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ABSTRACT

The Biological Sciences Curriculum Study (BSCS), with support from the National Science Foundation (NSF), is conducting the third phase of ENLIST Micros. ENLIST Micros: Phase I developed a set of training materials that present the knowledge and skills that science teachers need to use microcomputers in science teaching. Phase II developed a model for implementing microcomputers in science teaching. ENLIST Micros: Phase III builds on the first two phases to achieve the following major goals: (1) help teacher (K-12) improve their use of microcomputers in science teaching; (2) test three models for establishing a teacher enhancement project at sites throughout the nation; (3) determine the ability of regional sites to sustain a teacher enhancement project while phasing out external support; and (4) disseminate information about how to establish successful, self-sustaining teacher centers for improving science teaching. The need for educational reform, strategies for implementing microcomputers in science instruction, the ENLIST Micros implementation model, and extending ENLIST Micros throughout the United States are topics of discussion. (70 references) (KR)

ENLIST Micros: Phase III

Models For Establishing ENLIST Micros Teacher Centers

by

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ENLIST Micros: Phase III
Models for Establishing ENLIST Micros Teacher Centers

The Biological Sciences Curriculum Study (BSCS), with support from the National Science Foundation (NSF), is conducting the third phase of *ENLIST Micros*. *ENLIST Micros: Phase I* developed a set of training materials (text, instructor's guide, videotape programs, and computer software) that present the knowledge and skills that science teachers need to use microcomputers in science teaching. *Phase II* developed a model (leaders and building teams attending workshops and seminars and supporting each other) for implementing microcomputers in science teaching. *ENLIST Micros: Phase III*, a 42-month project that began February 1989, builds on the first two phases to achieve the following major goals:

- Help teachers (K-12) improve their use of microcomputers in science teaching.
- Test three models for establishing a teacher enhancement project at sites throughout the nation.
- Determine the ability of regional sites to sustain a teacher enhancement project while phasing out external support.
- Disseminate information about how to establish successful, self-sustaining teacher centers for improving science teaching.

The Need

More than 300 national reports have addressed the need for reform in education. Several of those reports mention the need for more and better use of information technologies in education (Association for the Education of Teachers of 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). The National Science Foundation showed leadership 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). Paul DeHart Hurd explained further that "quite likely, the disadvantaged learners of the near future will be those who lack the skills to exploit the micro-electronic information resource and synthesize the findings" (Hurd, NSF, 1982, p. 11).

From some statistics one might think schools have heeded those reports and that computers are used widely. Schools in the United States have purchased more than one million microcomputers (OTA, 1988). Publishers market more than 1,000 pieces of software for science instruction (OTA, 1988). Eight-five percent of students in one study, however, reported having never used a computer in science class (Martinez and Mead, 1988). Furthermore, when surveys asked teachers how much they use the computer to provide instruction in science, teachers indicated that typical science students spent fewer than 15 minutes per week working with computers (Weiss, 1987), that only six percent used microcomputers at least one hour per week per class (Lehman, 1985), and that computer usage in science classes occupied about three to six percent of the instructional time students spend on computers (Becker, 1987). Various surveys have found that only 15 to 40 percent of science teachers report using microcomputers (Lehman, 1985; Kherlopian and Dickey, 1985; Weiss, 1987; and Becker, 1987).

Teacher development may be the key to helping improve the use of microcomputers in science teaching. Weiss (1987) found that half or more of the science teachers at each grade level felt totally or somewhat unprepared to use computers as an instructional tool. Other researchers similarly have concluded that science teachers need more training to implement educational computing (Lehman, 1985; Kherlopian and Dickey, 1985; Weiss, 1987; Lamon, 1987; Winkler, 1986; and Roblyer, 1986).

Few colleges, however, provide educational computing courses for science teachers. Lehman (1986) surveyed colleges and universities to determine the kind of courses on educational computing available to science teachers. He found that only 24.5 percent of the institutions offered courses on instructional computing for science teachers and that only six percent required any type of field experience with microcomputers in science classrooms. Only 25 percent required courses on educational computing for certification.

Strategies for Implementing Microcomputers in Science Instruction

Research on educational change and staff development provides recommendations for how to implement educational innovations. Research on educational change identifies some of the reasons that teachers have been slow to respond to the call for increased use of microcomputers. Research on staff development describes how teachers learn and develop new skills and identifies effective strategies for the professional development of teachers. Both areas of research were applied in developing the *ENLIST Micros* model for implementing microcomputers in science teaching.

Educational Change Theory

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 (1986) found that it takes three or more years for teachers to make a substantial change in teaching.

Getting teachers to implement a new innovation, such as instructional computing, requires the commitment of the teachers. Consequently, several researchers (Beall and Harty, 1984; Berman and McLaughlin, 1977; Fullan, 1982; Rogers, 1983; Bandura, 1977; Smith, 1987; Fullan, Miles, and Anderson, 1988; Rogers and Shoemaker, 1971) have studied factors related to a teacher's proneness to implement microcomputers. A synthesis of those factors yields the following:

- The teacher must have confidence that he/she can successfully use a microcomputer (self efficacy).
- The teacher must believe that microcomputers can improve their teaching, ease some teaching tasks, and improve student learning (efficacy of educational technology). Achieving good and relatively immediate student results is one of the keys to attaining commitment from teachers.
- The teacher must believe that the costs of learning to use the microcomputer and of changing their teaching behaviors and materials ultimately will be less than the benefits gained from using microcomputers (practicality ethic). Practical innovations address student and teacher needs, fit well with the current teaching situation, and include concrete how-to-do-it information.
- The teacher must perceive that the educational technologies are not too complex to master and implement, that he/she can experiment with educational technologies on a limited basis in a low-risk environment, and that the use of microcomputers will receive positive notice by others.
- The teacher must believe that microcomputers are part of the established curriculum and that they are not just another fad.

The *ENLIST Micros* program attends to the issue of implementation proneness; it is designed to be an enjoyable and non-threatening experience for teachers. Teachers meet and work not only with teachers from their building but with teachers from other buildings in their district and with teachers from other districts, which reduces some of the pressure associated with risking failure in front of ones closest peers. Throughout the training, we have experienced teachers demonstrate practical approaches they employ to integrate the use of microcomputers into science teaching. The teachers also work extensively in small groups in which one of the members is a mentor teacher that has had success with instructional computing. We try to remove some of the pressure on the teachers by asking each teacher to determine the initial applications that he/she will experiment with in the classroom. The teachers develop their own plan for which applications to use, how much to use microcomputers, and when to use microcomputers in their classrooms. We take it slow and only ask that by the end of the first year the teacher will have reviewed several pieces of software, designed one or more lessons integrating microcomputers into other traditional activities, tried one or more lessons using microcomputers with their students, and participated in peer coaching one or more times. By letting the teachers establish their own goals and expectations, we find that we eliminate much of the computer anxiety that often blocks the teacher from the initial exploratory use of microcomputers.

In addition to the factors influencing implementation proneness, researchers (Fullan, Miles, and Anderson, 1988; Ellis, 1989a; Ellis and Kuerbis, 1987; Kuerbis and Loucks-Horsley, 1989; Edmonds, 1979; Kelley, 1980; Leithwood and Montogomery, 1981; Brickell, 1963; Emrick and Peterson, 1978; Fullan, 1982; Loucks and Zacchei, 1983; Meister, 1984; Sarason, 1971; Becker, 1986; Yin and White, 1984; Goor and Farris, 1982; National Commission for Employment Policy, 1985; Gray, 1984; Grady, 1983; White and Rampy, 1983; Watt and Watt, 1986; Winkler and Stasz, 1985) also have identified several factors that influence the successful implementation of microcomputers. These factors are as follows:

Related to Training and Consultation Support

- The teacher must participate in quality training activities.
- The teacher must receive follow-up consultation, support, and encouragement. The teacher must have the opportunity to practice the use of microcomputers with individual feedback (coaching) back in the classroom.
- The teacher must provide feedback about the implementation project and about his/her use of microcomputers, and schools systems must use that information to plan additional inservice and assistance, materials support, and possible modifications in plans, organizational arrangements, and the innovation itself.
- The teacher must have a clear picture of how microcomputers can improve science teaching.

Related to School District Support

- The school district must give the teachers time to participate in training, to plan lessons, to review software, and to collaborate with fellow teachers.
- The school district must provide the teachers and students easy access to microcomputers.
- The school district must provide the teacher and students easy access to sufficient quantities of good software.
- The central office of the school district must sanction and clarify the need for the use of microcomputers, give clear and consistent communication and pressure, provide assistance and resources for training, consultation, release time, and materials.
- The school district and building administrators must collaborate with teachers in developing a clear, long-range plan for implementing the use of microcomputers in the schools.
- The school district must form building implementation teams that have a shared vision of the change process, agree on and conduct a clear plan for implementation, provide technical coaching and assistance, arrange training, reinforce attempts to change, and put the program in the spotlight for everyone in the school community.
- The school district must provide incentive and psychic rewards to teachers, including special recognition, released time, salary credit, and technical support.
- The school board and community must support the need for implementing microcomputers in the schools.
- The principal must take an active role in initiating, sanctioning, supporting, and responding to the use of microcomputers. The principal must provide teachers access to resources, training, and assistance from others.
- The principal must establish in the school a positive environment conducive to change. The teacher must feel able to explore new approaches and to risk failure.
- The teacher must agree with administrators and other participating teachers on the need, appropriateness, and priority of using microcomputers in science teaching.
- The teacher must be involved in designing the implementation plan, selecting hardware and software, organizing the placement of hardware, scheduling the use of hardware, and training other teachers.

In addition to those above, Hord and Huling-Austin (1986, p. 97) 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."

The *ENLIST Micros* program has paid careful attention to those factors related to the successful implementation of microcomputers, which are listed above. The project has considerable control over the factors related to the quality and quantity of training and some control over the consultation support. The major focus of *ENLIST Micros III* is to train trainers to implement the *ENLIST Micros* program according to protocols that BSCS has developed while field testing the program for several years. BSCS has developed a set of course materials that provides information on how to integrate microcomputers into science instruction and an implementation guide that describes in detail the organization and activities for the training workshops and seminars as well as providing background readings and hard copies of transparencies for presentations. The instructors, therefore, work from a standard course template and supporting instructional materials. The instructors, however, must obtain input from participating teachers and administrators to help tailor the course to local needs and must be flexible and willing to make changes in the course as the training progresses.

For each *ENLIST Micros* project, BSCS recommends that an implementation team form to manage the project and to provide training and consultative support. The implementation team should dedicate the equivalent of 15 - 25 percent of one full-time position to managing the project, 15 - 25 percent to providing instruction, and 25 - 50 percent to providing consultative support to participating teachers in their schools. In some districts, a computer coordinator or science supervisor provides additional consultative support to the teachers. The mentor teachers, however, are the key component of follow-up support. Mentor teachers are assigned to building teams of participating teachers and meet with them on a regular basis and are expected to provide peer coaching and collegial support.

The project encourages the districts to support the implementation of microcomputers in science instruction. The school districts participate in the project on a voluntary basis and make a substantial contribution to the project (as much as $25,000 in cost sharing), which engenders a substantive commitment. The amount of support, however, differs from district to district, according to the resources available and the priority the district places on instructional computing and science education. Nearly every school district provides substitutes for the teachers for the initial two-day workshop, and several have released the teachers for peer coaching and to review software and plan lessons. Furthermore, results from the field test indicate that as a district participates in the project the availability of microcomputers and software available for science teachers increases dramatically to where most teachers report that hardware and software are no longer the major obstacles to increased implementation. Where the school district does not make a clear and substantial commitment and the principal does not support the project, however, teachers in those situations rarely make the same amount of progress in implementing microcomputers in science instruction.

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, however, by offering a one-shot workshop that may improve the teachers' concepts and attitudes, but often produces no change in teaching behaviors.

During the past three years, the *ENLIST Micros* training program has evolved through feedback from field testing the training strategies and 18 school districts with more than 400 teachers and through continually updating the program by applying research findings from other studies. Several studies (Wu, 1987; Stecher and Solorzano, 1987; Smith, 1987; BSCS, 1989; Stasz and Shavelson, 1985) have confirmed the following factors, which are employed in *ENLIST Micros* training programs, as characteristics of successful courses on the instructional use of microcomputers:

- Voluntary participation by teachers.
- Multiple training sessions offered over an extended period of time (one semester or more), coupled with follow-up support in the classroom.
- Credible and knowledgeable instructors. (Teachers often prefer other teachers as instructors.)
- Ongoing involvement of teachers in planning the course. (The instructors must be flexible and willing to adapt the course to the needs of the teachers.)
- Inservice activities matched to the experience and concerns of the teachers.
- Extensive hands-on practice with microcomputers that progresses from simple to complex exercises.
- Experience with applications of microcomputers that offer promise for improving science education, including tools for data acquisition (MBL) and data analysis (spreadsheet, database, telecommunications, graphing, and statistical packages), simulation, modeling, and communications (word processing and telecommunications).
- Comfortable, relaxed, low-risk environment.
- Appropriate balance between lecture and guided practice.
- Individualized attention.
- Clear expectations and relevant objectives.
- Practical, classroom-related materials and handouts.
- Inservice lessons linked to instruction.
- Peer interaction (teachers working together and sharing ideas in small groups).
- Recognition that computer use is a very complex task.
- Assistance for teachers in making the transition from theory into practice.

As stated above, follow-up in the classroom (coaching) is needed to change teaching behaviors. 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. Showers (1985) and Leggett and Hoyle (1987) recommend 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; organizing teacher sharing sessions about successful and unsuccessful lessons, and helping with the location and production of materials.

The ENLIST Micros Implementation Model

BSCS has developed a model and materials for helping K-12 teachers integrate microcomputers into science instruction. EME is the publisher of the *ENLIST Micros* text for the teachers, a video that models appropriate applications of microcomputers in science teaching, and two disks of software that provide a tutorial and segments of programs on software applications for science instruction (Ellis and Kuerbis, 1989; Ellis and Kuerbis, 1987). These materials are the backbone of the *ENLIST Micros* training program. BSCS has expanded the program into a comprehensive staff development program that includes training over time and substantive follow-up support in the classroom. We have developed and evaluated the *ENLIST Micros* training program with 18 school districts in the Pikes Peak region over a period of three years (Ellis, 1989a; Ellis and Kuerbis, 1988; and Ellis, 1989b). The program continues in the Pikes Peak region and remains to provide feedback for improving the implementation model.

Training Materials

BSCS based the *ENLIST Micros* text on a national needs assessment of school administrators, science teachers, science educators, and computer educators (Baird, Ellis, and Kuerbis, 1989; Ellis and Kuerbis, 1985). The text begins with an introductory chapter that orients the teacher to the use of microcomputers. This chapter is optional because most teachers have experience with basic operations. The second section provides an introduction to using microcomputers in science teaching, with chapters on appropriate applications of microcomputers in science teaching, how to integrate microcomputers into science teaching, how to locate and select science software, and an overview of available resources for information on using microcomputers. The last three chapters – with information on tool uses of the microcomputer, ideas about how to increase the implementation of microcomputers, and a final chapter on evaluating courseware – provide information for experienced users who may want additional information and may be in leadership roles in their schools. Each chapter includes readings about the topics being discussed and refers to sections of the accompanying video and computer software. The chapters suggest whole class, small group, and individual activities through which the teachers might learn the material.

The videotape includes four programs to accompany the text. The first video program presents a series of interviews with teachers and administrators discussing the use of computers in science teaching and is an ice breaker for reducing the teachers' anxieties about the personal consequences and costs of implementing microcomputers in science teaching. The second and third videos provide classroom scenes and interviews with teachers who are using various applications of microcomputers in their classrooms. The third video focuses on instructional strategies, including cooperative learning and a constructivist approach to learning, that promote the integration of microcomputers into instruction. The fourth video is an audio-slide presentation of how to use the *NSTA Microcomputer Software Evaluation Instrument* (Klopfer, 1983) to evaluate a software package.

The computer software provides sample segments from various applications, including a simulation, microcomputer-based laboratory package, on-line database, game, tutorial, and drill-and-practice programs. Each sample segment is accompanied by an on-screen discussion of the features and benefits of the application.

Training Activities

ENLIST Micros provides two levels of training activities, one for novice users and one for experienced users who want to serve as mentor teachers for novice users (see figure 1). The

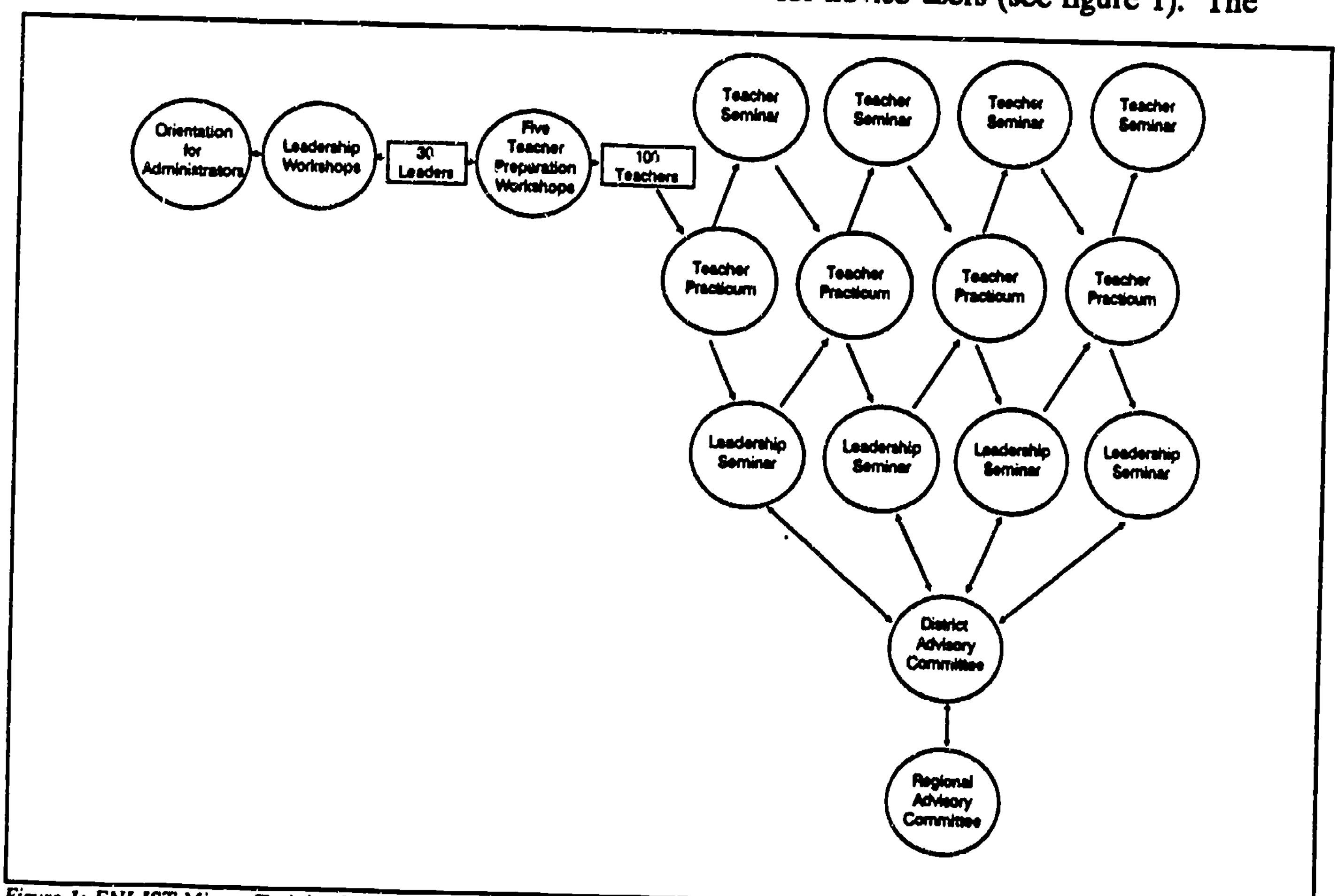

Figure 1: ENLIST Micros Training Model for one year's activities

program for novice users consists of an initial two-day workshop at the beginning of the school year followed by five after-school seminars scheduled throughout the school year. The first five chapters of the text provide the content of the two-day workshop for novice users. Approximately one-third of the time, the teachers are working in pairs or small groups reviewing software or designing lessons for a particular software package. Approximately one-third of the time, the course instructors provide the theory and rationale of how to integrate microcomputers into science instruction, and about one-third of the time, the participants work in small groups to discuss issues, identify potential barriers, and to make plans for their use of microcomputers. As their final task of the workshop, each participant develops an action plan for how they will implement microcomputers in their classrooms during the current school year.

Following the initial workshop, the participants meet once every four to six weeks for a seminar. The topics for the seminars are selected from those submitted by the participants. Seminars often consist of presentations during concurrent sessions, by teachers who are successful users of microcomputers, of lessons they have taught and of practical suggestions for how to integrate microcomputers into science instruction. A portion of each seminar is given over to forming special interest groups to study narrow topics, such as interactive laser discs, problem-solving software, microcomputer-based laboratory packages, applications of computer-based telecommunications, the use of spreadsheets or databases, tailoring AppleWorks for science teaching, locating and reviewing public domain software, and *The Voyage of the Mimi*. Participants form their own groups around areas of common interest. The presentations of practical applications by experienced teachers and the special interest groups provide the novice teachers with the practical knowledge they find useful and the interactions that they find rewarding. These experiences help instill confidence in the computer novices and help them translate into practice the research and content presented in the course.

Implementation Support

BSCS recognizes that training, no matter how effective, often is insufficient to successfully implement a complex innovation such as microcomputers. Successful implementation requires supporting the teachers as they go through the implementation process from planning to integrating the new practice into their teaching repertoire. *ENLIST Micros* provides for substantive on-going support of the teachers. The participating teachers are formed into implementation teams of four or five teachers with a mentor teacher as the leader. These teams should include teachers all from the same building, but occasionally teams consist of teachers from two or more buildings. Our experience indicates that teams with teachers from the same building are usually more successful, but a strong team leader can overcome the disadvantage of having members from more than one building.

The mentor teacher is the key to providing follow-up support and to helping teachers translate the training into practice. To prepare for their leadership role, the mentor teachers participate in a two-day leadership workshop and five follow-up seminars. During the leadership workshops, the mentor teachers learn about practical applications of research on educational change and staff development, discuss the *ENLIST Micros* implementation model, share ideas about how to support the novice teachers, and help plan the training program for the novice teachers. During the follow-up seminars the mentor teachers continue their study of staff development and educational change, discuss the issues and problems associated with helping their team members implement microcomputers, and help plan and prepare for the seminars for the novice teachers. The mentor teachers also conduct some of the training sessions for novice teachers and are to hold regular team meetings, provide collegial support, meet with team members individually, and provide peer coaching. Project staff visit the schools on a regular basis and meet with the mentor teachers to discuss the progress of their teams, teach lessons in the classrooms of participating teachers, help the teachers plan lessons, and observe some of the teachers as they teach lessons involving microcomputers.

Project staff also meet with school administrators to encourage them to sanction the project, to provide resources for the teachers, to meet with the participating teachers on a regular basis, and to provide support and encouragement. A few principals, computer coordinators, and science supervisors and one superintendent have completed all of the training and served as team leaders. It is not necessary for administrators to participate in the training for the implementation to be successful; the principal knowledgeable about the project and responsive to the needs of the participating teachers, however, is more likely to have a staff of teachers who successfully implement microcomputers.

Extending ENLIST Micros Throughout the United States

From February 1989 through August 1992, we shall develop, use, and evaluate three models for replicating *ENLIST Micros*, so that we can determine the most cost-effective approaches for replicating teacher enhancement projects, which help them become self-sustaining. During that time, we shall implement *ENLIST Micros* at 25 or more sites throughout the nation.

Trainer-of-Trainers Model

A trainer-of-trainers model is the most intensive model we are testing (see figure 2). Berger (1986) used this approach in a project to establish regional sites in Michigan to train teachers to use microcomputers. This approach provides the most intensive instruction and follow-up and is the most costly approach to disseminate training materials and methods; however, it is likely the most effective at getting sites to implement a new training program.

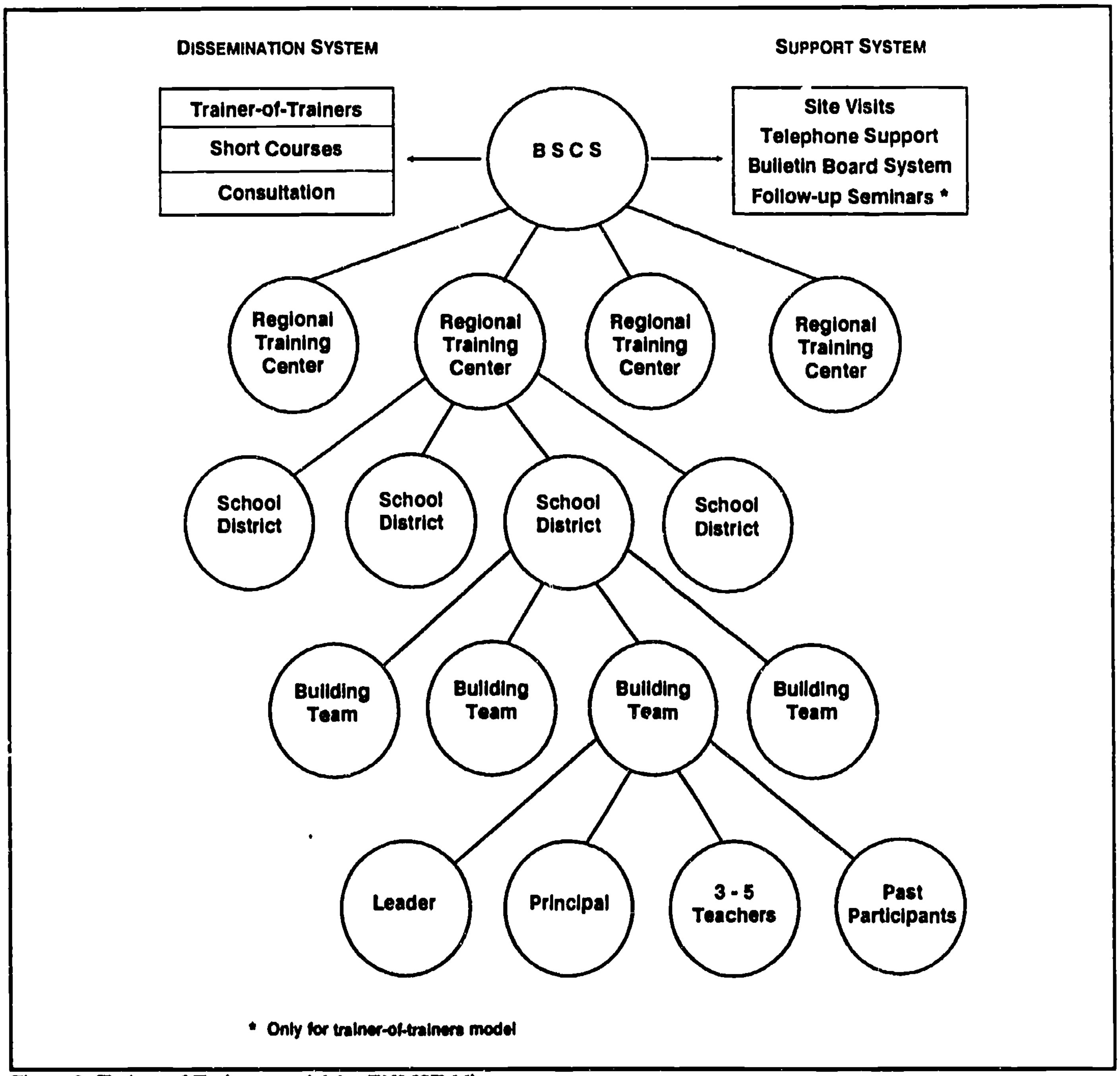

Figure 2: Trainer-of-Trainers model for ENLIST Micros

With the trainer-of-trainers (TOT) model, we shall provide in-depth training and follow-up support to implementation teams from 14 or more teacher centers around the nation. Each year in this model, we shall help implementation teams at four or five new teacher centers establish *ENLIST Micros*. Each year, BSCS staff, with advice from an advisory committee, selects, from available applicants, four or more sites to establish *ENLIST Micros* Teacher Centers. Each center commits to continuing the project for three years and to providing training and support to at least 50 teachers. The trainer-of-trainers model consists of a two-week summer institute, annual follow-up meetings, site visits by BSCS staff, and an electronic bulletin board system to enhance communication among sites. Staff from five centers attended a summer institute during 1989, and those centers are providing *ENLIST Micros* training and implementation support to more than 100 teachers during the 1989-90 school year. Figure 3 lists those five new centers and the original center in Colorado Springs.

The two-week summer institute presents the *ENLIST Micros* implementation model and materials, reviews the results of the field testing of the program, presents an in-depth review of research on educational change and staff development, and provides practical advice about conducting an *ENLIST Micros* implementation program. Each new teacher center sends three members of its staff to attend the summer institute. The first day of the institute is used to build relationships among the participants and to introduce the participants to the BSCS approach to using microcomputers in science teaching. During the second and third day, we conduct the two-day workshop that we use with novice teachers. The workshop is conducted as we would with novice teachers, with the exception that after each activity we take time to analyze what was done and why.

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Figure 3: ENLIST Micros Teacher Centers

Days four, five, and six of the institute are dedicated to presenting examples of applications of microcomputers for science teaching. A key feature is a full-day segment during which we take the participants through a unit on geological strata following the BSCS five-step instructional model (Bybee and Robertson, in press). Beginning on day seven, the remainder of the institute focuses on practical applications of the research on educational change and staff development; demonstrations and practice with additional state-of-the-art applications of microcomputers for science teaching, however, are scattered through these days. During the second week, a portion of each day is dedicated to the participants working with their center teams to develop plans for their projects. During the last day, each center team presents the implementation plan that will be the guide for its project for the next three years.

The center teams return to their regions and during the rest of the summer make the arrangements for their *ENLIST Micros* projects. BSCS continues to support the centers throughout their involvement in the project. A member of the BSCS staff visits each center twice during their first year of implementation and once during the second year; additional visits may be made at the request and support of the centers. During the site visit, the BSCS staff member may serve as a guest speaker at one of the training workshops or seminars, consult with center staff, or observe teachers in their classrooms and will interview center staff and participating teachers and administrators to gather information to evaluate the project.

Twice during the first year of participation and once in subsequent years, each center team will attend a follow-up leadership seminar, held at a regional or national meeting of the National Science Teachers Association. During the leadership seminars, guest speakers and project staff present additional information about implementation and staff development and the center teams share ideas about their implementation projects. At the second meeting, center teams present the results from the current year's project. The teams will have developed portfolios of documents that they use to provide evidence of their success.

Telephone and computer-based telecommunications are the other means by which BSCS staff will support the centers. Project staff will contact each center by phone on a regular basis to ascertain the status of their project. In addition, center staff will contact BSCS and other centers through the telephone and the use of the BSCS computer bulletin board. These forms of communication will augment the site visits and will be used to provide immediate consultative assistance to resolve problems as the arise.

Consultation Model

The consultation model for replicating *ENLIST Micros* involves BSCS staff serving as consultants and does not include any formal trainer-of-trainers program. In this model, school districts, intermediate educational agencies, or universities may request consultation to help establish their own teacher enhancement program. We might satisfy such a request by proving information about how to train teachers to use microcomputers in science teaching (the *ENLIST Micros* curriculum and model) and follow that with one or two visits to the site to help plan and conduct the training program.

The two-week summer institute and follow-up seminars are not part of the consultation model, which therefore is much less intensive and costly than the TOT model. NSF is not supporting this approach; centers are to support the consultation model through a service fee. We shall encourage these sites to implement the full *ENLIST Micros* program. Consultation is the typical model that many college faculty use when they provide inservice training. If this model is successful at establishing *ENLIST Micros*, then project directors of other teacher enhancement projects should be encouraged to follow this approach.

Dissemination Model

The dissemination model involves providing one-day workshops at national conventions to people who want to implement *ENLIST Micros*; follow-up is not part of this model. The workshop is an abbreviated version of the summer institute. Participants, however, are presented the material through lecture and small group discussion rather than through direct experience.

The dissemination workshop is a proven method to replicate educational projects. The National Diffusion Network (NDN) uses workshops effectively as its primary method to disseminate information about successful educational programs. The NDN approach usually involves a presentation by the project director that may last as long as one day. People interested in using the program attend the workshop, either in person or electronically.

Workshops may be the most cost-effective method of dissemination, because they place the burden for the major costs for travel and subsistence with the person being trained. In this approach, one trainer can disseminate information about a program to many potential users at the same time. The disadvantage is that the trainer has little opportunity to work with the user one-on-one and therefore can not help the user adapt the program to the site. Using this approach, in three years, we expect to disseminate information about ENLIST Micros to more than 100 trainers. We recommend that the trainers implement the complete *ENLIST Micros* program to achieve the best results.

Conclusion

During the past six years, BSCS has developed, tested, and refined a curriculum and implementation model for helping science teachers integrate the use of microcomputers in science teaching. BSCS has found the *ENLIST Micros* program to be effective with teachers in the Pikes Peak region of Colorado, which is continuing into its fifth year; the fourth and fifth years are supported entirely by the local school districts. During 1989-90, BSCS established five new teacher centers for *ENLIST Micros*. BSCS provided the staff from each of these centers with a two-week summer institute, two follow-up leadership seminars, two site visits, and consultative support via telephone and computer bulletin board. We have preliminary anecdotal information from the five new centers that *ENLIST Micros* is successful in other regions of the United States. BSCS staff, with the assistance of staff at each of the centers, is gathering information to evaluate the effectiveness of the trainer-of-trainers approach to replicating *ENLIST Micros* program at regional sites, which includes little or no direct interaction between BSCS and the school districts and teachers served in those regions. BSCS will use the results of this year's efforts to refine and improve the trainer-of-trainers program for the subsequent two years of the project, during which eight or more additional regional teacher centers will establish *ENLIST Micros* projects. BSCS will report the findings of this project following the completion of each year's work.

ENLIST Micros III is just one of several projects that are establishing teacher centers for the improvement of science instruction. For the Star Schools project, the Technical Education Research Centers (TERC) is establishing teacher centers to help middle school science and mathematics teachers implement projects including computer-based telecommunications. The BSCS also is establishing teacher centers for its project to develop a middle school science curriculum. The BSCS teacher centers for the middle school project will begin as field-test sites and evolve into primary teacher centers for implementing the curriculum. Each primary teacher center will train and support several additional secondary teacher centers that will help local teachers implement the BSCS middle school curriculum.

BSCS and TERC are involved in preliminary discussions about linking our teacher centers together into a nation-wide network. We would like to extend to other developers and trainers the opportunity to participate in this network of teacher centers. We believe that for centers to become self-sustaining they need initial seed money from external sources, which should be phased out over a period of a few years, assistance from developers to design the training materials and implementation models, and the opportunity to offer multiple implementation projects to local school districts. By supporting the implementation of several projects, the teacher center will be in a position to help the school districts select projects that best fit their needs, and the teacher center might generate sufficient local support to maintain a core staff.

The teacher is the key to improving instruction and student learning of science, and teachers require intensive, long-term training and support if they are to increase their knowledge and modify their teaching practices according to the current recommendations for reform in science education. BSCS and TERC believe that, with a network of teacher centers that provide intensive training and follow-up support to local school districts, we can bridge the gap between innovative science curricula and the successful implementation of those materials in science classrooms.

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