesting secondary effect was that 84.2 percent of the participants were using the computer to teach nonscience subjects.

The remaining MUST items assessed specific ways in which the participants used microcomputers to provide instruction or manage instruction. As we expected, the majority of participants used the microcomputer in recording grades and developing print material as ways to help them manage instruction. In addition, drill and practice, tutorials, and games were the most common approaches the participants used with the computer to provide instruction. We were pleased to find, however, that many of the participants had their students use the microcomputer as a tool to learn science—especially as a lab instrument, to record data, and to print reports.

We did not specifically teach the participants about the computer as an object of instruction; a majority of participants, however, indicated that they did teach about microcomputers, with nearly all of those who taught about microcomputers indicating they taught students how to operate a computer and how it is used in science. Only 18.2 percent indicated they had students write computer programs. The most common programs students wrote were programs to solve problems in science.

In the workshops and seminars, we demonstrated and asked participants to practice the use of the computer in a variety of instructional modes. Early in the training, most of the participants used only one or two modes of instruction with the computer; they demonstrated a piece of software to the whole class or they set up a computer in the back of the room as an enrichment center for individual students to use when they completed their homework. We wanted the participants to integrate the use of the computer into the mainstream of their instruction and we wanted all students to use the computer as a central component of learning. Therefore, we asked teachers to try using the computer with small groups, large groups, and with individual students. We found that for each of these ways of grouping students nearly three-fourths of the participants were using that type of grouping.

An important goal of the project is to develop a support network for teachers who use educational computing in science. During the first year of the project, we did not ask the participants to help other teachers to begin using microcomputers, because most were novice users themselves. We found, however, that 59.0 percent of the participants indicated that they had helped other teachers implement microcomputers. We plan to capitalize on the participants' willingness to help others in the remaining years of the project.

At the advisory committee meeting following the first year of training, the project staff reviewed the data they gathered during interviews and observations and from participants' journals. Those data supported the results of the MUST checklist.

Barriers to Implementation

Our final evaluation task was to determine the barriers to increased implementation of educational computing in school science. We asked participants to indicate on the MUST checklist the level of support from administrators and peers, the availability of microcomputers and software, and barriers to increased use. Table 5 lists the responses to items related to barriers to implementing microcomputers.

In general, the majority of the participants had some supplies and software available for using microcomputers in science teaching and felt that they had at least adequate support from fellow teachers and school administrators. The exception to this was that 51.6 percent of the participants felt they had poor or no support from their superintendents. The participants perceived that support for using microcomputers decreased the higher the level in the organizational structure, with the greatest support from teachers and the least from district-level administrators. By checking one or more of seven potential barriers to implementing microcomputers, the participants indicated that time to prepare and plan for use (69.2 percent checked this) and software availability (69.2 percent) were the most significant barriers and that personal lack of knowledge and skills (17.9 percent), personal lack of interest (0.0 percent), and student interest (0.0 percent) were not significant barriers.

Table 5

Microcomputer Use in Science Teaching Checklist by Grade Assignment

Percentages for Barriers

Item	K-6	7-9	9-12	7-12	Admin	Total
Supplies available	83.3	100.0	92.3	50.0	100.0	89.7
Poor or no support						
Department chair	25.0	42.9	18.2	0.0	0.0	27.3
Principal	18.2	55.6	15.4	0.0	0.0	29.4
Computing supervisor	20.0	50.0	50.0	0.0	0.0	42.9
Curriculum supervisor	25.0	50.0	42.9	0.0	0.0	38.9
Superintendent	33.3	83.3	50.0	100.0	0.0	51.6
Technician support	41.7	33.3	21.4	100.0	50.0	35.9
Fellow teachers	27.3	50.0	14.3	100.0	0.0	27.8
Other	0.0	0.0	0.0	0.0	0.0	0.0
Significant barriers						
Personal interest	0.0	0.0	0.0	0.0	0.0	0.0
Personal knowledge	25.0	25.0	14.3	0.0	0.0	17.9
Personal time	75.0	62.5	78.6	50.0	33.3	69.2
Equipment and supplies	58.3	37.5	50.0	50.0	0.0	46.2
Software	75.0	50.0	64.3	100.0	100.0	69.2
Support	25.0	25.0	14.3	50.0	0.0	20.5
Student interest	0.0	0.0	0.0	0.0	0.0	0.0
Other	16.7	0.0	14.3	50.0	33.3	15.4
If barriers removed more use	100.0	100.0	100.0	100.0	100.0	100.0

We asked the participants whether they would use the microcomputer more if the existing barriers were removed. One hundred percent indicated they would.

At the advisory committee meeting following the training, the project staff met and discussed the results of the MUST questionnaire, the participants' journals, informal interviews, and classroom observations. Table 6 lists the barriers the staff and advisory committee identified as the most significant impediments to implementing educational computing in school science. Barriers one and two are significant for many of the participants. Barriers three, four, and five are very significant for a minority of the participants. The last three barriers were overcome by the participants during our training; we feel, however, that for many teachers (particularly teachers not identified as potential leaders) these may be the most difficult barriers to overcome.

Table 6
Barriers to Use of Microcomputers

1. Time to preview courseware, order courseware, and plan and prepare lessons
2. Access to good software for science instruction
3. Availability of hardware and supplies
4. Support from central and building administration
5. Technical support
6. Changing approach to teaching
7. Fear of failure (self-efficacy)
8. Low priority (not a core component of curriculum)

DISCUSSION AND IMPLICATIONS

In general, the training workshops, seminars, and practicum were successful at increasing the participants' implementation of microcomputers. The changes on the Stages of Concern Questionnaire and the results of the checklist of microcomputer use in science teaching indicated that the participants were beginning the process of implementing microcomputers in science teaching. From research on the process of educational change, however, we know that it often takes three or more years for teachers to integrate a new teaching approach fully into their regularly used teaching tactics and strategies—what CBAM researchers (Hall and Hord, 1987) have termed "institutionalization." If we have interpreted the results correctly, we should find an increase in use of microcomputers as we continue our support of the participants during the last two years of the project. It is not possible, however, to generalize the results of this first-year's training to all science teachers, because district administrators hand picked the participants as potential leaders in their school science programs. After the second and third years of the project, when we will train science teachers who have not been identified as leaders, we should be able to make more appropriate generalizations.

The list of barriers to implementing microcomputers in school science is one aspect of the evaluation that we find very useful. We were surprised to find that microcomputers were available in some way or another to nearly all of the teachers. Just having them available, however, is not sufficient; it is important that the microcomputers be available to the teachers in their classrooms whenever they need them. Moreover, if the primary location of the microcomputers is in a computer laboratory, their use by teachers and students is minimal.

The most important barrier by far is the lack of time available to teachers to preview educational software, to plan appropriate uses of the software, and to manage the use of software. Few publishers have integrated software programs into a complete instructional package—including unit and lesson plans, laboratory worksheets, text readings for the students, and supplemental media resources. "The Voyage of the Mimi" (Bank Street College, 1986) is, however, one of the best examples in science that integrates the use of computer software into a larger instructional package.

Furthermore, the use of software in science teaching appears to be enhanced when teachers have access to software that is part of an instructional package.

Implications for Year Two

Following the first year of the project, the advisory committee met with project staff, three administrators from districts involved in the project, and two participants from year one to analyze the results of year one and to make recommendations for year two. The advisory committee recommended that the basic design of the teacher preparation activities for year two remain the same. In addition, the advisory committee recommended that we require the participants to write action plans to indicate and describe their commitment to implement educational computing and that we ask the participants to meet regularly in building teams to identify barriers and solutions to implementation.

Table 7 lists the tasks for new participants during year two.

Table 7
Tasks for New Participating Teachers

- Participate in teacher training activities.
- Assess personal and institutional strengths and weaknesses.
- Develop action plans.
- Interact with leader and team members.
- Review courseware.
- Design lessons and unit integrating educational computing.
- Use microcomputer to manage science instruction.
- Use microcomputer to enhance student learning of science.
- Discuss and evaluate personal use of educational computing.
- Observe and evaluate use by others.

Year two introduces the use of leaders to help the participants implement educational computing (figure 2). During the second advisory committee meeting, we used the results of year one to plan the leadership training activities for year two. All of the major components of the BSCS implementation model are in place during year two. We train leaders who work with building teams of three to five teachers to implement educational computing in science. The leaders participate in a 16-hour leadership workshop prior to the workshops for new participants and in four three-hour seminars during the school year.

Each seminar for leaders occurs two weeks prior to the participant seminar. The focus of the leadership training is to continue the study of how to use educational computing in school science, to learn and practice leadership skills such as peer coaching and small-group problem solving, to plan intervention strategies for use with building teams, and to plan the training workshops and seminars for the participants. The leaders are to attend all of the workshops and seminars for the participants and conduct many of the activities at those meetings. Table 8 lists the tasks for leaders for year two.

Table 8
Tasks for Leaders

- Improve personal implementation of educational computing in school science.
- Participate in leader preparation activities.
- Practice leadership skills.
- Assist with teacher preparation activities.
- Develop action plans.
- Lead building teams in implementation.
- Coach teams in implementation.
- Coach team members.
- Become liaison with administrators.
- Work to solve impediments to implementation.
- Build district and regional network and organizational structure.
- Monitor implementation.
- Evaluate project.
- Disseminate information.

As a result of the year one evaluation, we plan to involve superintendents, curriculum supervisors, and building principals more in year two of the project. We established an orientation for administrators for the beginning of the school year prior to the leader and participant training activities. The purpose of the orientation is to describe the project to the administrators, to review the commitments made by the participants and districts, and to ask the administrators to work with us and their teachers to implement educational computing. Table 9 lists the tasks we encouraged the administrators to perform.

Table 9
Strategies for Administrators

- Set educational computing as a priority in a memo and in discussions at staff meetings.
- Provide hardware, software, and supplies.
- Arrange release time to attend training, observe peers, and plan and prepare lessons.
- Establish building and district policies and procedures.
- Establish building, district, and regional committees on educational computing in science.
- Meet with building teams.
- Meet informally with participants and leaders.
- Participate in training seminars.
- Put microcomputer and software in teacher workroom.
- Establish highly visible pilot classrooms and schools for educational computing in science.
- Disseminate information on the project.

CONCLUSION

The most important finding from this study is that if one adheres to the guidelines for training teachers available from the literature on staff development and educational change, teachers can and will change their teaching behaviors. It is very easy, however, to underestimate the time and resources required to implement change in schools. Even a seemingly simple change such as educational computing, which teachers can implement in their individual classrooms without an overhaul of schools, is immensely complex and difficult. Helping teachers and schools change requires a systematic effort, with intensive on-going support over a period of three or more years. Science educators, school leaders, and the public must learn that school improvement is not an event but a continual process of renewal and refinement.

This study demonstrates the importance of allocating resources to staff development and implementation along with those for curriculum development. Fortunately, the National Science Foundation has recognized the importance of implementation in school improvement by requiring that implementation be an integral part of all curriculum development projects it funds. As Gene Hall (1986) says, "it is not enough to build pretty boxes; what is important is to get the boxes used."

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Appendix A

School Districts Participating in Year One

Agate School District Re-50
Agate, Colorado

Academy School District 20
Colorado Springs, Colorado

Big Sandy School District 100J
Simla, Colorado

Calhan School District RJ1
Calhan, Colorado

Colorado Springs School District 11
Colorado Springs, Colorado

Edison School District 54JT
Yoder, Colorado

Elbert School District 200
Elbert, Colorado

Falcon School District 49
Peyton, Colorado

Fountain School District 8
Fountain, Colorado

Harrison School District 2
Colorado Springs, Colorado

Lewis-Palmer School District 38
Monument, Colorado

Manitou Springs School District 14
Manitou Springs, Colorado

Miami-Yoder School District 60JT
Rush, Colorado

Peyton School District 23J
Peyton, Colorado

Widefield School District 3
Colorado Springs, Colorado

Woodland Park School District RE-2
Woodland Park, Colorado

Appendix B

Members of the Project Advisory Committee

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Appendix C

Microcomputer Use in Science Teaching Checklist

MICROCOMPUTER USE IN SCIENCE TEACHING CHECKLIST

Name ____________________ District ________________________

Date ____________________ School ________________________

Grade level K 1 2 3 4 5 6 7 8 9 10 11 12 Admin

[Circle the appropriate grade levels]

Subjects taught ____

1. Do you have microcomputers available in your school for science teaching?

______yes ______no

If yes, how many of each do you have available?

______Apple II
______IBM pc
______MacIntosh
______Radio Shack
______Commodore
______Other ____

If yes, how are the computers distributed? (check all that apply)

______one is in my room all of the time
______two or more are in my room all of the time
______one or more are available on a temporary basis to put in my room
______one or more are available in a location outside of my room
______computers are available in the computer lab
______other ____

2. How often do you teach science?

______100% of days in the school year
______ 75% of days in the school year
______ 50% of days in the school year
______ 25% of days in the school year
______ 0% of days in the school year

3. Do you use a microcomputer in science teaching?

______yes ______no

If yes, how often do you use a microcomputer in science teaching?

______with 100% of units
______with 75% of units
______with 50% of units
______with 25% of units
______with less than 25% of units

4. Are you using a microcomputer for teaching other subjects or for other purposes?

______yes ______no

If yes, describe the other uses:

____
____
____

IF YOU DO NOT USE THE MICROCOMPUTER IN TEACHING SCIENCE, SKIP TO QUESTION 11.

5. For which of the following tasks do you use the microcomputer to organize and manage instruction in science?

______developing, administering or scoring student tests
______recording student grades and progress
______developing print materials for student activities
______developing software for student activities
______organizing and inventorying supplies and equipment
______prescribing and directing student activities
______computing and performing analysis of data about students
______preparing administrative paperwork
______other ______________________________

6. In which of the following ways is the microcomputer used in your science class as a tool to enhance the learning of science?

______to gather data as a laboratory instrument
______to record and display data as tables or graphs
______to calculate and display statistics
______to organize and retrieve data in a database
______to retrieve information from a source with a telephone hookup
______to build and study models for phenomena and systems
______to prepare printed documents and reports from investigations by students
______other ______________________________

7. In which of the following ways is the microcomputer used in your science class to deliver instruction?

______drill and practice
______simulations
______tutorial
______interactive videodisc
______remediation
______core instruction
______enrichment
______other ______________________________

8. In which of the following methods do you make microcomputers available to your science students?

______demonstration
______individual work
______small groups
______whole class working on multiple computers simultaneously
______other ____

9. Are any of the microcomputer activities in your science course used to teach the students about microcomputers?

______yes ______no

If yes, what are your goals for teaching about microcomputers?

______history of computers
______awareness of the role in society
______how to operate a computer
______how a computer works
______how a computer is used in science
______other(s) ____

10. Do you have your science students write computer programs?

______yes ______no

If yes, what are the purposes of the programs?

______to learn how to write simple programs
______to learn how to use the computer to solve problems in science
______to develop educational software to teach science to other students
______to develop programs to help you manage instruction
______other

11. Do you have any software and supplies available for using microcomputers in your science teaching?

    ______yes______no

    If yes, how much do you have available?

    ______number of pieces of software for science instruction
    ______number of pieces of software for managing instruction
    ______expenditure each year for software and supplies you can use just in your classroom

12. How much assistance and encouragement does your administration provide for your use of microcomputers in science teaching? (fill in blank with the appropriate number)

    (1) maximum (2) strong (3) adequate (4) poor (5) none

    ______department chair
    ______building principal
    ______educational computing supervisor
    ______curriculum supervisor
    ______superintendent
    ______other ________________________________

13. How much technical support is available to help you for your use of microcomputers in science teaching?

    ______maximum
    ______strong
    ______adequate
    ______poor
    ______none

14. How much support do your fellow teachers give you for your use of microcomputers in science teaching?

______maximum
______strong
______adequate
______poor
______none

15. What are the most significant barriers to increasing your use of microcomputers in science teaching?

______personal lack of interest
______personal lack of knowledge and skills
______time available to plan and prepare for use
______availability of equipment and supplies
______support from administration and other teachers
______interest of students
______other ____

16. If the existing barriers were removed, would you use the microcomputer

______the same ______ more ______ less?

17. Do you feel that your participation in the ENLIST-Micros workshop effected your use of computers?

______yes______no

If yes, what has been the effect?

____
____
____

What specific computer uses can you attribute to your participation in the *ENLIST Micros* workshop?

____
____
____

18. Have you used skills acquired in the ENLIST-Micros workshop to help other teachers begin using microcomputers?

    _____yes _____no

    If yes, how many have you helped? ____________________

    What skills did you help the other teacher(s) acquire?

    ____
    ____
    ____

19. What is the most valuable use of microcomputers for teachers?

    ____
    ____
    ____

20. Do you have any questions or other information you would like to share on the subjects addressed in this interview/questionnaire?

    ____
    ____
    ____

Appendix D

Stages of Concern Questionnaire

Concerns Questionnaire

Name ______________________________

In order to identify these data, please give us the last four digits of your Social Security number:

___ ___ ___ ___

The purpose of this questionnaire is to determine what people who are using or thinking about various programs are concerned about at various times during the innovation adoption process. The items were developed from typical responses of school and college teachers who ranged from no knowledge at all about various programs to many years experience in using them. Therefore, **a good part of the items on this questionnaire may appear to be of little relevance or irrelevant to you at this time.** For the completely irrelevant items, please circle "0" on the scale. Other items will represent those concerns you **do** have, in varying degrees of intensity, and should be marked higher on the scale.

For example:

This statement is very true of me at this time.	0 1 2 3 4 5 6 (7)
This statement is somewhat true of me now.	0 1 2 3 (4) 5 6 7
This statement is not at all true of me at this time.	0 (1) 2 3 4 5 6 7
This statement seems irrelevant to me.	(0) 1 2 3 4 5 6 7

Please respond to items in terms of **your present concerns**, or how you feel about your involvement or potential involvement with *Using Microcomputers in Science Teaching.* We do not hold to any one definition of this innovation, so please think of it in terms of **your own perception** of what it involves. Since this questionnaire is used for a variety of innovations, the name *Using Microcomputers in Science Teaching* never appears. However, phrases such as "the innovation," "this approach," and "the new system" all refer to *Using Microcomputers in Science Teaching.* Remember to respond to each item in terms of **your present concerns** about your involvement or potential involvement with *Using Microcomputers in Science Teaching.*

SoC Questionnaire Items - Using Microcomputers in Science Teaching

0	1	2	3	4	5	6	7
Irrelevant	Not true of me now		Somewhat true of me now			Very true of me now	

1.	I am concerned about students' attitudes toward this innovation.	0 1 2 3 4 5 6 7
2.	I now know of some other approaches that might work better.	0 1 2 3 4 5 6 7
3.	I don't even know what the innovation is.	0 1 2 3 4 5 6 7
4.	I am concerned about not having enough time to organize myself each day.	0 1 2 3 4 5 6 7
5.	I would like to help other faculty in their use of the innovation.	0 1 2 3 4 5 6 7
6.	I have a very limited knowledge about the innovation.	0 1 2 3 4 5 6 7
7.	I would like to know the effect of reorganization on my professional status.	0 1 2 3 4 5 6 7
8.	I am concerned about conflict between my interests and my responsibilities.	0 1 2 3 4 5 6 7
9.	I am concerned about revising my use of the innovation.	0 1 2 3 4 5 6 7
10.	I would like to develop working relationships with both our faculty and outside faculty using this innovation.	0 1 2 3 4 5 6 7
11.	I am concerned about how the innovation affects students.	0 1 2 3 4 5 6 7
12.	I am not concerned about this innovation.	0 1 2 3 4 5 6 7
13.	I would like to know who will make the decisions in the new system.	0 1 2 3 4 5 6 7
14.	I would like to discuss the possibility of using the innovation.	0 1 2 3 4 5 6 7
15.	I would like to know what resources are available if we decide to adopt this innovation.	0 1 2 3 4 5 6 7
16.	I am concerned about my inability to manage all the innovation requires.	0 1 2 3 4 5 6 7
17.	I would like to know how my teaching or administration is supposed to change.	0 1 2 3 4 5 6 7
18.	I would like to familiarize other departments or persons with the progress of this new approach.	0 1 2 3 4 5 6 7

0	1	2	3	4	5	6	7
Irrelevant	Not true of me now		Somewhat true of me now			Very true of me now	

19.	I am concerned about evaluating my impact on students.	0 1 2 3 4 5 6 7
20.	I would like to revise the innovation's instructional approach.	0 1 2 3 4 5 6 7
21.	I am completely occupied with other things.	0 1 2 3 4 5 6 7
22.	I would like to modify our use of the innovation based on the experiences of our students.	0 1 2 3 4 5 6 7
23.	Although I don't know about this innovation, I am concerned about things in the area.	0 1 2 3 4 5 6 7
24.	I would like to excite my students about their part in this approach.	0 1 2 3 4 5 6 7
25.	I am concerned about time spent working with nonacademic problems related to this innovation.	0 1 2 3 4 5 6 7
26.	I would like to know what the use of the innovation will require in the immediate future.	0 1 2 3 4 5 6 7
27.	I would like to coordinate my efforts with others to maximize the innovation's effects.	0 1 2 3 4 5 6 7
28.	I would like to have more information on time and energy commitments required by this innovation.	0 1 2 3 4 5 6 7
29.	I would like to know what other faculty are doing in this area.	0 1 2 3 4 5 6 7
30.	At this time, I am not interested in learning about this innovation.	0 1 2 3 4 5 6 7
31.	I would like to determine how to supplement, enhance, or replace the innovation.	0 1 2 3 4 5 6 7
32.	I would like to use feedback from students to change the program.	0 1 2 3 4 5 6 7
33.	I would like to know how my role will change when I am using the innovation.	0 1 2 3 4 5 6 7
34.	Coordination of tasks and people is taking too much of my time.	0 1 2 3 4 5 6 7
35.	I would like to know how this innovation is better than what we have now.	0 1 2 3 4 5 6 7

Using Mi-rocomputers in Science Teaching

PLEASE COMPLETE THE FOLLOWING:

1. What level is your assignment? _____K-6 ______6-9 ______9-12 ______K-12

2. Female ______ Male ______

3. Age: ____20-29 _____30-39 _____40-49 _____50-59 _____60-69

4. Highest degree earned:

________Associate _______Bachelor ______Masters _____Doctorate

5. Number of years teaching: ____________

6. Number of years in present school: ____________

7. How long have you been using microcomputers in science teaching, not counting this year?

________never _______one year ________two years _______three years _______four years _______five years or more

8. In your use of microcomputers in science teaching, do you consider yourself a:

____nonuser ____novice ____intermediate ____old hand ___past user

9. Have you received any formal training in using microcomputers in science teaching (workshops, courses)?

yes ________no ________ If yes, please describe briefly.

____

____

10. Are you currently in the first or second year of use of some major innovation or program other than using microcomputers in science teaching?

yes ________no ________ If yes, please describe briefly.

____

____

11. Please check to see that you have written the last four digits of your Social Security number on the front page of this questionnaire. Thank you for your help.