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ABSTRACT

The purposes of the Colorado Science Teaching Enhancement Program (CO-STEP) are to improve the background in science content and the instructional skills of teachers in grades four through six throughout Colorado and to support the implementation of effective instruction. A network of six Teacher Development Centers in Colorado coordinate teacher enhancement programs and follow-up implementation support. Physical science (physics, chemistry, geology, meteorology, and astronomy), life science, and environmental science content that is essential to teaching science in the upper-elementary grades is a central focus of the program. Teachers also learn how to infuse the science content into their curriculum and instruction. During the program teachers develop instructional skills, including cooperative learning, constructivist-based teaching strategies, and innovative assessment procedures. Participating teachers adapt instructional units from existing curriculum materials and field test, evaluate, and revise the units for use in their classrooms. This document discusses the project goals and objectives, project design, rationale for CO-STEP, general model of the teacher development program, the teacher development program, evaluation plan, evaluation results (quantitative and qualitative) for each of the centers, and conclusions. Contains 67 references. (LZ)

Intervening in the Professional Development of Science Teachers: The Colorado Science Teaching Enhancement Program

by

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Interim report of formative evaluation
of CO-STEP

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Intervening in the Professional Development of Science Teachers:
The Colorado Science Teaching Enhancement Program

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Figure 1: Center directors

The purposes of the Colorado Science Teaching Enhancement Program (CO-STEP) are to improve the background in science content and the instructional skills of teachers in grades four through six throughout Colorado and to support the implementation of effective instruction. During the fall of 1991, with support from BSCS and participating colleges and school districts, BSCS initiated a pilot test of the CO-STEP project at Centers in Colorado Springs and Pueblo. In June 1992, BSCS received support from the National Science Foundation to expand the pilot test to include a total of six Centers (see figure 1). During the past three years, BSCS has formed a network of six Teacher Development Centers in Colorado and has conducted a trainer-of-trainers program for instructors from those six Centers (Ellis and Maxwell, 1993). The Teacher Development Centers coordinate teacher enhancement programs and follow-up implementation support for teachers who participate in the project. Physical science (i.e., physics, chemistry, geology, meteorology, and astronomy), life science, and environmental science content that is essential to teaching science in the upper-elementary grades is a central focus of the teacher development program. Teachers also learn how to infuse the science content into their curriculum and instruction. Throughout the 60-months of support from the National Science Foundation (NSF), teachers develop instructional skills, including cooperative learning, constructivist-based teaching strategies, and innovative assessment procedures. Center staff and instructors model these instructional techniques for the participating teachers during the lectures, discussions, field activities, and laboratory sessions of the science courses. Participating teachers adapt instructional units from extant curriculum materials and field test, evaluate, and revise the units for use in their classrooms.

1.1 Project Goals and Objectives

The three goals of CO-STEP are: 1) to improve the science background of elementary teachers, 2) to help teachers apply new pedagogical strategies in teaching, and 3) to assist teachers in adapting instructional units for science education. CO-STEP has the following objectives:

- Establish a Colorado network of six Teacher Development Centers to support collaboration among science faculty, science educators, and teachers for the improvement of science instruction in upper-elementary grades
- Conduct a trainer-of-trainers program to prepare effective teacher educators for each Teacher Development Center
- Develop the leadership skills of teachers in grades four through six who will assist colleagues in improving science instruction
- Improve the understanding of science concepts, science processes, and the nature of science of teachers and their colleagues
- Enhance the science teaching methods of teachers and their colleagues
- Document the effectiveness of a teacher development model at enhancing the science knowledge and instructional skills of upper-elementary school science teachers
- Disseminate the teacher development model and effective approaches for teacher enhancement to teacher educators throughout the nation

1.2 Project Design

During the 60-months of support from NSF, the project staff will build an infrastructure to provide teacher development and follow-up implementation support directly to approximately 300 teachers and indirectly to 600 additional classroom teachers; these teachers will serve 25,000 students. CO-STEP will serve the teachers at a cost to NSF of approximately $1,700 per teacher

1.2.1 Teacher development network. BSCS has established in Colorado a state-wide network of six Teacher Development Centers Figure 2 presents the infrastructure of the teacher development network. Each Teacher Development Center (TDC) is a collaborative partnership among a university and one or more school districts Most sites are affiliated with her the Colorado systemic initiative or with the Colorado Alliance for Science Each TDC has a director and coordinator that are responsible for managing the NSF-supported aspects of the project. The Teacher Development Centers will continue beyond NSF support

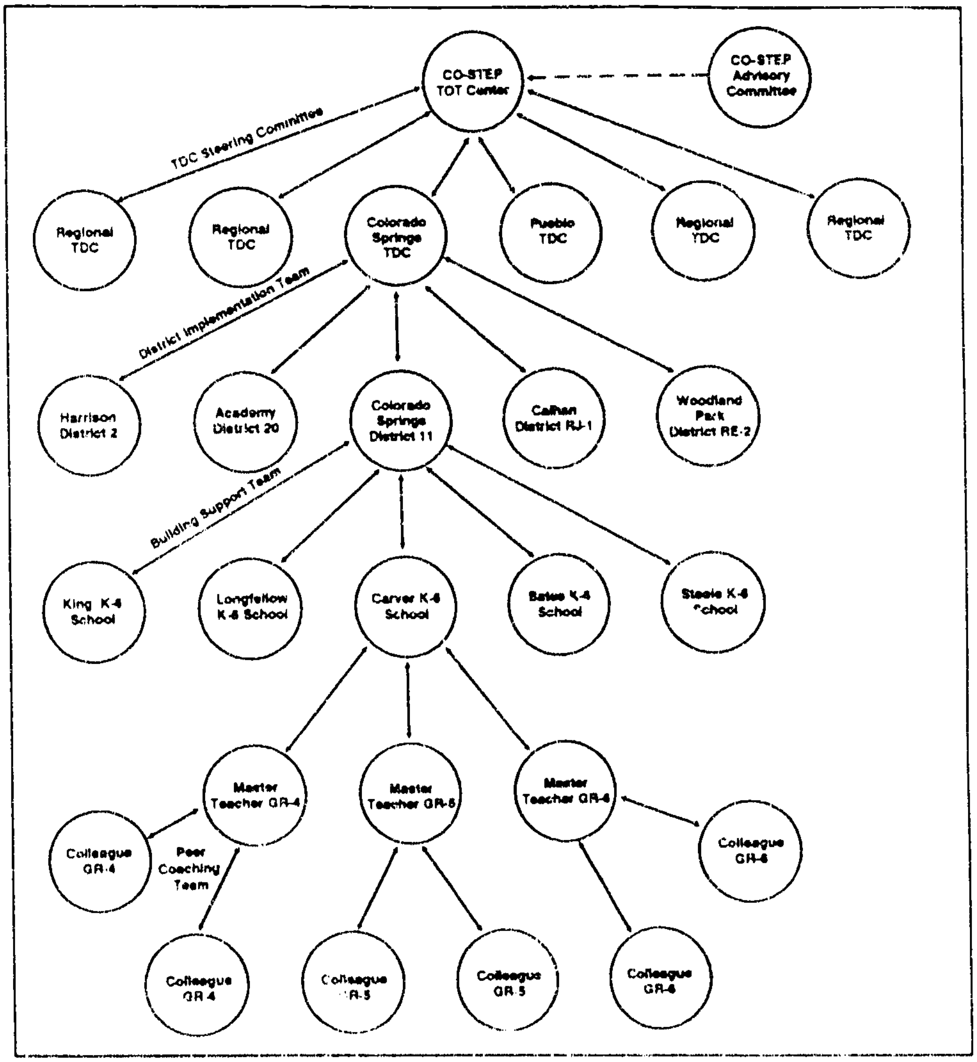

Figure 2 Teacher development network

1.2.2 Trainer-of-trainers program. BSCS is conducting a trainer-of-trainers (TOT) program for the staff from each of the six Teacher Development Centers A maximum of four staff members from each Center (e g , the Center director, the site coordinator, the site evaluator, and a master teacher and an administrator or both) are participating in the BSCS TOT program

To prepare the Centers to design, conduct, and evaluate their teacher development projects, BSCS is conducting the following TOT courses

- *TOT institute.* BSCS staff conducted a staff development program for the staff members from the Centers One institute was held during the summer of 1992 for the first four centers, and individual institutes were held for the last two centers as they joined the project. During the TOT institute, the Center staff studied the basic design for the teacher development program for CO-STEP, learned about the science content and instructional strategies that are the focus of the program, adapted the basic design to their situation, and developed an implementation plan for their project.

- *TOT seminar.* BSCS staff convene regular meetings (bi-monthly in years one and two and quarterly thereafter), at various sites throughout the state, to encourage project staff to share the results of their teacher development programs and to continue study of effective approaches to teacher development. BSCS staff also conduct two or more site visits to each Center during the school year. BSCS staff hold one seminar early each spring during which project staff review their Strategic Planning Course and Science Content Course and develop a course syllabus and implementation plan for their Curriculum Planning Course. BSCS staff also serve as guest speakers for each Center throughout the project.

Each Center receives the following incentives for participation in the project:

- One initial site visit by BSCS staff for consultation with the Center leadership team, school administrators, and teachers from all participating districts.
- Up to $30,000 in matching funds during the first year of participation, up to $20,000 during the second year, and up to $10,000 the third year. In addition, each of the Centers will receive a total of $45,000 to provide stipends to teachers for the summer institutes ($500 per teacher).
- Travel and living accommodations for four members of the Center staff to attend the TOT institute, workshops, and seminars.
- Follow-up consultation and support from BSCS staff, including site visits.

In return for support from BSCS and the Center, the Center asks each district participating in the Center to

- provide each participant with a maximum of six release days during each school year to attend the teacher development sessions and to participate in collaborative planning and coaching,
- support the costs for an administrator to coordinate the district program and to provide classroom support to participating teachers,
- allocate $500 to each participating elementary classroom teacher each year to purchase curricular materials and equipment, and
- authorize field trips for students to conduct science studies.

2.0 Rationale for CO-STEP

2.1 The Need

Citizens read daily and hear constantly about science issues such as earth quakes, mass transportation, communication technology, air pollution, water conservation, waste disposal, and global warming. In the last decade, the urgency of problems such as population growth, resource use, and environmental degradation has increased and expanded from the concerns of a few scientists to a crisis for many citizens. From local to global perspectives, the situation demands attention from an enlightened citizenry, an ideal that Jefferson felt was a prerequisite for an effective democracy. Unfortunately, the evidence indicates that American citizens are neither enlightened about nor attentive to science-related issues (Mullis and Jenkins, 1988, Miller et al., 1989).

Science education is in an era of reform. After more than a decade of reflection, study, and national reports, many large-scale projects of curriculum development and teacher education are underway. The inescapable presence of science and technology-related issues and the extensive reform of educational programs present the need and opportunity for improved science education. Establishing a substantial conceptual and experiential foundation during the elementary years seems the most reasonable place to begin developing a citizenry that both understands science and technology and acts to improve interactions with the world.

CO-STEP embodies the new directions in elementary school science exemplified in the following national reform efforts: *Project 2061: Science for All Americans* and *Benchmarks for Science Literacy* (AAAS, 1989, AAAS, 1993), *National Science Education Standards* (NRC, 1994), *Getting Started in Science: A Blueprint for Elementary School Science Education* (The National Center for Improving Science Education, 1989), and *New Designs for Elementary School Science and Health* (BSCS and IBM, 1989). Central to all three reports are the following recommendations. The new science programs should

- provide basic education in science and technology for all students.
- focus on major themes in science and technology;
- emphasize less content in greater depth;
- enable children to learn by constructing meaning from hands-on experience,
- incorporate cooperative learning; and
- coordinate with comprehensive school reform efforts involving schools, teachers, and the curriculum

Schools in the United States, however, have yet to act decisively in providing programs that will prepare students with the knowledge and skills they will need to address contemporary challenges such as oil spills, limited natural resources, starvation, the destruction of the rain forests, and future challenges yet unknown (AAAS, 1989). This is particularly true for minority students, who are becoming the majority of the students in public schools (AAAS, 1989; Hodgkinson, 1986, Vetter, 1988). BSCS designed this project, therefore, to establish a network of Centers to support the implementation of innovative curriculum and pedagogy in elementary school science.

But, there are barriers to science education during the elementary years. Research suggests that one of the barriers to science education stems from teachers' misgivings about their competence to teach science. Teachers with a poor background in science may not have the personal interest in nor commitment to educating students about the environment. The research indicates that this barrier is based upon poor science content and a lack of knowledge about how to approach the development of instructional activities (Ham and Sewing, 1988). Elementary science teachers especially are in need of content updates in physical science. The research on barriers to environmental education also indicates the effectiveness of having teachers experience a workshop designed to improve the content background and pedagogy of the teachers (Ham, Rellergert-Taylor, Krumpe, 1988).

2.2 Teacher Development Model

BSCS believes that a constructivist approach to instruction is appropriate not only for elementary students but for their teachers as well. Teacher development rather than teacher training is the focus of the proposed project. We would like the teachers to become reflective practitioners (Schon, 1991, Grimmett and Erickson, 1988, Mohr and MacLean, 1987, Cruickshank, 1987; Clift, Houston, and Pugach, 1990) who are empowered to study and implement improvements to their instructional practice (content and pedagogy). Throughout our work with the Center leadership teams we encourage these teams to use the following strategies to promote reflective teaching

- *Reflection on learning*: teachers use interviews of students, concept mapping, reflective note taking, analysis of case studies, and small group discussions to reflect on their own learning and students' learning
- *Reflection on self*: teachers keep a journal, write a personal biography, and develop a metaphor for their own teaching style
- *Reflection on action*: teachers use microteaching, videotapes of their own lessons, observations of expert teachers, study groups, peer coaching, and mentoring and conduct case study research
- *Reflection on program improvement*: teachers interpret results from interviews of students, parents, and other teachers, innovation configuration checklists, and student outcome data

For changes in the teaching of science in the elementary classroom to occur, teachers must learn about and experiment with the new pedagogy, such as a constructivist approach to learning, cooperative learning, and activity-based science (Little, 1982; Joyce and Showers, 1988). Teachers also need to improve their pedagogical content knowledge - knowledge about how to interpret science content for students. The introduction of teachers to the new pedagogy and science content for elementary science is central to the project. Through this model for staff development, the master elementary teachers are introduced to science content, the new curriculum and pedagogy for elementary science, and the effective strategies for implementation (Fullan, Bennett, and Rolheiser-Bennett, 1990).

For any innovation to become integral to a school's instructional program, the school's personnel must complete the cycle of implementation: initiation, implementation, and institutionalization. Each phase is critical to the long-term success of any new program initiative because what happens during one phase of implementation influences what happens during subsequent phases. More importantly, successfully implemented programs include a plan for the activities of all three phases from the outset.

2.2.1 Initiation. Initiation establishes the impetus for change. The events that occur during initiation have a profound effect on the eventual outcomes of the innovation. During the initiation phase, schools 1) become familiar with the philosophy and features and the innovation, 2) pilot test the innovation with a few teachers, 3) decide whether or not to adopt part or all of the components of the innovation, and 4) design the implementation plan. Marshaling a broad base of support for the innovation is the critical task of the Center leadership team during initiation. The school improvement program will have a long-term impact on teaching only if district administrators, teachers, and principals are central to the planning of the implementation of the innovation from the outset (Berman and McLaughlin, 1974; Fullan, 1982). During this phase, the implementation team asks questions: How does this new program help us achieve our goals for instruction? How can we design a comprehensive plan for staff development? What are our long-range plans to implement this program? How can we ensure that the changes in science education become lasting?

2.2.2 Implementation. Implementation, the phase in which teachers begin to use a new program, requires at least three to five years, during which time the leaders for change take many actions to support teachers. If these actions are not part of a strategic plan for implementation, the innovation probably will not become integral to a school's instructional program. Essential to this plan are activities for training, consultation, support, and monitoring the program's implementation. These activities should be performed by all members of the district implementation team, composed of the principal, a district administrator, and a member of the Center. The school-based team (principal and teachers) provides the ongoing and daily support that teachers need to use an activity-based science program. For example, the principal ensures that teachers have the materials they need and consults with teachers about the program, while the teachers help their colleagues plan and solve problems. The consultants external to the school – the district administrators and staff of the Center – provide more comprehensive staff development emphasizing the latest trends in science education and strategies for implementation. CO-STEP capitalizes on these experiences and the extant research by preparing the staff of the Centers to use effective staff development and implementation strategies. During all phases of implementation, the BSCS staff serve as consultants to the staff of the Centers.

2.2.3 Institutionalization. Another goal of this proposed project is to promote regional Teacher Development Centers that are self-sustaining after the grant period ends. The funds from NSF, the Eisenhower program, and support from BSCS provide only the seed money for such Centers. The Centers must be willing to commit significant funds and staff to make the Centers self-sustaining.

The critical role of the Center is to support the long-term or institutionalized use of innovative approaches to the teaching of science. For institutionalization to occur, the members of the leadership team must consider how they will ensure that changes in elementary science are widespread. Institutionalization requires no less effort on the part of the leadership team than initiation or implementation, but the activities are qualitatively different. During this final phase of implementation, teachers need support to integrate the science curriculum into other areas. Furthermore, plans for staff development must include strategies to educate new teachers and to enhance the skills of teachers who have begun using the innovation.

Although research about the institutionalization of both innovative instructional approaches and Centers is minimal, there are some promising trends. For example, recent research suggests that when universities and school districts collaborate to improve schools, changes occur in classroom instruction (Fullan, Bennett, and Rolheiser-Bennett, 1990). When principals and teachers work together with teams of teachers, activity-based science curricula are more likely to become integral to the instructional program of the school (Muscella, 1989). An important facet of institutionalization is renewal whereby the Center staff prepare teachers to integrate other curricular areas into the science program (Hall and Hord, 1987). For example, constructivism and cooperative learning are applicable to many different curricular areas and therefore benefit elementary teachers responsible for teaching many different disciplines. BSCS helps the Centers become self-sustaining by providing ongoing support to the Center staff through regular planning meetings, quarterly meetings of the CO-STEP advisory committee, site visits, telephone monitoring, and Internet. In addition, when the Centers develop their plans for implementation, BSCS staff suggest strategies for the long-term implementation of new pedagogical approaches to elementary science.

2.3 Factors Related to Educational Change

CO-STEP incorporates results from research on educational change in its teacher development program and follow-up implementation support. Educational change is a long and tedious process that begins 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 an innovation such as a new approach to elementary science 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 predisposition for implementing various educational innovations. A synthesis of those factors yields the following:

- The teacher must have confidence that he or she can successfully implement the new materials and teaching practices (self-efficacy).
- The teacher must believe that the innovation will improve teaching, ease some teaching tasks, and improve student learning (efficacy of the innovation).
- The teacher must believe that the costs of implementing the innovation and of changing their teaching behaviors and materials ultimately will be less than the benefits gained from using the innovation (practicality ethic).
- The teacher must perceive that the innovation is simple to master and implement, that he or she can experiment with the innovation on a limited basis in a low-risk environment, and that he or she will receive positive feedback from others for using the innovation.
- The teacher must believe that the innovation is part of the established curriculum and that it is not a fad.

In addition to the factors influencing a predisposition to implementation, researchers (Fullan, Miles, and Anderson, 1988; Ellis, 1989a; Ellis and Kuerbis, 1987; Kuerbis and Loucks-Horsley, 1989; Edmonds, 1979; Kelley, 1980; Leithwood and Montgomery, 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; Gray, 1984; Grady, 1983; White and Rampy, 1983; Watt and Watt, 1986; Winkler and Stasz, 1985) also have identified factors that influence the successful implementation of educational innovations. These factors are as follows:

Related to Teacher Development and Consultation Support

- The teacher must participate in quality teacher development activities.
- The teacher must receive follow-up consultation, support, and encouragement. The teacher must have the opportunity to practice using the new materials and teaching strategies with individual feedback (coaching) back in the classroom.
- The teacher must provide feedback about the implementation project and about his or her use of the innovation.
- School systems must use that feedback from teachers to plan additional inservice and assistance, to provide supportive materials, and to consider possible modifications in plans, organizational arrangements, and the innovation itself.
- The teacher must have a clear picture of how the innovation 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 educational materials, and to collaborate with fellow teachers.
- The school district must provide the teachers and students easy access to necessary equipment and materials.
- The central office of the school district must sanction and clarify the need for the innovation, give clear and consistent communication, apply pressure, provide consultation, release time, materials, and resources for training.
- The school district and building administrators must collaborate with teachers in developing a clear, long-range plan for implementing the innovation 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 incentives and psychic rewards to teachers, including special recognition, release time, salary credit, and technical support.
- The school board and community must support the need for the innovation.
- The principal must take an active role in initiating, sanctioning, supporting, and responding to the innovation. The principal must provide teachers with 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 the innovation.
- The teacher must be involved in designing the implementation plan, selecting the educational materials, designing the instructional units, organizing the equipment and materials, scheduling the use of the materials, and training other teachers.

BSCS has investigated the factors related to successful implementation. CO-STEP will attend to these factors in the design of its teacher development program. 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 the *CO-STEP* program, as characteristics of successful implementation programs:

- Voluntary participation by teachers
- Multiple teacher development 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 the materials and teaching strategies that progresses from simple to complex exercises.
- Experience with instructional applications that offer promise for improving science education
- 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 science teaching is a very complex task.
- Assistance for teachers in making the transition from theory into practice

Teachers need follow-up in the classroom (coaching) to change their 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 sharing sessions for the teachers to discuss successful and unsuccessful lessons, and helping with the location and production of materials.

3.0 Design for Change

The teacher development program incorporates the latest research in learning theory, pedagogy, curricular organization, and educational technology. Each Center adapts the general model to the needs and interests of their participants, therefore, each site emphasizes the components of the program in different ways. The following sections describe components that constitute the general model of the CO-STEP teacher development program.

3.1 A Constructivist Teaching Model

Constructivist learning theory suggests students learn best when they are allowed to construct their understanding of concepts. The phrase "constructing their understanding," means the following:

- *Prior knowledge.* Students begin with the knowledge, skills, and understanding they bring to the classroom. By the time children enter school, they already have what are to them reasonable explanations for how the world works. However, those explanations are usually based on limited experiences.
- *Common experiences.* The purpose of the science curriculum is to provide students with a common set of experiences that invites them to examine their current understanding. The new experiences either support their understanding or give them a reason to question their thinking.
- *Specific information.* Next, students are given more specific information about the concept or phenomenon under investigation. Students are introduced to terms and find out how those terms apply to their previous experiences.
- *Additional experience.* Students participate in more experiences that challenge or elaborate upon their ideas and the information they just received. They use those experiences and the new information to confirm, refute, or expand what they have been thinking.

- *Constructing an understanding*. Throughout this entire process, students question, ponder, discuss, argue, and come to some conclusions about how this aspect of their world works. In this way, they construct a new or refined understanding of the concept or phenomenon under investigation.

The following describes the steps of the BSCS instructional model that teachers can use to help students through the process of conceptual change.

1. *Engage the learner*. These activities mentally engage students with an event or question. Engagement activities capture students' interest and help them to make connections with what they know and can do.
2. *Explore the concept*. Next, students encounter hands-on experiences in which they explore the concept further. They receive little explanation and few terms at this point, because they are to define the problem or phenomenon in their own words. The purpose at this stage of the model is for students to acquire a common set of experiences from which they can help one another make sense of the concept. Students must spend significant time during this stage of the model talking about their experiences, both to articulate their own understanding and to understand another's viewpoint.
3. *Explain the concept and define the terms*. Only after students have explored the concept does the curriculum and/or teacher provide the scientific explanation and terms for what they are studying. Students then use the terms to describe what they have experienced, and they begin to examine mentally how this explanation fits with what they already know.
4. *Elaborate on the concept*. The next stage of the model serves to help students elaborate on their understanding of the concept. They are given opportunities to apply the concept in unique situations, or they are given related ideas to explore and explain using the information and experiences they have accumulated so far. Interaction between the students is essential during the elaboration stage. By discussing their ideas with others, students can construct a deeper understanding of the concepts.
5. *Evaluate students' understanding of the concept*. The final stage of the model has a dual purpose. It is designed for the students to continue to elaborate on their understanding and to evaluate what they know now and what they have yet to figure out. Although the key word of this stage is evaluate, the word does not indicate finality in the learning process. Indeed, students will continue to construct their understanding of these broad concepts throughout their lives.

Use of the "5 Es" ensures that children are active in the learning process. In most textbook programs, students are passive learners. They acquire information by reading about science or by participating in experiences for which the answers are given on the next page of the book. Such learning is meaningless because it does not relate to what students have observed, or experienced, or otherwise already know or have judged to be true.

Meaningful learning does take time. If students are truly to understand the world, they cannot simply read, memorize, and recite isolated bits of information and vocabulary words. They must take time to wrestle with new ideas, to discuss their ideas with their classmates and teacher, to collect data and use that data to draw conclusions, and finally to relate what they are learning to the world around them.

The instructional model proposed for this program accommodates cooperative approaches to learning. Cooperative learning has a dual advantage of having a significant research base and a widespread popularity among elementary school personnel.

3.2 Cooperative Learning

Cooperative learning is not so much learning to cooperate, as it is cooperating to learn. In cooperative groups, students help one another articulate opinions, compare perceptions, share solutions, and develop skills for leadership and teamwork. Research indicates such cooperation leads to higher achievement (Johnson, Johnson, and Holubec, 1986). Many studies have shown positive effects for both high- and low-ability learners, dispelling the myth that high-achieving students will not progress if they interact with students of lesser ability.

Recent studies show that students are more positive about each other when they learn to work cooperatively, regardless of ability, ethnic background, or handicap. Students who have cooperative skills are more able to appreciate the perspective of others, are more positive about taking part in controversy, have better developed interaction skills, and have more positive expectations about working with others than students from competitive settings have (Johnson et al., 1981; Sharan, 1980).

The teacher also benefits in this process because students in a cooperative setting take more responsibility for classroom management. Hands-on science requires that the students interact with materials, and cooperative learning is structured so that the students, not the teachers, manage the materials. The process begins in kindergarten; primary grade students can manage materials well. Furthermore, within the framework of cooperative learning, students take more responsibility for helping each other with assignments and problems. That alleviates some of the stress on the teacher to maintain order and to keep the students on task.

Another benefit of cooperative learning is improved self-confidence for many students. Because the teammates become responsible for each other's learning and have a vested interest in each other's success, all students tend to be more successful. Success builds self-confidence. By working together, the students find out that each has something important to contribute to the group's work. As they find out that their ideas can be useful to others, the students become more self-confident.

At BSCS, we have applied the model of cooperative learning developed by David W. Johnson and Roger T. Johnson of the Cooperative Learning Center, University of Minnesota, Minneapolis. We employ seven basic tenets of this model:

- *Positive interdependence.* In cooperative groups, each student has a responsibility to the team. Goals or tasks are structured so that the students must concern themselves with the performance of all members of the group, not just their own performance.
- *Social skills.* At the foundation of cooperative learning are social skills that help students share leadership, communicate effectively, build trust, and manage conflict. Generally, the students do not come to the classroom with those skills; the skills must be defined clearly and taught in much the same way that academic material is taught.
- *Individual accountability.* Each member of the cooperative group is held accountable for the performance of all. It becomes the team's responsibility, not the teacher's, to ensure that everyone participates.
- *Heterogeneity.* Cooperative groups should be heterogeneous in terms of ability, sex, ethnicity, and other personal characteristics.
- *Leadership.* All members of the groups share leadership responsibilities. Each member has a job to do, and the group has no formal leader.
- *Partnership.* In their groups, the students focus on both the academic assignment and the skills they need to work together. They review the success of their assignment and how well they cooperated, and they try to improve both.
- *Teacher as consultant.* The teacher acts as a consultant to the students. Problems are turned back to the group for resolution. That aspect of cooperative learning is often difficult at first, but it is crucial to the success of cooperative learning in the classroom. Students must have ownership over the process as well as the content of the lesson.

Cooperative learning is not something that happens in a classroom overnight. It occurs incrementally and requires time, patience, and constant reinforcement. Teachers tell us, however, that it is worth the effort. In the early grades, teachers should begin with very basic skills such as asking students to move into groups quickly and quietly, speak softly, share the things they use, do their jobs, and take turns. As students become more skilled in working together, they can practice more sophisticated skills. Examples of these behaviors include asking for help and giving help, showing you are interested in what others are saying, talking about several solutions before choosing one, criticizing ideas, not people, looking for evidence before changing your mind, and asking questions to help understand another's point of view. These skills accumulate over the years. Students in high school, for example, should have a large repertoire of social skills that they can use in the classroom and in other settings.

3.3 Authentic Assessment

All to often science improvement efforts focus on either curriculum or instruction or both and exclude one of the driving forces for science programs – assessment. The national reform effort, however, recognizes that assessment is a critical component of science education reform (AAAS, 1989; NRC, 1994; NCISE, 1989; Pelavin Associates, Inc. 1991; Lawrenz, 1991). Leaders in education are c ncerned that current standardized tests used to assess student and program outcomes do not measure adequately the most important outcomes of an effective science program, those outcomes that address higher levels of thinking, understandings of major conceptual themes, and the ability to apply science understandings and approaches to solving real-world problems. Because nearly all assessment instruments primarily use multiple choice, true-false, and matching kinds of questions, these instruments most ef ectively measure the lower levels of Bloom's taxonomy (knowledge, comprehension, application). At the same time, science education reform is stressing the importance of de-emphasizing factual information.

Currently, educators are rethinking assessment. "Authentic assessment" is the current phrase being used by those in the forefront. According to Frances Lawrenz (1991), authentic assessment involves maximizing congruence between the desired outcomes of the program and the assessment procedures. Lawrenz (1991) suggests that in addition to multiple choice tests, authentic assessment procedures include:

- *Essay tests.* Essay tests provide information on a student's ability to organize and communicate information and provide the opportunity for students to present individual opinions and perspectives.
- *Practical assessment.* Practical assessment (sometimes called performance-based testing) provides information on how well students can perform science skills such as using apparatus and measuring instruments, making observations, and designing experiments.
- *Portfolios.* A portfolio is a collection of documents, products, artifacts, and work in progress produced by students as part of their learning. An artist's portfolio illustrates the nature of a student portfolio. Examination and review of a student's portfolio provides a rich and diverse source of information about not only what the student has learned but also about the process of learning.
- *Observations and interviews.* Interviews to probe students' understandings allows the teacher to probe deeply into individual student's understanding of complex science concepts. Observations of classroom activity provide information about how the students are learning and about how well they work together. Both procedures provide information the teacher may use to make program improvements.
- *Dynamic assessment.* In this approach, the assessment and teaching are intertwined, as they should be. The teacher uses a variety of ongoing assessment procedures to gather feedback from students, the teacher uses the information regularly to make m l-course corrections in instruction. Palencsar and Brown (1984) call this reciprocal teaching.
- *Projects.* Projects c nducted by students can provide information about a student's ability to design, conduct, and communicate results of scientific inquiry. Teachers can assess the process by which the student developed the product as well as the quality of the final product itself.

3.4 Thematic Approach

Teachers and developers organize elementary science curricula in a variety of ways. Most curric a are organized according to a listing of science topics, this type of elementary science curriculum covers the major concepts of multiple scientific disciplines and is sometimes called the encyclopedic approach to science. During the 1960's, however, the Science Curriculum Improvement Study (SCIS) and Elementary Science Study (ESS) took radical approaches to restructuring elementary science curricula. The SCIS program organized its curriculum around a few major themes of science. ESS organized its units around interesting science phenomena such as molds, structures, mirrors, and two-dimensional and three-dimensional geometry. One way to capture a student's interest is to organize the curriculum to engage the student in learning science through doing science. The ESS program presents science as a human activity of exploring and making sense out of the natural world. It is an example of a thematic approach to curriculum, in which students mess around with materials or organisms, such as a meal worm, and try to construct an understanding of how meal worms interact with the world and how they grow and reproduce.

CO-STEP introduces the participating teachers to a thematic approach as a way of organizing science units. A thematic approach has much promise as a way of organizing science curriculum and instruction. We propose that a thematic approach has the following advantages for organizing science instruction:

1. It is interesting and motivating to students.
2. It engages students in learning science through a constructivist approach.
3. It involves students in studying current and relevant scientific problems.
4. It establishes a direct link between science and personal and social issues by studying locally relevant topics and questions.
5. It provides relevance for the science content that the students are learning.

3.5 Educational Technology

The CO-STEP project introduces teachers to effective uses of educational technology for science education. Science instruction may be improved not only by refinements in pedagogy, curriculum, and approaches to learning, but also by improving the technologies that teachers use to teach and students use to learn. During the past decade, educational technology has changed more than any other facet of instruction. With the advent of microprocessors, educators discovered new tools for teaching and learning.

In a recent study supported by International Business Machines (IBM), BSCS investigated the ways in which new educational technologies might enhance elementary school science and health (BSCS, 1989). As part of the IBM study, BSCS made recommendations about educational courseware for elementary school science and health. BSCS recommends that science teachers select and use courseware packages that 1) achieve the goals and objectives of the curriculum, 2) integrate with other print and hands-on instructional materials, 3) engage the students in active learning, 4) accommodate a range of reading, writing, and math skills, and 5) accommodate a variety of developmental levels. BSCS recommends that elementary science teachers consider including the following uses of educational technologies in their curriculum and instruction:

- *Information Processing Tools.* Students can use the microcomputer to acquire, process, analyze, organize, explain, and report scientific information. Using the microcomputer as an information processing tool is the most powerful and productive way that students can use the microcomputer. The microcomputer can connect to electronic probes to gather information about scientific phenomena, as with probes to measure temperature, light, motion, pH, pulse rate, and sound. Students may use database, spreadsheet, statistical, and graphing programs to organize and examine patterns and relationships in scientific data and system modelers to build graphical and quantitative models for natural phenomena.
- *Communication Tools.* Students may use word processing, graphing, and drawing programs to report their results, interpretations, and explanations of scientific investigations. With more advanced communication tools, science students may publish their work. Desktop publishing enables students to produce high-quality publications at a reasonable cost. Telecomputing, the computer connected to an electronic network, enables students to disseminate the results of the work instantly to other students and scientists around the world.
- *Courseware for Learning Science Content.* Students may use the microcomputer as an instructional tool. Microcomputers can present science content through tutorials, simulations, and games. In addition, the microcomputer makes possible a true multimedia learning environment. The microcomputer connected to a laser videodisc player and/or CD-ROM player at the student's request can provide a wide variety of video images (still and motion), stereo sound, bilingual narrative, animation, and text.

- *Courseware for Practicing Science Skills*. Students may use the computer to practice science and mathematics skills (such as measuring, identifying and controlling variables, and interpreting graphs) and to drill on science and mathematics facts (decimal arithmetic, safety rules, and parts of the human body).

3.6 Localized Curriculum Adaptation.

In CO-STEP, project staff assist teachers in adapting their curriculum and instruction to their local situation. The teachers adapt extant curriculum materials to produce instructional units that provide students the opportunity to investigate science and technology relevant to their region of Colorado.

We propose that localized curriculum adaptation has the following advantages over wholesale adoption of commercial programs:

- *Practicality*. School districts are asking teachers to develop curriculum aligned with district and state frameworks. Teachers find the idea of adapting extant curricula a practical approach to completing this task.
- *Interest*. Local adaptation of extant curriculum provides teachers the opportunity to personalize the science curriculum. They are able to modify units and individual activities to emphasize areas of interest to their students and to themselves.
- *Relevance*. The activities are linked to local issues. The students can relate to the topics and issues and therefore are more interested in learning.
- *Immediacy of application*. The students can apply the science concepts immediately to solving problems within their community.
- *Citizenship education*. Students can apply what they have learned in their science class by being active citizens. The science units can include an effective action component, where the students implement a group or personal action to improve the quality of life in their community. Effective action activities might include presenting a proposal to the city council or the school board, forming a recycling program for the school, changing personal behaviors, or implementing conservation campaigns at home and school.

3.6.1 Process of adaptation. During the series of academic year courses and curriculum planning courses, project staff and science instructors introduce the teachers to major concepts from the field of physical science (i.e., physics, chemistry, geology, meteorology, and astronomy), life science, and environmental science, current science and technology issues in various regions of Colorado, the process of curriculum adaptation, and a wide variety of elementary science education materials. The teachers work in teams, consisting of three to five teachers from the similar grade level. Each team produces one unit by adapting activities from extant science education programs to one of the science and technology issues and needs for their region. The teams revise the activities to form a unit that incorporates constructivist-based teaching model, cooperative learning, authentic assessment, and educational technology.

The teachers pilot test their units during the following school year. During the pilot test, project staff conduct a course to help the teachers design and conduct a thorough evaluation of the units (an action research project). Following the pilot test, project staff encourage the teachers to revise and share their units with fellow teachers.

3.6.2 Sources of activities Each site uses a variety of local resources to enhance their content courses and curriculum planning courses. Colorado has many resources for science education. For example, the United States Space Foundation has its headquarters in Colorado Springs. The Bear Creek Nature Center and Beidleman Environmental Center in Colorado Springs have many programs and materials on environmental education. Other sites take field trips to the Rocky Mountain National Park and to other state and national parks. Several school districts have established outdoor education centers that are available for use by teachers and students participating in the project. Each of the university partners for the project have collections of elementary science curriculum materials and science reference materials. Some of the materials that the teachers explore are:

- Science Curriculum Improvement Study (SCIS)
- Elementary Science Study (ESS)
- BSCS: Science for Life and Living
- Life Lab Science Program
- Lawrence Hall of Science: The Full Option Science System (FOSS)
- EDC: Improving Urban Elementary Science: A Collaborative Approach
- TERC: NGS Kids Network
- Outdoors Biology Instructional Strategies (OBIS)
- Activities from National Science and Technology Week

4.0 The Teacher Development Program

Each CO-STEP site provides a comprehensive teacher development program for inservice elementary science teachers. The teacher development program consists of five interdependent courses provided each year in a three-year cycle. During the first semester, the implementation team for each new district team joining the project completes a Strategic Planning Course. During the following semester in a Science Content Course, Center staff provide the teachers with the science background necessary to design and implement a science unit. The science content varies from year to year and from site to site in the sequence of physical science, life science, and environmental science. The third course, the Curriculum Planning Course, provides the teachers the opportunity to develop a science unit, to learn the science content and pedagogy for teaching a science unit, to plan the implementation of the unit, and to design an action research study. In the following semesters, when the teachers implement the units, the fourth course, the Action Research Seminar, guides the teachers through the process of implementing and evaluating their units. The fifth course, the Leadership Seminar, introduces the teachers to the leadership skills they use in designing and conducting a program for school science improvement. The staff at each site adapt these courses in response to local needs and interests of participating schools and institutions (college and schools).

4.1 Strategic Planning Course

Each team earns one semester credit in the strategic planning course during their first few months of involvement of the project. The purpose of the course is for the teachers from each building to work with their building principal, and district-level administration to produce a strategic plan for science program improvement for their building. When more than one building from a district is involved in the project these building teams collaborate together to produce a unified approach for science improvement for grades four through six in their district.

Center staff, with assistance from BSCS staff, begin the course with an overview of the major innovations included in the project - constructivism, cooperative learning, authentic assessment, thematic approach, localized curriculum adaptation, and educational technology. The members of the district implementation teams participate in team building activities to help them develop skills for collaborative planning. The core of the course focuses on strategic planning. Much of their work involves gathering information from and building consensus among their fellow teachers and administrators in the district. Once the participants are acquainted with the process, they spend the remainder of the course producing their strategic plan. The end product of the course is a strategic plan for the improvement of the school and district science program and for improvement of each teacher's science instruction.

4.2 Science Content Courses

All teachers who participate in the project must complete a series of three Science Content Courses (physical, life, and environmental science) for three semester credits each immediately prior to planning and implementing science units in their classrooms. The courses meet for a total of 45 hours, after school for three-hour sessions or for occasional day-long sessions. Each session follows a constructivist-based approach to teaching.

Approximately one-third of the course is large-group instruction (reading/lecture/discussion/educational technology) and two-thirds or more is laboratory or field-based activities. The science content is selected to provide the background in physical science, life science, and environmental science relevant to teaching science in the upper elementary grades. Many of the hands-on activities are from elementary science programs, including the Science Curriculum Improvement Study (SCIS), the Elementary Science Study (ESS), and the new NSF elementary science projects (e.g., FOSS, BSCS, InSights) and high school science programs (e.g., ChemCom, Interactive Media Science Project, and BSCS Green Version). Other hands-on activities are adapted from college laboratory activities to reinforce key science concepts. Educational technologies, such as interactive video disks, information processing tools (word processing, databases, spreadsheets, and graphing utilities), and computer courseware (simulations, tutorials, and drill and practice) are an integral part of the instructional materials used in the course.

4.3 Curriculum Planning Course

Each year following the science content course, the teachers complete a four-credit course to plan science units to pilot in their schools. During the Curriculum Planning Course (60 or more hours of direct instruction), the teachers prepare to teach science units based on the science discipline area from the Science Content Course. The teachers accomplish the following tasks during the Curriculum Planning Course:

- Learn about instructional design, teaching strategies, and procedures to support the implementation of educational innovations
- Review and evaluate extant curriculum materials
- Construct science units from extant educational materials, based on their in-depth study
- Design assessment procedures to evaluate student learning
- Design an action research project to evaluate the effectiveness of their units
- Develop an action plan for implementing their units and action research projects

4.4 Action Research Seminar

Each of three years during the semester following the Curriculum Planning Course, the participants pilot test the units and instructional strategies they developed during the summer. Project staff conduct a course (for one semester hour of graduate credit) to provide assistance and support to the teachers as the teachers implement the new approaches to teaching. The course typically consists of five three-hour, after-school meetings, interspersed throughout the fall semester.

The content of the course focuses on implementation and evaluation issues. The teachers form action research teams to study the implementation of the science units and instructional strategies. In action research, the project staff guide the teachers as they establish research questions and hypotheses, design a research study, identify procedures for collecting data (qualitative and quantitative), gather the data, analyze the data, and report the results. According to several researchers (Loucks-Horsley, et al, 1987; Hopkins, 1985; Huling and Johnson, 1983) action research is an effective way to empower teachers to improve instruction. In addition to action research, project staff provide results from research on implementation and science education. The teachers also have opportunities to form special-interest groups to investigate educational issues of particular interest, to share teaching ideas and materials, and to meet in building teams to discuss implementation issues.

During unit implementation, the teachers form peer coaching teams within each building. The school district releases members of the team to observe his or her teammates and to provide peer coaching and collegial support. Information about peer coaching is provided during the Curriculum Planning Course and Action Research Seminar. Project staff supervise the peer coaching teams, meeting with each team periodically throughout the school year.

4.5 Leadership Seminar

Each of three years during the school year, the teachers design and implement projects for science program improvement in their schools. For one semester hour credit, the teachers meet five times during the spring semester to share results from their teacher development programs. In addition, Center staff conduct activities to develop the leadership skills of the teachers. Topics studied include peer coaching, staff development, educational change, and adult learning. The teachers gather data from their fellow teachers on the effectiveness of the school-based teacher development programs.

The teachers, with assistance from the Center staff, assume leadership roles in their districts. Each is recognized in their school building as the lead teacher for science at his/her grade level. As part of the leadership course the teachers collect information from their colleagues and design strategies to improve the science program in their school and district. They serve on school, district, and state science curriculum committees. A few participants are serving on a state committee to develop standards for science education. The teachers have implemented a variety of strategies to promote improvements in their science programs including organizing and conducting inservice workshops for colleagues, establishing science resource centers in their schools, successfully seeking grant support to purchase science materials, organizing school and district science fairs, organizing a whole-school day on science, and participating in national implementation projects, giving presentations at professional meetings.

5.0 Evaluation Plan

BSCS designed an evaluation plan to assess success at attaining the project objectives stated in section 1.1. We formulated our evaluation plan according to the model provided in the *User-Friendly Handbook for Project Evaluation* (Stevens, et al, 1993). We developed questions to guide the evaluation and identified the data collection approach, respondents, and schedule of data collection. Table 1 provides the framework for the evaluation plan.

We use a variety of procedures to collect the data for the evaluation of the project. We administer a questionnaire to teachers at the beginning of their involvement in the program and once a year thereafter. We also collect data through artifacts, observations, and interviews. The following sections describe the data collection procedures in detail.

5.1 Teacher Questionnaire

We developed a self-report questionnaire by combining project-developed instruments and externally-developed instruments. The teacher questionnaire includes a biographical data form, a checklist on innovations in science teaching, the *Science Teaching Efficacy Beliefs Instrument* (STEBI) and the *Stages of Concern Questionnaire* (SoCQ).

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Table 1: Evaluation Design

Question 1: How have teachers improved in their use of innovative approaches to teaching science?			
a How much time do they spend teaching science? b How much time do they allocate to different modes of science teaching? c Do they value innovative approaches to science teaching? d Do they emphasize innovative approaches to science teaching? e. Are they willing to incorporate innovative approaches into their science teaching? f How prepared are they to incorporate innovative approaches into their science teaching? g. How prepared are they to teach other teachers to use innovative appro... hes in their science teaching? h To what extent do they incorporate innovative approaches into their science teaching	- teacher questionnaires - unit plans - portfolios - teaching logs - reflective journals - classroom observations - interviews	Teachers	- yearly - before and after teaching unit - during teaching of unit
Question 2: How have teachers changed in their belief that they can teach science well?			
a How have teachers changed in their personal efficacy for science teaching? b. How have teachers changed in their outcome expectancy for science teaching?	Teacher questionnaire: *Science Teaching Efficacy Belief Instrument*	Teachers	yearly
Question 3: How have teachers changed in their concerns about teaching science?			
How have teachers changed in their concerns about teaching science?	Teacher questionnaire: *Stages of Concern Questionnaire*	Teachers	yearly
Question 4: Has the project successfully established six regional teacher development centers?			
a Have six centers offered the specified teacher development program? b. Has the specified number of teachers completed each year of the program? c Do the centers have plans to become self-sustaining?	Center staff Teachers	Quarter reports Site visits Interviews Questionnaires Site visits Interviews	quarterly semiannually annually semiannually
Question 5: Have teachers become leaders for science program improvement?			
a What have teachers done to improve the science program in their school? c What have teachers done to improve the science program in their district? c What have teachers done to improve the science program in the state?	Teachers Center staff	Portfolios Journals Interviews Quarter reports Interviews and site visits	Throughout school year Quarterly Semiannually

5.1.1 Biographical data form. At the beginning of their participation, the teachers complete a biographical data form The biographical data includes job assignment, grade level(s), educational background, teaching experience, age, sex, ethnic origin, and availability of chapter one funds

5.1.2 Innovations in science teaching. Teachers complete an innovation checklist on the number of minutes in a week devoted to science instruction, the time spent preparing for science class, and the relative time spent on various instructional modes hands-on, discovery-based, teacher demonstrations, student worksheets, reading textbook, using other textbooks. Each participant completes a questionnaire on their perceptions of their involvement with the innovations in science teaching that are the focus of the project constructivism, cooperative learning, major conceptual themes, assessment, educational technology, nature of science and [reduced] emphasis on science facts The questionnaire asks teachers to indicate their involvement in the innovations by responding to questions such as: How valuable is each of the following in elementary school science instruction? How much emphasis do you place on each of the following? How willing are you to incorporate each of the following into your teaching? How well prepared are you to incorporate each of the following into your teaching? How well prepared are you to teach other teachers how to use the following in their teaching?

5.1.3 *Science Teaching Efficacy Beliefs Instrument.* Teachers complete the STEBI at the beginning of the project and yearly thereafter. Riggs and Enochs (1990) developed the STEBI as a self-reporting instrument to assess elementary teachers' efficacy toward science teaching The STEBI is based on Bandura's (1977) research on beliefs and self-efficacy Bandura suggests that individuals develop a generalized expectancy concerning cause-effect relationships based upon personal life experiences. They also develop a set of beliefs concerning their own ability to cope with particular situations Teacher efficacy beliefs are dependent upon the specific teaching situation Ashton, Webb, and Doda (1983) found that teachers may have higher teacher efficacy with some students than with others The STEBI is composed of two subscales (1) personal science teaching efficacy beliefs and (2) science teaching outcome expectancy. Subscale one relates to teachers' belief that they can teach science effectively, and subscale two relates to teachers belief that students can learn science successfully Subscale one has an alpha reliability coefficient of .92, and subscale two has an alpha reliability coefficient of .77. All item to total correlations for the two subcales were higher than .53 and .34 respectively

5.1.4 *Stages of Concern Questionnaire*. We use the *Stages of Concern Questionnaire* (SoCQ) to document the process of change of the participants. The SoCQ (Hall, George, and Rutherford, 1979) was developed at the University of Texas R&D Center as part of the Concerns Based Adoption Model to measure how teachers perceive an innovation and how they feel about it These perceptions range from early concerns about how the innovation will affect oneself to concerns for the tasks required to implement the innovation, the impact the innovation will have on students, and the ways the innovation might be improved. In in-depth studies to establish the validity of the SoCQ, Hall, George, and Rutherford (1979) found that the SoCQ accurately measures the Stages of Concern about the Innovation According to Hall, George, and Rutherford (1979, p. 10), "the SoC Questionnaire appears to do an even better job than other measures and clinical judgments." In testing the reliability, Hall, George, and Rutherford (1979) obtained alpha coefficients of internal reliability for the seven subscales ranging from .64 to .83 and test-retest correlations for the seven subscales ranging from .65 to .86. Participants completed the SoCQ prior to participation and at the end of each yearly cycle. We designed CO-STEP to reduce initial high informational, personal, and management concerns that elementary teachers have about implementing hands on, minds on science programs. As teachers begin to incorporate innovative approaches to science teaching into their school program, we expect management concerns to increase, followed by and increase in consequence, collaboration, and refocusing concerns as the teacher becomes a successful user.

5.1.5 Qualitative data. We collect a variety of qualitative data to assess change in teaching practice. We collect artifacts from center staff including implementation plans, course syllabi, and quarterly and annual reports. Center staff collect and summarize the following artifacts from teachers: unit plans, teaching logs, reflective journals, class assignments, action research reports, and portfolios of the implementation of their unit. Project staff review and synthesize information from a sample of these artifacts to assess the nature of the teacher development program and the changes in teacher knowledge and practice.

We also collect information through observations and interviews. BSCS staff visit each site at least twice a year to provide support and assess progress. During the site visits, BSCS staff observe sessions of the teacher development program, observe classroom teaching, interview project staff, and interview participants (individually and in focus groups). We collect information about the nature of the teacher development program and about changes in teaching practice. We solicit input on secondary effects of the project such as teachers establishing a science resource center in their building. Center staff also collect information through classroom observation and interviews of teachers and summarize that information for BSCS staff.

6.0 Results

We first analyzed the evaluation data for the whole group and then for each separate site. Table 2 presents the biographical data for the teachers broken down by site and for the all participants from all sites combined. Table 3 presents the percentages of responses for each site and combined sites for the checklist of innovations in science teaching. The asterisks by items indicate that there was a significant change (.05 level) for that item when comparing the pre and posttest for the first cohort of participants for combined sites. Two of the sites (Colorado Springs and Pueblo) were excluded from the analysis, because they do not have pretest data. We used a different assessment form for Colorado Springs and Pueblo during the non-funded, pilot phase of the project. We analyzed the second cohort of participants separately, because they received a somewhat different treatment than the first cohort, the second cohort started during the second year of the project. We found few differences, however, between the analysis of the data for the first and second cohorts.

When analyzing the pre/post comparison for the STEBI data combined for the four sites that had complete data, we found a significant improvement in personal efficacy beliefs about science teaching and for outcome expectancy (see table 4).

Scale	test	N	df	Mean	SD	t-value	2-tail sig
Outcome Expectancy	pre	82	148	42.82	11.72	2.36	.019
	post	68		38.56	10.01		
Personal Efficacy	pre	88	155	34.28	7.64	-3.94	.00
	post	69		38.86	6.63		

Table 4. t-test comparison for STEBI for combined sites

TABLE 2: How time is used in science teaching

	CC			DC			CSU			GJ			UNC			USC			Totals		
	pre	post	post post	pre	post	post post	pre	post	post post	pre	post	post post	pre	post	post post	pre	post	post post	pre	post	post post
Number of respondents		7	6	29	27		23	11	6	23	23	21	14	10			17		89	95	33
*10 How many minutes of science instruction per week do you usually provide your students?																					
less then 20		.	.	.	.		13.0	9.1	.	.	.	4.8	.	10.0					3.4	2.1	3.0
20 minutes		14.3	16.7	.	.		4.3	.	.	.	4.3	.	7.1	.			5.9		2.2	3.2	3.0
40 minutes			.	3.4	3.7		8.7	.	.	4.3	.	4.8	.	10.0			5.9		4.5	3.2	3.0
60 minutes		14.3	.	6.9	3.7		.	.	.	26.1	4.3	14.3	14.3	10.0			5.9		11.2	5.3	9.1
80 minutes		28.6	.	20.7	11.1		4.3	.	66.7	21.7	8.7	.	21.4	10.0			.		16.9	8.4	12.1
100 minutes			50.0	3.4	7.4		13.0	.	.	.	8.7	19.0	21.4	.			5.9		7.9	5.3	21.2
120 minutes		42.9	16.7	13.8	22.2		17.4	9.1	16.7	21.7	26.1	23.8	14.3	30.0			41.2		16.9	27.4	21.2
more than 120		.	16.7	51.7	51.9		39.1	81.8	16.7	26.1	47.8	33.3	21.4	30.0			35.3		37.1	45.3	27.3
11 How much time do you spend preparing for science class?																					
less then 20			.	3.4	3.8		8.7	9.1	16.7	.	13.0	9.5	.	10.0			.		3.4	6.3	9.1
20 minutes		42.9	16.7	27.6	7.7		21.7	[illegible]	16.7	21.7	4.3	28.6	42.9	30.0			16.7		27.0	14.7	24.2
40 minutes		42.9	33.3	3.4	30.8		21.7	18.2	16.7	56.5	43.5	19.0	50.0	30.0			22.2		29.2	31.6	21.2
60 minutes		14.3	16.7	17.2	11.5		21.7	9.1	50.0	13.0	26.1	28.6		10.0			22.2		14.6	17.9	30.3
80 minutes		.	.	10.3	7.7		4.3	27.3	.	8.7	.	9.5	.	.			16.7		6.7	8.4	6.1
100 minutes		.	.	17.2	7.7		8.7	9.1	.		8.7	4.8	.				5.6		7.9	6.3	3.0
120 minutes		.	.	10.3	11.5		4.3	.	.	.	.	.	.	.			5.6		4.5	4.2	.
more than 120		.	33.3	10.3	19.2		8.7	9.1	.	.	.	.	7.1	10.0			11.1		6.7	10.5	6.1
12 For the last science unit you taught, during what percentage of the daily lessons did each of the following occur																					
Hands-on activities																					
0-9%		.	.	6.9			4.3	.			.	.	.				.		3.4	.	.
10-19%			.	3.4	3.7		13.0	.	.	8.7	.	.	.	10.0			5.8		6.7	3.1	.
20-29%				17.2			4.3	.	16.7	4.3	.	.		20.0			5.6		7.9	3.1	3.0
30-39%		.	.	20.7	7.4		4.3	9.1	16.7	.	4.3	4.8		.			.		7.9	4.2	6.1
40-49%		14.3	.	13.8	7.4		.	9.1	.		8.7	.	7.1	10.0			16.7		5.6	10.4	.
50-59%			50.0	6.9	14.8		4.3	.	.	26.1	13.0	14.3	14.3	.			5.6		12.4	8.3	18.2
60-69%			16.7	10.3	29.6		8.7	9.1	16.7	8.7	17.4	9.5	21.4	10.0			11.1		11.2	16.7	12.1
70-79%		28.6	.	6.9	14.8		13.0	18.2	.	4.3	13.0	9.5	7.1	30.0			16.7		7.9	17.7	6.1
80-89%		42.9	.	6.9	18.5		30.4	9.1	50.0	26.1	13.0	33.3	35.7	10.0			16.7		22.5	16.7	30.3
90-100%		14.3	33.3	6.9	3.7		17.4	45.5	.	21.7	30.4	28.6	14.3	10.0			22.2		14.6	19.8	24.2
*13 For the last science unit you taught, during what percentage of the daily lessons did each of the following occur																					
Discover based learning																					
0-9%				6.9			8.7			8.7		4.8							6.7		3.0
10-19%		14.3		13.8	3.7			9.1		17.4	4.3			30.0			11.1		9.0	9.4	
20-29%				27.6	7.4		17.4		50.0	17.4	4.3	9.5		10.0			11.1		18.0	6.3	15.2
30-39%				13.8	18.5		21.7	9.1		8.7	4.3	.	14.3				11.1		14.6	9.4	
40-49%		14.3		13.8	14.8			27.3			8.7			30.0			11.1		4.5	15.6	
50-59%			33.3		11.1		8.7	9.1		4.3	13.0	14.3	21.4				11.1		6.7	9.4	15.2
60-69%		14.3		6.9	29.6					4.3	13.0	9.5	21.4	10.0			5.6		6.7	14.6	6.1
70-79%		14.3	16.7	10.3	7.4		26.[illegible]		16.7	13.0	17.4	14.3	7.1				16.7		14.6	10.4	15.2
80-89%		28.6	33.3	3.4	3.7		13.[illegible]	18.2	33.3	13.0		23.8		20.0			5.6		7.9	8.3	27.3
90-100%		14.3	16.7	3.4	3.7		4.[illegible]	27.3		13.0	34.8	23.8	35.7				16.7		11.2	16.7	18.2

*significant at .05 level

(Continued)

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Table 2 (continued)

14. For the last science unit you taught, during what percentage of the daily lessons did each of the following occur																					
Teacher demonstrations																					
0-9%		28.6	16.7	.	3.7		13.0	9.1	16.7	30.4	21.7	14.3	.	.			16.7		11.2	12.5	15.2
10-19%		42.9	50.0	13.8	25.9		30.4	.	50.0	30.4	21.7	23.8	35.7	40.0			22.2		25.8	24.0	33.3
20-29%		14.3	16.7	27.6	14.8		21.7	27.3	33.3	21.7	39.1	38.1	28.6	20.0			27.8		24.7	25.0	33.3
30-39%		14.3	16.7	24.1	25.9		13.0	27.3	.	13.0	4.3	9.5	21.4	20.0			16.7		18.0	17.7	9.1
40-49%		.	.	13.8	3.7		13.0	.	.	4.3	8.7	9.5	.	20.0			11.1		9.0	7.3	6.1
50-59%			.	10.3	18.5		4.3	18.2	.	.	4.3		7.1	.			.		5.6	6.3	.
60-69%			.	.	3.7		.	18.2	.	.	.	8	7.1	.			.		1.1	3.1	3.0
70-79%		.		8.9	3.7		4.3	.	.	.	.		.	.			.		3.4	1.0	.
80-89%		.	.	.	.		.	.	.	.		.	.						.	.	.
90-100%		.	.	3.4	.			.	.	.	.	.		.			5.6		1.1	1.0	.
15. For the last science unit you taught, during what percentage of the daily lessons did each of the following occur																					
Students do worksheets or handouts																					
0-9%		71.4	16.7	17.2	7.4		30.4	18.2	16.7	39.1	47.8	23.8	28.6	30.0			38.9		28.1	31.3	21.2
10-19%		14.3	33.3	20.7	18.5		34.8	27.3	16.7	30.4	[illegible]	28.6	50.0	30.0			27.8		31.5	24.0	27.3
20-29%		.	33.3	10.3	25.9		17.4	18.2	33.3	17.4	7	23.8	7.1	30.0			16.7		13.5	17.7	27.3
30-39%		.	16.7	24.1	25.9		8.7	9.1	16.7	8.7	4	14.3	14.3				5.6		14.6	13.5	15.2
40-49%			.	17.2	18.5		8.7	9.1			.	4.8		.			5.6		7.9	7.3	3.0
50-59%		14.3		3.4	3.7		.	9.1	16.7	4.3	.						5.6		2.2	4.2	3.0
60-69%			.	3.4				9.1	.			4.8		10.0					1.1	2.1	3.0
70-79%			.	3.4			.	.	.	.	.								1.1	.	.
80-89%			.	.						.	.								.	.	.
90-100%		.	.				.			.			.							.	.
16. For the last science unit you taught, during what percentage of the daily lessons did each of the following occur																					
Students use a textbook																					
0-9%		85.7	50.0	48.3	40.7		82.8	81.8	83.3	82.6	95.7	78.2	35.7	70.0			94.4		64.0	75.0	72.7
10-19%		.	33.3	20.7	22.2		13.0	9.1	16.7	17.4		9.5	14.3	10.0					16.9	8.3	15.2
20-29%			.	13.8	18.5		4.3	.	.	.	4.3	9.5	21.4	10.0			5.6		9.0	8.3	6.1
30-39%		14.3	16.7	3.4	14.8			.			.	4.8	28.6	10.0					5.6	6.3	6.1
40-49%			.	3.4	.		.	9.1	.		.		.						1.1	1.0	.
50-59%			.		3.7			.	.	.	.	.	.				.		.	1.0	.
60-69%			.	3.4	.		.		.			.		.			.		1.1	.	.
70-79%		.	.	3.4	.				.				.	.					1.1	.	.
80-89%								.												.	
90-100%		.	.	3.4				.	.		.		.						1.1	.	.
17. For the last science unit you taught, during what percentage of the daily lessons did ea[illegible] of the following occur																					
Stude[illegible]s us[illegible] second [illegible] textbo[illegible]																					
0-9%		85.7	66.7	65.5	74.1		95.7	90.9	83.3	82.6	100	81.0	85.7	90.0			100		80.9	89.6	78.8
10-19%		14.3	33.3	13.8	14.8		4.3		16.7	13.0		4.8	7.1						10.1	5.2	12.1
20-29%				10.3				9.1				4.8	7.1						4.5	1.0	3.0
30-39%					7.4					4.3									1.1	2.1	
40-49%				3.4								4.8							1.1		3.0
50-59%				3.4								4.8		10.0					1.1	1.0	3.0
60-69%																					
70-79%				3.4	3.7														1.1	1.0	
80-89%																					
90-100%																					

Table 3: Means of items from innovation checklist

	CC			DC			CSU			GJ			UNC			USC			Totals		
	pre	post	post post	pre	post	post post	pre	post	post post	pre	post	post post	pre	post	post post	pre	post	post post	pre	post	post post
Number of respondents		7	6	29	27		23	11	6	23	23	21		10			18		75	95	33
Share with us your perceptions, thoughts, or feelings about each of the following topics																					
How valuable is each of the following in elementary school science instruction?																					
*20 Constructivism		3.71	4.00	3.28	3.78		3.48	3.45	3.67	3.30	3.61	3.86		3.60			3.56		3.35	3.64	3.85
21 Cooperative learning		3.57	3.67	3.24	3.40		3.65	3.55	3.83	3.26	3.57	3.48		3.30			3.44		3.37	3.47	3.57
22 Major conceptual themes		3.57	3.83	3.03	3.11		3.26	3.45	3.33	3.39	3.57	3.48		3.30			3.06		3.21	3.30	3.51
*23 Assessment and evaluation		3.71	3.83	3.41	3.56		3.57	3.18	3.00	3.17	3.22	3.33		2.90			3.33		3.39	3.33	3.36
24 Educational technology		3.00	3.33	3.45	3.30		3.22	3.00	3.17	3.17	3.09	2.90		3.50			3.11		3.29	3.18	3.03
25 Nature of science		3.14	3.83	3.07	3.15		3.17	3.36	3.17	2.87	3.26	3.24		3.70			3.06		3.04	3.24	3.33
26 Science facts		3.00	3.00	2.93	2.89		2.82	3.09	2.83	2.65	2.39	2.38		2.40			2.83		2.81	2.74	2.58
When you are teaching, how much emphasis do you place on each of the following?																					
*27 Constructivism		3.29	3.50	2.48	2.93		2.83	3.00	3.33	3.04	3.22	3.67		3.30			3.11		2.76	3.10	3.58
28 Cooperative learning		3.29	3.17	2.97	3.22		3.43	3.45	3.67	2.87	3.09	3.14		3.00			3.50		3.06	3.25	3.24
*29 Major conceptual themes		3.00	3.17	2.03	2.89		2.61	2.91	3.33	3.04	3.30	3.24		3.30			2.89		2.83	3.04	3.24
*30 Assessment and evaluation		2.29	2.83	2.86	2.81		2.74	2.82	2.50	2.83	2.96	2.90		2.40			3.00		2.81	2.80	2.82
31 Educational technology		1.86	2.83	1.90	1.70		2.09	2.09	2.17	2.30	2.13	2.33		2.20			2.78		2.08	2.11	2.34
*32 Nature of science		2.43	3.50	2.24	2.59		2.57	2.82	2.67	2.26	2.78	2.86		3.60			2.89		2.35	2.81	2.94
33 Science facts		2.29	2.50	2.83	2.89		2.39	3.09	2.83	2.78	2.35	2.38		2.50			2.63		2.68	2.69	2.48
How willing are you to incorporate each of the following into your teaching?																					
34 Constructivism		3.86	1.67	3.62	3.81		3.74	3.64	3.83	3.65	3.78	3.95		3.70			3.67		3.67	3.75	3.88
35 Cooperative learning		4.00	3.33	3.69	3.70		3.78	3.73	3.83	3.57	3.74	3.76		3.40			3.78		3.68	3.72	3.70
36 Major conceptual themes		4.00	3.83	3.55	3.48		3.43	3.73	3.50	3.78	3.61	3.67		3.60			3.50		3.59	3.59	3.67
37 Assessment and evaluation		3.57	3.67	3.48	3.59		3.48	3.55	3.17	3.57	3.35	3.43		3.30			3.50		3.51	3.48	3.42
38 Educational technology		3.43	3.50	3.62	3.56		3.30	3.45	3.83	3.65	2.95	3.24		3.60			3.44		3.53	3.38	3.30
*39 Nature of science		3.71	3.50	3.34	3.44		3.17	3.64	3.83	3.04	3.43	3.24		3.80			3.22		3.20	3.48	3.39
40 Science facts		3.00	3.00	3.28	3.15		3.09	3.45	3.33	3.26	2.74	2.67		2.90			3.12		3.21	3.04	2.85
At the present time, how well prepared (having the knowledge and skills) are you to incorporate each of the following into your teaching?																					
*41 Constructivism		2.57	3.00	.00	2.70		2.22	2.64	3.50	2.17	3.00	3.52		3.00			3.06		2.12	2.85	3.42
42 Cooperative learning		3.14	3.17	3.21	3.63		3.30	3.27	3.83	2.39	2.87	3.29		3.30			3.50		2.99	3.31	3.36
*43 Major conceptual themes		2.57	3.50	2.38	2.78		2.39	3.09	3.33	2.83	2.87	2.95		3.10			2.61		2.52	2.82	3.12
*44 Assessment and evaluation		2.00	3.00	2.62	2.74		2.43	2.91	3.00	2.48	2.74	3.05		2.70			2.33		2.52	2.63	3.03
*45 Educational technology		2.57	3.00	1.52	1.92		2.00	2.82	3.00	1.78	2.04	2.14		1.60			2.50		1.75	2.20	2.45
*46 Nature of science		2.29	3.33	2.17	2.56		2.04	3.00	3.33	2.17	2.48	2.81		3.20			2.56		2.13	2.64	3.00
*47 Science facts		2.57	2.67	2.52	2.85		2.35	3.18	3.17	2.22	2.52	2.81		2.70			[illegible]		2.37	2.75	2.85
At the present time, how well prepared are you to teach other teachers how to use the following in their teaching?																					
*48 Constructivism		1.74	2.83	1.10	2.33		1.48	2.09	2.83	1.30	2.35	3.38		2.20			2.17		1.28	2.22	3.18
*49 Cooperative learning		2.14	3.33	2.24	3.11		2.52	3.00	3.17	1.57	2.04	2.76		2.30			3.11		2.12	2.69	2.94
*50 Major conceptual themes		2.00	2.83	1.45	2.48		1.78	2.73	2.67	1.91	2.30	2.81		2.60			2.28		1.69	2.41	2.79
*51 Assessment and evaluation		1.42	2.50	1.76	2.37		1.57	2.45	2.50	1.78	2.00	2.81		1.80			1.89		1.71	2.06	2.70
*52 Educational technology		2.14	2.83	1.03	1.56		1.43	1.73	2.67	1.30	1.57	2.05		1.30			2.17		1.24	1.75	2.30
*53 Nature of Science		1.86	3.00	1.55	2.41		1.48	2.73	2.83	1.35	2.17	2.62		2.20			2.22		1.47	2.29	2.73
*54 Science facts		1.86	1.83	1.79	2.48		1.40	2.82	2.67	1.83	1.87	2.52		2.20			2.58		1.71	2.31	2.42

*significant at .05 level

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The profile of the SoCQ (see figure 3) follow the expected pattern of a decrease in initial high informational and personal concerns and a beginning increase in consequence, collaboration, and refocusing concerns, which indicates that teachers are undergoing the typical process of change (Hall and Hord, 1987).

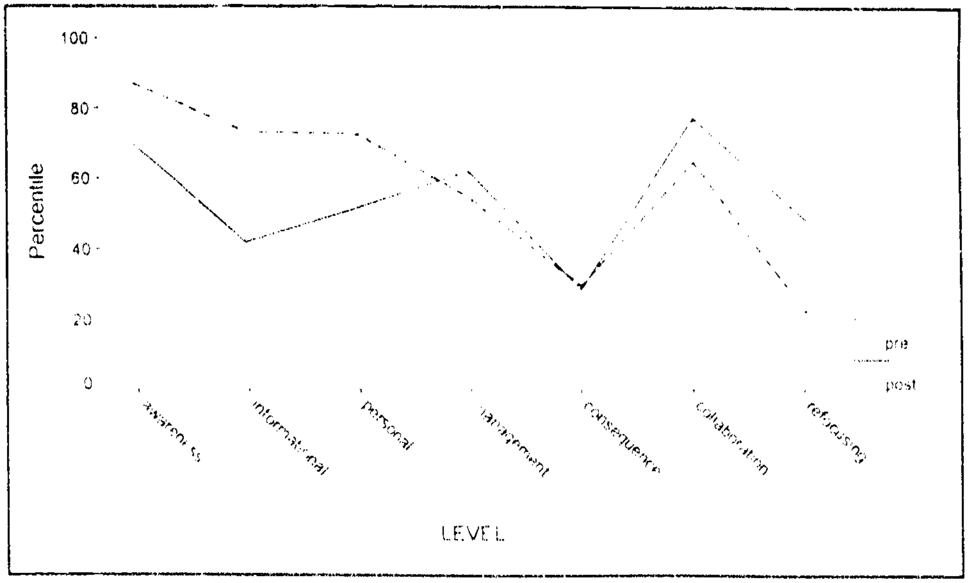

Figure 3. SoCQ profile for all sites

The following sections describe the results of the evaluation at each site at the midpoint of the five-year project. We report the results in the sequence that the sites entered the CO-STEP project: Colorado Springs and Pueblo (Fall 1991), Fort Collins and Grand Junction (Fall 1992), and Mesa County and Greeley (Spring 1993).

6.1 The Colorado College in Colorado Springs (started in 1991)

The Colorado College Center currently has 33 participants from six different school districts located in the Colorado Springs area. The school districts include: 1) Academy School D-20 with four schools and a district population of 6,083 elementary students; 2) Colorado Springs School District D-11 with four schools and a district population of 16,049 elementary students; 3) The Colorado Springs School, an independent school, with an elementary student population of approximately 100 students; 4) Fountain-Fort Carson School District with three schools and a district population of 2,454 elementary students; 5) Harrison School District with one school and a district population of 5,886 elementary students; and 6) Woodland Park School District with one school and a district elementary school population of 1,264 students. The Colorado College Center has the most diversity of grade levels represented in its group with 16 percent being middle-level teachers, 32 percent being primary-level teachers, and the remainder from grades 4-6. Of the teachers, 84 percent are in self-contained classrooms; 36 percent have masters degrees; 27 percent have 10 or fewer semester credits in science; 52 percent have less than 10 years of teaching experience; and 87 percent are Caucasian.

6.1.1 Partnerships and cost sharing. The Colorado College (CC) is the primary subcontractor for the Colorado Springs CO-STEP Center. Colorado College's cost sharing contribution totals $18,000.00 for the first three years of the project. In addition, Colorado College was one of four CO-STEP centers that applied for and received a teacher enhancement grant from the Environmental Protection Agency to provide supplemental support for the environmental science program during 1994-95. The Colorado College received $7,500.00 from EPA.

6.1.2 Teacher development program. Colorado College and BSCS collaborated in the fall of 1991, prior to NSF funding, to initiate a pilot CO-STEP program in Colorado Springs. We recruited 18 area elementary teachers for an initial planning and orientation meeting. Fourteen teachers, comprising five school-based teams, began the project in November of that year. The course offerings of the pilot phase included: Strategic Planning Seminar (15 contact hours), Physical Science

Content Course (45 contact hours), a Summer Curriculum Planning Institute (60 contact hours), an Implementation and Action Research Seminar (15 contact hours), and a Leadership Seminar (15 contact hours). During the second and third years of the program, the staff of the Colorado Springs Center adjusted the schedule of CO-STEP meetings to adapt to the calendar for The Colorado College's graduate program, which includes a six-week summer program. The CO-STEP program at CC redistributed the total number of contact hours by increasing the number of contact hours during the summer and by spreading the remaining contact hours evenly over the school year. The schedule adjustment has worked well for the center staff and participants, because there is sufficient contact in seminars and classroom visits during the school year to maintain participant interest and commitment to the program.

The first cohort of participants were engaged in a strategic planning course during the fall of 1991. They completed the physical science course during the spring of 1992. The physical science course focused on physical systems, energy and energy transfer, and chemistry. The latter was based on the CHEM program from the Lawrence Hall of Science, but with modifications to model an active, constructivist approach to teaching. BSCS received NSF funding during the spring of 1992, and Colorado College became the first official regional center for CO-STEP. Center staff, with support from BSCS staff, held the first Curriculum Planning Institute at CC during the summer of 1992. During the summer institute, participants continued their investigation of the physical sciences (force, motion, energy--all adapted from the Intermediate Science Curriculum Study) and worked in teams to adapt a physical science unit for use with their students in the fall.

The first cohort of participants taught their units during the fall of 1992 and took part in action research and leadership seminars. Colorado College CO-STEP staff made several classroom visits to observe the units being taught and to assist the participants in evaluating the effectiveness of the unit. Participants found that they were teaching more hands-on activities than before CO-STEP, but that the units were too long, covered to many concepts, and often were not constructivist in nature. During the past two years, these participants have reduced the number of concepts included in their units and have made significant progress in using constructivist teaching.

During the summer of 1993, the Center staff conducted a second science content course (as part of the first six-week summer institute) focusing on life, environmental, and geological sciences. Biology and Geology faculty from CC co-taught the content course with the Center director, who is a professor of education. At this time, a second cohort of participants joined the first resulting in a total of 32 participants for 1993. As part of the summer institute, participants also completed the requirements for the curriculum planning course, working in teams to adapt a life, environmental, or geological science unit for use with their classes in the fall. Colorado College staff also provided instruction in pedagogy and assisted participants in designing assessment procedures for their units.

During the fall of 1993, the Center director conducted an intensive recruitment of new CO-STEP participants, which resulted in 24 new CO-STEP participants joining the program in December. A strategic planning seminar was held during the spring semester of 1994 for the new participants while the other group of experienced CO-STEP participants continued to work on action research, assessment, and leadership. Participants engaged in activities to develop performance assessment tasks and developed rubrics for assessing student performance of those tasks. They compared their rubrics with those of other participants and with those of the original developer of the performance task with excellent results. Participants also examined and discussed the implications of the various national and state recommendations and standards for science education.

During 13 June through 22 July in the summer of 1994, the Colorado College conducted the Environmental Science Course and the Curriculum Planning Course. The summer program included: (1) a one-day field study on ecology near Florissant, Colorado, (2) a three-day trip to study the Arkansas Watershed (the main source of water for the community of Colorado Springs), (3) three weeks of on-campus work during which participants worked in the chemistry laboratories with CC science faculty on water-related chemistry, reviewed environmental education resources, and developed their unit plans on environmental science, (4) a one-week session at the Baca Center of Colorado College (located in the San Louis Valley) where they contined to work on ecological field studies with CC faculty, and (5) a final week on campus refining their unit plans and sharing them with their colleagues. Center staff held regular seminars during the fall of 1994 and spring of 1995 on action research, constructivist teaching, assessment, and leadership.

6.1.3 Qualitative information As of fall 1994, based upon notes from classroom visits, reviews of participants' journals, and staff reflections after seminars and institutes, the participants have made and continue to make excellent progress. Participants report that their students respond well to the hands-on and minds-on approach they are using. Many participants are serving on building and district level science committees and report that they often assist fellow teachers regarding elementary science curriculum and instruction.

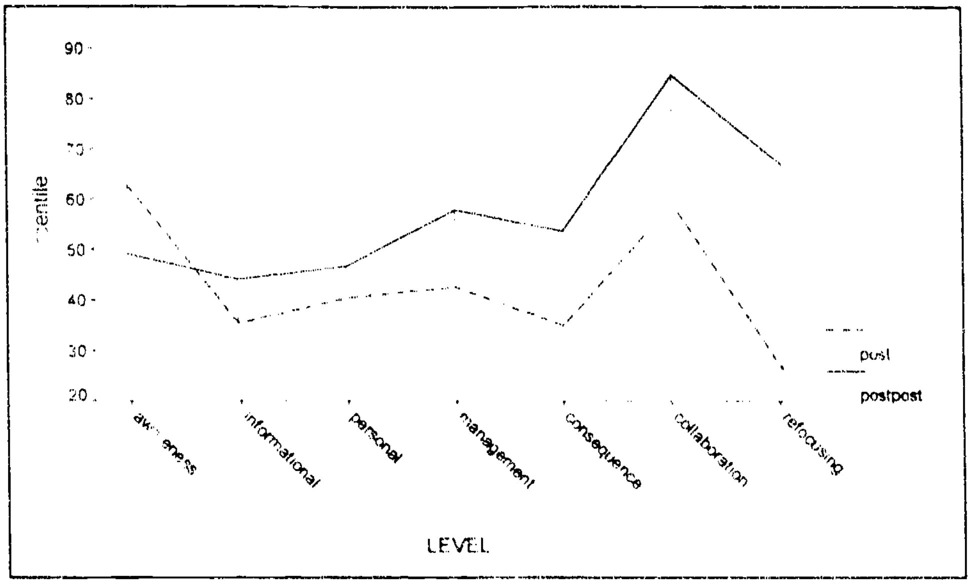

Figure 4. SoCQ profile for Colorado Springs

6.1.4 Quantitative data. We found significant increases (.05 level) in the number of minutes teachers spent per week teaching science, in teachers' perception that they emphasize (1) major conceptual themes and (2) educational technology in their teaching, in teachers' willingness to incorporate educational technology in their teaching, in teachers' perception that they are well prepared to incorporate constructivism into their teaching, and in teachers' perception that they are well prepared to teach other teachers to use (1) constructivism, (2) major conceptual themes, (3) and educational technology in their teaching. There were no significant changes in either subscale for the STEBI. The SoCQ results in figure 4 for Colorado Springs represent only the post and postpost data for the first cohort of participants, because these participants did not complete the SoCQ prior to the pilot phase of the project. The results, however, follow the anticipated pattern of teachers making progress in the process of change. The management, consequence, collaboration, and refocusing concerns all increased.

6.1.5 Plans for sustaining the program During the fall of 1993, the Colorado College CO-STEP Director submitted a proposal to NSF to institutionalize CO-STEP in a new graduate program, Master in Arts in Teaching (MAT) in integrated natural sciences. The proposed program would allow current CO-STEP participants the option of applying for the degree and using their CO-STEP course work and activities as credits toward the degree. The MAT degree proposal was approved unanimously by the college faculty at its December, 1993 meeting. Colorado College received the grant from NSF Teacher Enhancement to work with Colorado College faculty to refine the work they began with the CO-STEP program and to extend it to another level (middle school science teachers). With the adoption of the MAT program and the growing interest and support of the college science faculty for CO-STEP at Colorado College the continuation of the goals and objectives of the CO-STEP program is assured.

6.2 University of Southern Colorado in Pueblo (started in 1991)

There are 21 participants in the CO-STEP program at the Pueblo Center. The participants are from D-60 (schools in the City of Pueblo) and D-70 (schools within Pueblo County excluding those in the City of Pueblo). Pueblo D-60 with 22 elementary schools that serve 8,825 students has 11 participants, and Pueblo County D-70 with seven elementary schools that serve 2,050 students has ten participants. The size of the student populations for the schools across both districts ranges from 85 to 630. Of the participants, 60 percent are in grades 4-8, 85 percent teach in self-contained classrooms, 55 percent have a masters degree, 90 percent have more than 10 semester hours in science; 65 percent have 10 or more years of teaching experience. 35 percent are Hispanic and the remainder Caucasian, and 65 percent indicated their school qualifies for Chapter One Funds.

6.2.1 Partnerships and cost sharing. The University of Southern Colorado (USC) is the primary subcontractor for the Pueblo CO-STEP Center. The University's contribution for the Pueblo CO-STEP Center is $5,935.00 for the first three years of the project. In addition, USC was one of four CO-STEP centers that in 1994 applied for and received an EPA Environmental Education Grant (USC received $7,500.00) to supplement the instructional program for environmental science during the 1994-95 school. The Pueblo CO-STEP Center is a collaborative project between the University of Southern Colorado, Pueblo D-60, and Pueblo County D-70. D-60 and D-70 will contribute $108,264 in cost sharing over the first three years of the project. Total cost sharing contributions amount to $121,681.

The Pueblo Center took the lead in collaborating with Adams State College (ASC) to establish a Master of Arts degree in Elementary Education with an emphasis in science teaching. The University of Southern Colorado is prohibited by state law from offering graduate degrees in education, but did encourage and support the establishment of the degree program through ASC. The CO-STEP courses initially were offered as independent study credits though the college of natural sciences at USC, but once ASC established its program the teachers were able to transfer the credits from USC to ASC. To complete the requirements for the master's degree, participants received credit for several of the CO-STEP courses; in addition, they completed 10 hours of core courses from the ASC program, completed a written comprehensive exam (with two questions on science education prepared by CO-STEP staff) and completed a field research study (based on action research on one of their units).

6.2.2 Teacher development program. USC and BSCS collaborated in the fall of 1991 to initiate a pilot CO-STEP program in Pueblo. During the fall of 1991, 18 area elementary teachers participated in an initial planning and orientation meeting. Fourteen teachers comprising five school-based teams began the project in November of that year. The instructors for the pilot phase during the first year were BSCS staff members, the center director from Colorado College, and Curriculum Specialists from D-60 and D-70. The first year's course offerings included Strategic Planning (15 contact hours), Physical Science Content Course (45 contact hours), a Summer Curriculum Planning Institute (60 contact hours), an Implementation and Action Research Seminar (15 contact hours), and a Leadership Seminar (15 contact hours).

6.2.3 Qualitative information. The participants' response to the physical science course that we offered during the first year was very positive The teachers indicated in their journals that as they became more familiar with the physical science concepts, their comfort level increased. The field trips to the Comanche Power Plant (energy transfer), the Garden of the Gods (Geological history of the Pikes Peak region), and the Olympic Training Center (sports physics) were quite successful Many of the teachers felt uncomfortable initially during the first year's leadership seminar; they indicated in their journals that they did not like the idea of being an instructor for an "inservice workshop" with colleagues. The staff recognized the problem and worked with the teachers to develop an operational definition for leadership that included a broader view of what lead teaches do, including both formal and informal leadership tasks At the conclusion of the leadership seminar, most of the teachers felt comfortable with the leadership role that they were assuming in their individual schools Some felt comfortable enough that they served on their district's K-12 Science Committee. One of the participants stated, "I know I don't know everything there is to know in science but, I know what good science instruction for elementary students looks like and some of the other members of the Science Committee don't" By their third year, most of the participants indicated that they felt comfortable enough to conduct science staff development activities within their building, and several had made presentations at district, state, and regional science conferences.

One of the participants in the Pueblo CO-STEP program was nominated and received the Presidential Award for Excellence in Teaching Elementary Science and Mathematics. Another, was nominated for and received the Colorado Association of Science Teachers' Elementary Science Teacher of the Year Award This teacher indicated in her CO-STEP journal, during the first year, that she joined the program because she felt uncomfortable with her science teaching and wanted to explore some new approaches She also was disappointed that she could not find any other teachers in her building that first year to join her in CO-STEP (building teams were required to join the project, but Pueblo staff made an exception for her the first year). By the second year, two additional teachers from her building joined CO-STEP, by year three, the building staff decided to use hands-on and minds-on science as their instructional theme for the year In a recent visit to the school, we were told that every teacher in the building is teaching hands-on science this year and the halls of the building were decorated with student murals, each reflecting the science units they were studying in their classes.

One of the Pueblo teams was instrumental in designing and equipping a science laboratory in its building The team then designed and implemented a staff development program to assist their colleagues in effectively using the facility to teach inquiry science. Later, this team decided to develop a portion of their school site for use as an outdoor science area. Working with colleagues and students, they contacted parents and business people to raise the funds needed to develop the school site.

During one of the classroom visits by BSCS and Pueblo CO-STEP staff, the observers commented on the integrated approach the teacher was using to the science unit she was teaching (marine ecology) There were paper fish, algae, and other marine organisms hanging from the ceiling, student stories about marine organisms, and several investigations in progress The teacher credits her CO-STEP classes, because before she joined the project her science classes had been only reading from the text and answering the questions at the end of the chapters When the staff asked why or what in CO-STEP made her change she replied that "doing science in CO-STEP made me realize that science is fun and important and a great way to learn"

The Pueblo CO-STEP participants initially were reluctant to try the action research portion of the CO-STEP program The requirement for the Action Research Seminar was to identify a question to investigate that related in some way to their science unit, which they adapted from extant materials. Several teachers stated that they didn't know what to look for or how they could find answers to their questions and wanted the Pueblo CO-STEP staff to tell them what to "research." With staff guidance, the teachers worked through the first year of their action research with some frustration and limited success. By the beginning of the second year, they had a much clearer understanding of action research, and at the end of the action research seminar for the second year, the reports of findings were excellent. The participants were pleased with their research and many indicated that for the first time they really knew what their students learned. One participant stated that she now knew what her students learned and what they didn't learn and had some ideas on what changes she could make to improve their learning. On one recent classroom visit, participants indicated that they hoped that the Pueblo CO-STEP group can continue to meet and share as they have been doing for the past three years, because they would like to continue to grow.

The Pueblo CO-STEP staff and some of the participants are working with the educational curator at the Pueblo Zoo to put together cooperative learning activities for use by elementary teachers. The activities involve organizing a field trip to the Zoo that encourages students to be active rather than passive learners. They also worked with the staff of the local nature center, a raptor recovery center, and members of the Department of Natural Resources staff members to adapt and develop constructivist-based activities for their school programs. These are just two of several such projects in which the Pueblo CO-STEP staff and participants have become involved within the community.

Nine of the participants are completing the requirements for the masters degree program through ASC. Each was able to use the knowledge and experience they had with action research to develop and conduct their field study. The four field studies submitted thus far received high marks and satisfactorily met the requirements of ASC. The findings support that the kind of science being taught by CO-STEP participants results in significant improvements in student understandings and attitudes toward science.

6.2.4 Quantitative data. Because the Pueblo Center started in the pilot phase of the project and we did not collect the same information for their pretest, we do not have data to compare their pretest and posttests. We have not received the questionnaires from the Pueblo Center for their posttest; therefore, we have no quantitative comparisons to share at this time.

6.2.5 Plans for sustaining the program. The Pueblo CO-STEP staff plan to continue with CO-STEP once NSF support ends by folding the program into their district staff development program. They are working with USC staff members to offer science courses for elementary teachers that will align with district, state, and national guidelines. The Center staff indicate that they plan to continue to work with Adams State College to provide opportunities for elementary teachers in D-60 and 70 to enroll in the the new masters degree program. They recently sent out an announcement to the school districts in the region inviting elementary teachers to take part in their science staff development program.

6.3 Colorado State University in Fort Collins (started in 1992)

The CO-STEP Center in Fort Collins began during the summer of 1992, and serves 32 participants from the Poudre R-1 school district in northeastern Colorado. Poudre R-1 has 29 elementary schools serving the city of Fort Collins and the rural areas in Larimer County. The CO-STEP Center serves 15 schools (12,881 students). Individual school populations range from 43 to 642 students. Of the participants, 68 percent are from grades 4-6, 84 percent are from self-contained classrooms, 36 percent have a masters degree, 40 percent have ten credit hours or less in science, 40 percent have less than ten years of teaching experience, 94 percent are Caucasian, and 39 percent indicate that their school qualifies for Chapter One funds. The Center has served 32 teachers each year; six have dropped out during that time but were replaced by others. The six participants who left the program did so because they changed teaching assignment, moved out of the district, or had family or health problems.

6.3.1 Partnerships and cost sharing The Center staff are employed by the Colorado Science, Mathematics, and Technology Education Center (CSMATE) at Colorado State University. During 1993-94, the University provided $11,928.00 in support of the CO-STEP project; Poudre R-1 provided $8,000.00 in cost sharing through teacher release time, consultant support, and materials support for the teacher-adapted units. During 1994-95, the Fort Collins Center participated with the CO-STEP Centers in Colorado Springs, Pueblo, and Greeley in a grant for teacher enhancement from the Environmental Protection Agency. The Centers are using the EPA funds (a total of $25,000 for all four Centers with $5,000 of that for CSMATE) as support for the environmental science portion of their teacher development programs. Total cost sharing for the 1994-95 school year is $24,928.

6.3.2 Teacher development activities The Center at CSU followed the general CO-STEP model for teacher development, with the exception that they scheduled most of the activities during the summer at the request of the participants. Center staff reported that they conducted classroom visits to support the implementation of the teacher-adapted units; developed the syllabi for the Environmental Science Course and Curriculum Planning Course; administered post-tests for participants for year two and pre-tests for new participants; and presented on CO-STEP at the annual meeting of the Colorado Association of Science Teachers. The syllabi for the Environmental Science Course and Curriculum Planning Course included the following schedule of activities:

October, 1994:	strategic planning (3 hrs.)
February, 1995:	Heart of the Rockies - an environmental education workshop (3 hrs.)
April, 1995:	strategic planning (3 hrs.)
May, 1995:	Stalking Education in the Wild - an environmental education workshop (2 days)
	Winter Ecology - a curriculum development workshop (3 hrs.)
July, 1995:	Keystone Science School - an environmental education workshop (3 days)
	Teton Science School - an environmental education workshop (4 days)
	Canyonland's Field Institute - an environmental education workshop (4 days)
	Environmental Education - a wrap up session (1 day)

The Center's annual report for 1994-95 indicated that the Center staff have redesigned the program successfully to meet participants' needs for increased emphasis on science content and constructivist-based pedagogy and for increased opportunity for intra-school planning. Participant response to the physical science and life science content courses was excellent, with many participants adapting the activities and investigations from the content courses for their own classroom.

6.3.3 Qualitative information The participants have each adapted and implemented a physical science and a life science unit from the FOSS program, which is the district's science program. The participants have been leaders for science education in their individual buildings. A few participants have made presentations at local and state science meetings. Most participants indicate in their journals that they have made several changes in their instructional program and in their approach to teaching science. Participants state that student interest in science has increased due to the use of cooperative learning and an inquiry approach to teaching. Classroom observations by the Center staff substantiated the self-report data.

CO-STEP participants receive recognition for their expertise in science education. Several CO-STEP participants serve on the science committee for Poudre R-1 and assist with staff development in science. During the 1993-94 school year, one participant was nominated for the National Presidential Award for Excellence in Science and Mathematics Teaching and another was chosen as teacher of the year for her school.

The Fort Collins Center has established strong partnerships, under the guidance of CSMATE. Adams State College is encouraging participants to apply credits received from the CO-STEP program toward a Master of Arts in Elementary Education with an emphasis in science education. Center staff collaborated with principal investigators from the CONNECT Project, BSCS staff, and the director of CSMATE in holding a state-wide planning conference at CSU in March for individuals and organizations in Colorado involved in teacher development in science. A series of mini-conferences on science staff development are planned for individuals and organizations that serve specific populations (e.g., elementary school science, middle school, high school, and informal science education).

6.3.4 Quantitative data. We found significant increases (.05 level) in the number of minutes of science taught and the percent of time spent on teacher demonstrations. We found significant increases (.05 level) in teachers' perception of how valuable assessment and evaluation is to elementary school science instruction, in teachers' perception of how well prepared they are to incorporate (1) major conceptual themes, (2) educational technology, and (3) nature of science into science teaching, and in teachers' perception of how well prepared they are to teach other teachers about (1) major conceptual themes, (2) assessment and evaluation, (3) educational technology, (4) nature of science, and (5) science facts. We found no significant change in either personal efficacy or outcome expectancy on the STEBI. The SoCQ profile followed the expected pattern of teachers undergoing the process of change, with the initial high information and personal concerns prior to the project decreasing over the next two years (see figure 5). The teachers had high collaboration concerns throughout the project, which is evidence of the importance that team building played in the project.

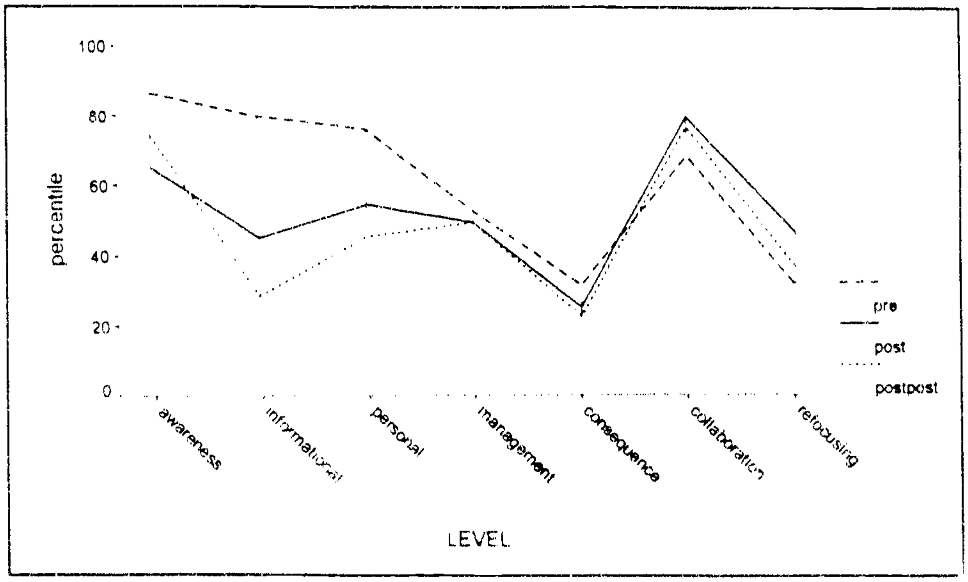

Figure 5. SoCQ profile for Fort Collins

6.3.5 Plans for sustaining the program. CSMATE's mission is to serve as the focal point for program development, for research, and for fostering improvement in innovations and reforms in science, mathematics, and technology education. In discussion with the CSMATE administration and staff, they indicate that they intend to continue the CO-STEP program into the future. They developed an excellent working relationship with Poudre R-1. The CO-STEP coordinator now serves in an advisory capacity on the district science committee. Other school districts in their region have contacted the Center coordinator to seek staff development for their elementary teachers based upon the CO-STEP program.

6.4 Mesa County Valley Schools in Grand Junction (started in 1992)

The CO-STEP Center in Grand Junction is in its third year of involvement in the BSCS CO-STEP project. Mesa County Valley Schools has 8,523 student in 20 elementary schools, with individual student populations in buildings ranging from 253 to 672 students. Mesa County Valley Schools includes both urban schools, which are located within the city of

Grand Junction, and rural schools Twenty eight teachers, representing ten of the District's 20 elementary schools, are participating in the CO-STEP program at the Grand Junction Center Of the teachers, 68 percent are in grades 4-6 with the remainder in grades 1-3; 85 percent are in self-contained classrooms; 79 percent have less than a masters degree; 68 percent have received ten or less semester hours in science; 54 percent have less than ten years of teaching experience, and 93 percent are Caucasian Each teacher participant made a three-year commitment to remain in the program through the complete cycle of content courses. The program began with 30 participants, and five dropped out during the first two years, which was half of the anticipated attrition for this intensive project When designing the project, BSCS anticipated that as many as ten participants would drop out each year, because they would move out of the district, would change teaching assignments, or would have other assignments that would conflict with continued involvement in such an intensive program Five new participants were added at the beginning of year two The coordinator for the center indicated in her annual report for the second year that the work of the CO-STEP participants generated great interest in the district and it was easy to fill the positions vacated Through informal and formal leadership efforts, participants in the CO-STEP program are providing support for the district's other 300 elementary teachers

6.4.1 Partnerships and cost sharing. Working in conjunction with faculty from Mesa State College in Grand Junction, staff from Mesa County Valley Schools operate the CO-STEP Center in Grand Junction. Each year of the project school district and the college provide substantial contributions to the project. During 1993-94, Mesa County Valley Schools provided $27,280, and Mesa State College contributed $3,600.00 in consulting services.

6.4.2 Teacher development program The teacher development program for CO-STEP in Grand Junction closely follows the general CO-STEP model and includes 1) a strategic planning seminar for participants during the first year of their involvement. 2) a content course each spring, (1993 - physical science. 1994 - life science, and 1995 - environmental science). 3) a leadership seminar; 4) a curriculum planning institute for three weeks each summer for participants to review curriculum resources and to adapt the district's adopted program (the Delta Modules) using the knowledge and skills developed through CO-STEP, and 5) an action research course during the fall each year.

6.4.3 Qualitative results. The Center Coordinator indicates that the CO-STEP program engendered much interest among elementary teachers throughout the district. The number of inquiries from teachers about the program indicates that they will have no difficulty maintaining a high level of participation throughout the first three years of the project

The Center staff, in conjunction with the CO-STEP program in Douglas County, developed and submitted a teacher education proposal to the Environmental Protection Agency for supplemental funding ($1[illegible],000) that would allow CO-STEP teachers from the two programs to work together to plan environmental education units This supplemental funding will provide teachers and their students in each district the opportunity to conduct science investigations (e g., water use and quality in each community) and to communicate with teachers and students doing similar studies in another part of the state

Staff and participants in the CO-STEP program are leaders in the district's efforts at science program improvement Two teachers received a $600 grant from a local company to develop "science suitcases" for each grade level in their building and to conduct staff development sessions on those materials for their colleagues One of the participants received a Classroom Connections Award for a science unit she developed and submitted to the Public Service Company of Colorado Many participants report sharing CO-STEP activities and strategies with colleagues in their schools Through a variety of informal leadership efforts, the CO-STEP teachers have encouraged and supported colleagues in using a constructivist approach in their science teaching They were instrumental at introducing the Eduquest Personal Science Laboratories into their Chapter Two schools and assumed responsibility for the district's in-service program for elementary school science. The district has devoted a portion of Title Two funds to support leadership activities of the CO-STEP teachers

CO-STEP has strengthened the ties between Mesa State College and Mesa County Valley Schools Dr Gary McCallister, biology professor and Dr Norma Smith, Dean of the College of education are serving on the steering committee for the CO-STEP Center. The CO-STEP coordinator serves on the strategic planning team for the Mesa State branch of the CONNECT project (Colorado's Statewide Systemic Initiative). In her annual r rt, the CO-STEP coordinator stated, "Local teachers, administrators, and college professors with expertise in the pedagogy important to CO-STEP, make it possible for the program to work here."

The CO-STEP coordinator indicated that the participants have exhibited a strong commitment to changing the way they teach science CO-STEP teachers are using more hands-on and minds-on activities in their classrooms. Many have incorporated cooperative learning into their science program and are using it in teaching in other content areas as well. During one school visit, the BSCS project director and the center coordinator observed several tea ers working with their students on an ecology unit dealing with predator/prey relationships The students, which included a number of special e ucation students, were working in teams examining owl pellets, developing dioramas, and w ting stories about predators and their role in natural communities.

Ten of the participants participate in the Master's degree program offered through Adams State College. This is a special degree program that Adam's State College developed for the CO-STEP project Adams State College includes several of the CO-STEP courses in their masters program. CO-STEP participants who complete the program will receive a Masters of Arts in Elementary Education with an emphasis in science.

6.4.4 Quantitative data. We found significant changes (.05 level) in the number of minutes of sc nce taught per week (increased), the percentage of time spent on discovery-based learning activities (incr sed), the amount of time students spent using a second or third textbook (decreased), the perception that constructivism is valuable in elementary sc ool science instruction (increased), the willingness to use ed catio al technology in teaching (decreased), the perception hat they are well prepared to incorporate constructivism into teaching (increased), the perception that they are prepared to teach other teachers about (1) constructivism, (2) cooperative learning, (3) major conc ptual themes, (4) assessment and evaluation (5) the nature of science, and (6) science facts (increased)

We found a significant improvement (.05 level) in personal efficacy toward teaching science, but not for outcome expectancy for science teaching Table 5 provides the results of the Analysis of Variance for the STEBI instrument It is not unusual for teachers to first change their belief that th can teach science well before they change their belief that students will learn science successfully Ac ording to Hall and Hord (1987) for the first three years, or more, of implementing new approaches to teaching, teachers often focus their attention on, informational.

	Sc ce	D.F	Sum of Squares	Mean Squares	F Ratio	F Prob
Outcome Expectancy	Between groups	2	191 25	95 63	32	45
	Within groups	60	7026.18	117 10		
	Total	62	7217 43			
Personal Efficacy	Between groups	2	680.06	340 03	47	00
	Within groups	62	2489 69	40 16		
	Total	64	3169 75			

Table 5 Analysis of Variance Pre Post Postpost for STEBI for Grand Junction

personal, and ma..agement concerns and do not begin to concentrate on refining the program to maximize student learning until later in the process of implementation. The teachers must first successfully teach and see improvements in student learning, before they have expectations for improved student outcomes. This general pattern of teacher concerns is supported by the results of the SoCQ (see figure 6). At the beginning of the project teachers had high informational and personal concerns. at the end of the first and second years, the teachers' informational and personal concerns decreased and management and consequence concerns increased. Perhaps because of the emphasis on working in teams, collaboration concerns were high throughout the project

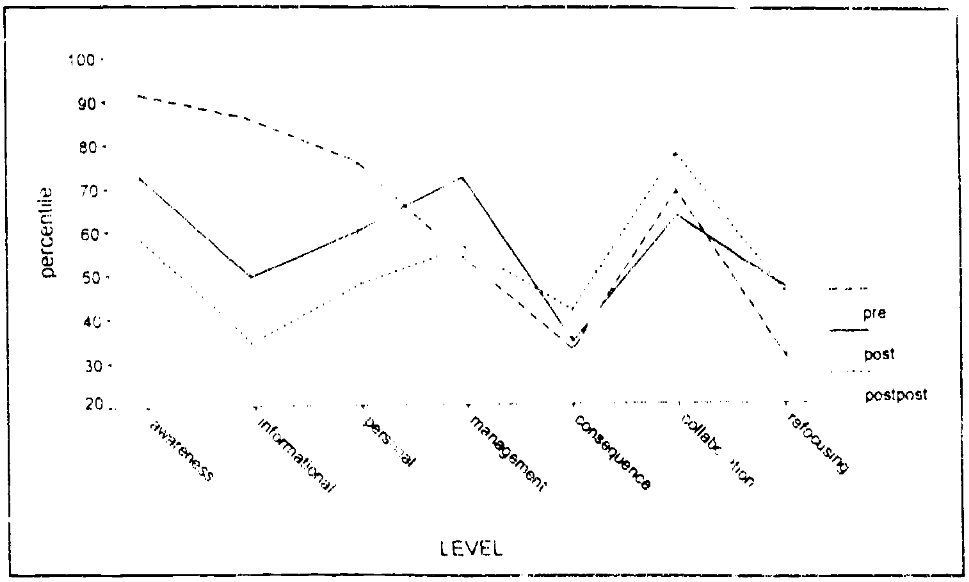

Figure 6: SoCQ Profile for Grand Junction

6.4.5 Plans for sustaining the program Several building principals and district-level administrators have indicated a desire and a commitment to continue the program after NSF funding ends. They estimate that they can continue the program at a cost of $20,000 per year. Center staff along with building and district-level administrators are seeking funds through reallocation of district funds and from the community and state agencies.

6.5 University of Northern Colorado in Greeley (started in 1993)

There are 19 participants in the CO-STEP project at the Greeley Center. The participants represent both urban and rural settings. The participants are from seven schools and three school districts: one of two elementary schools is from Eaton, which has 484 students in the district, five of thirteen schools are from Greeley, which has 5,685 students in the district, and one of seventy-nine schools is from Denver Public Schools, which has a student population of 62,673. Of the participants, one-third are in grades 1-3 and the remainder are in grades 4-6, two-thirds teach in self-contained classrooms; 40 percent have a masters degree, all have more than 10 semester hours of science, 40 percent have less than 10 years of teaching experience, 20 percent are Hispanic and the rest are Caucasian, and 93 percent indicate that their school qualifies for Chapter One funds.

6.5.1 Partnerships and cost sharing The University of Northern Colorado (UNC) is the primary subcontractor for the UNC CO-STEP Center. The UNC CO-STEP Center formed partnerships with the Greeley Schools D-6, Eaton Schools RE-2, and the McMeen School in Denver. The University's contribution to the CO-STEP Center is $23,230 for the first three years of the project. The UNC Center was one of four centers that in 1994 applied for and received an EPA Environmental Education Grant (UNC received $5,000) to supplement the instructional program for environmental science during the 1994-1995 school year. The Center staff is collaborating with BSCS staff and the CONNECT site at UNC/Greeley D-6 (one of the twelve partnerships in Colorado's Statewide Systemic Initiative) to conduct the staff development program for Greeley and UNC CO-STEP participants during the summer of 1995

6.5.2 Teacher development program. The major goal of the UNC CO-STEP program is to assist participating teachers in planning, designing, and implementing improvements in their science and mathematics curricula, assessment procedures, and teaching strategies. To meet the needs of the districts and participants, the Center staff designed the following staff development program:

1) Content/pedagogy (summer each year)
2) Curriculum design and implementation (summer and fall each year)
3) Implementation/action research (fall and spring each year)
4) Leadership (summer each year)
5) Strategic planning (summer and fall of the first year)

The courses and seminars in this design attain the general CO-STEP model of 110 hours of direct instructional time. The unique feature of the program is that the majority of the instructional time is scheduled in the summer to accommodate the needs of the university and participants. A special emphasis of the UNC Center is on providing intensive follow-up support and coaching to participants in their classrooms during the school year. In addition to being instructors for the courses and seminars, the staff members are assigned to a school team of participants and meet with them on a weekly basis throughout the school year. In the other CO-STEP Centers, the staff members typically visit less frequently, ranging from once a month to twice a year. During the visits UNC Center staff meet and consult with participant teams and individuals, observe science classes, and assist participants in teaching one or more of their unit lessons.

6.5.3 Qualitative information. During the fall of 1993, the Center staff offered two all-day workshops on curriculum implementation, strategic planning, and leadership. The content focus for the 1994-95 program is environmental science. The staff arranged for a special two day session at the Rocky Mountain National Park with an environmental educator, Mark DeGregario of the National Park Service, who worked with participants using ecological and environmental activities, and investigations. Participants responded positively to these program activities.

The participants are making substantial progress in improving their school science programs. One of the participants established a special "elementary chemistry" program for at-risk students in her school. The initial goals and objectives for this program were: (1) to introduce the key elements of a chemistry lab by providing a basic understanding of laboratory techniques, (2) to introduce fundamental chemistry concepts such as a basic understanding of atoms and their structure, and (3) to introduce and engage students in the use of scientific processes. Students studied prominent scientists from their own culture and other cultures, and were urged to attend college and pursue studies in chemistry or one of the other sciences.

6.5.4 Quantitative data. The participants at the Greeley Center did not complete the innovation checklist as part of their pretest, therefore, we could not make comparisons between pre and posttest on those variables. We found no significant changes for either STEBI subscale. The SoCQ profiles (see figure 7) followed the expected pattern of a decrease in initial high information, personal, and management concerns, which indicates that teachers are making progress in the process of change.

6.5.5 Plans for sustaining the program. The UNC Center is building a partnership with the University and with the CONNECT site in UNC/Greeley. [illegible] Hackett, a professor of science education at UNC who serves with the local branch of the CONNECT project, joined the staff of the UNC CO-STEP Center for its third project year. His goal is to unite the CONNECT project, the mission and interests of UNC, and the CO-STEP project into a coherent whole. The plan is for the

CO-STEP project to continue beyond year three, and beyond NSF funding, as one activity of the CONNECT project and to integrate the courses into the offerings at UNC. As in the work at UNC, we are finding that a key feature of sustaining the work of the CO-STEP project beyond NSF funding is the institutionalization of the courses into the regular offerings of a college or university.

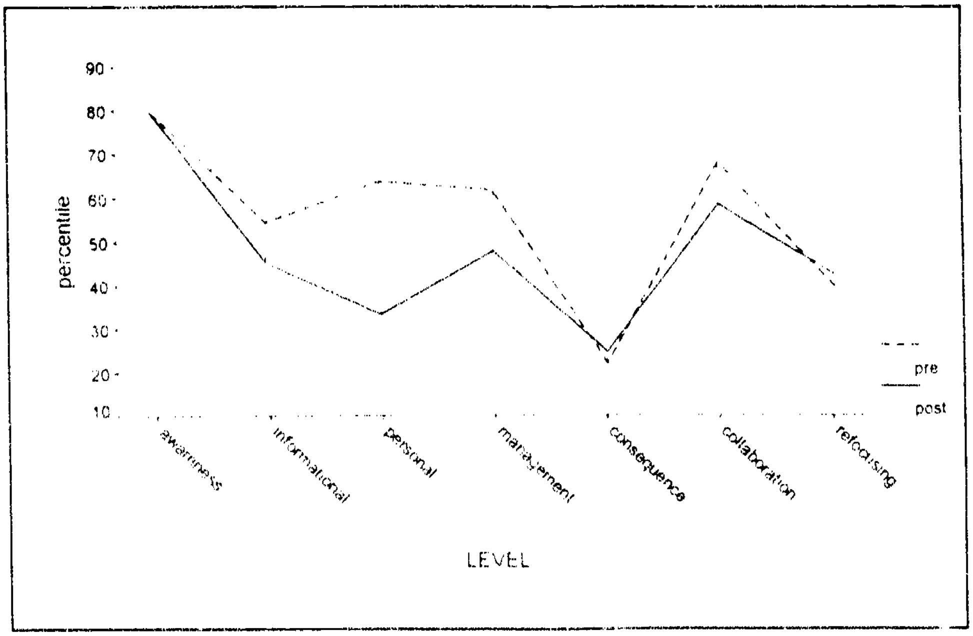

Figure 7. SoCQ profile for Greeley

6.6 Douglas County Public Schools in Castle Rock (started in 1993)

The CO-STEP Center in Douglas County started its work during the fall of 1993. Douglas County RE-1 has approximately 10,622 elementary students and 380 elementary teachers. Douglas County RE-1 is located south of the city of Denver and includes both suburban and rural areas. It is one of the fastest growing school districts in the nation. The district administration is involving select CO-STEP participants in redesigning the science program. The district has an outdated framework for elementary science that includes guidelines for content and process skills, but has no formal science program. Several CO-STEP participants are involved in developing district science standards based on the Colorado State Science Standards; the next step will be to adopt, adapt, and/or develop an elementary science program for the district.

The Douglas County Center has 29 participants from 11 of the 21 elementary schools in the school district. During the first two years, only four members dropped out of the program. The initial group consisted of 31 participants, and two new teachers were added from schools already participating in CO-STEP. Of the participating teachers, 84 percent are from grades 4-6, 100 percent are in self-contained classrooms, 32 percent have a masters degree, 65 percent have earned 10 or less semester hours in science, 61 percent have less than ten years of teaching experience, 93 percent are Caucasian, and 15 percent indicate that their school qualifies for Chapter One funds.

6.6.1 Partnerships and cost sharing. The school district is the subcontractor for the Douglas County Center. The Center is collaborating with the University of Colorado - Denver to provide participants with an opportunity to earn a masters degree in elementary education with a science focus. The district is providing $17,217 per year in support of the project. In addition, the district provides the participants each with $75 to purchase curriculum materials for the science units developed in CO-STEP. Another $6,900 in registration fees for graduate credit are being paid by participants desiring credit each year.

6.6.2 Teacher development program. Douglas County is unique in that many of their elementary schools operate year-round. Therefore, the generall model BSCS developed for the CO-STEP program did not fit their operation. With the

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assistance of BSCS, staff of the Douglas County Center developed a teacher development program that incorporated the goals and objectives of the CO-STEP program, but whose schedule was compatible with year-round schooling. In the Douglas County plan, participants meet twice a month for evening sessions throughout the year, with an occasional additional Saturday session to meet the required number of contact hours for the programs' components. Because there is no extended summer vacation, the Curriculum Planning Course is sheduled during the regular school year. An unanticipated, positive effect of the CO-STEP project is that Douglas County Schools are using the collaboration with the University of Colorado - Denver as a model for how to design and deliver intensive staff development to their teachers.

The CO-STEP program in Douglas County began with a strategic planning seminar presented by district administrators and BSCS staff. The physical science course followed the strategic planning seminar. The Center uses secondary science teachers, who are familiar with the content and pedagogy empahsized in CO-STEP, as the instructors for the science content courses. BSCS staff collaborate with the instructors in planning the content courses and provide assistance and support during the courses. A BSCS staff member, Don Maxwell, occassionally serves as a guest instructor.

The content course each year (during October through February) is followed by a Curriculum Planning Course (during March through mid-July) in which participants review resource materials and programs related to the science content area they just studied. Then, working in teams, the participants develop a science unit to use with their students by adapting extant materials and programs to a constructivist approach. During September through November each year, the participants are involved in a series of seminars dealing with leadership and action research. The Action Research Seminar and the new Science Content Course alternate sessions during October and November. The schedule is demanding for participants, but during the first two years they have maintained a high level of commitment to the project.

6.6.3 Qualitative information The Center staff indicated in their annual report (July 1994) that the participants are encouraged by the support they are receiving from building principals and fellow teachers. One school adopted the improvement of school science as a major goal for the coming year, with CO-STEP participants being asked to assume the leadership.

Assessment has been a special emphasis of the Doublas County Center. In the Curriculum Planning Course, the participants examined assessment techniques as part of the development of a science unit. The quality of the physical science unit was evaluated with a rubric developed by Center staff. As another component of the overall assessment of the project, the Center staff evaluated teacher-developed portfolios containing responses to eleven journal articles/book chapters and resources that would help them to be a better science teacher. Center staff worked with individuals and small groups as they developed their units to ensure they incorporated the CO-STEP components related to pedagogy. The presentations made by participants during the last curriculum planning session were excellent. Groups presented their units and responded to questions and suggestions form other participants. Participant evaluations of the institute indicated a high level of learning by participants and a desire for clearer expectations from instructors.

The leadership seminar focused on assisting teachers in developing a meaningful framework for effective professional development and on understanding the change process associated with implementing their strategic plans. Content for the seminar included 1) five models of staff development (Dennis Sparks), adult learning theory (Malcolm Knowles), Concerns Based Adoption Model (Gene Hall and Shirley Hord), peer coaching, transitions management (William Bridges), staff development paradigm shifts (Dennis Sparks), and the RPTIM school improvement model (Fred Wood). Participants wrote two papers in reaction to journal articles related to staff development and change. A final paper was required that described how the concepts and models taught in the class would be used to support implementation of the strategic plan for their site Evaluations of the leadership course were extremely positive Participants appreciated looking at the processes and strategies of implementation

The Action Research seminar focused on assisting participants in conducting action research in their classrooms Each participant formulated a question, the answer to which was of special interest to him or her The book *How to Use Action Research in the Self Renewing School* (Sagor, 1992) served as a text. Participant feedback about the quality of the course was very positive. Some participants felt the course requirements were to high for one hour of credit This is consistent with what we found in other centers were there was an in-depth focus on action research. the first attempts can be a struggle We found in the other centers that when the participants go through the second year of the action research seminar that they find the research study easier to conceptualize and conduct and more meaningful to their teaching

6.6.4 Quantitative data. We found significant improvements (.05 level) in teachers' use of (1) hands-on activities and (2) discovery-based learning, teachers' perception that constructivism is valuable in elementary school science instruction; teachers' perception that they are well prepared to incorporate (1) constructivism and (2) cooperative learning into their teaching and teachers' perception that they are well prepared to teach other teachers how to use (1) constructivism, (2) cooperative learning, (3) major conceptual themes, (4) assessment and evaluation, (5) nature of science, and (6) science into their teaching For the STEBI, we found a significant increase (.05 level) in teachers' personal efficacy beliefs about science teaching, but not in teachers' outcome expectancy for students in science (see table 6) The SoCQ results (see figure 8) follow the expected pattern of a reduction in informational and personal concerns and a slight increase in consequence and collaboration concerns

Scale	test	N	df	Mean	SD	t-value	2-tail sig.
Outcome Expectancy	pre	28	51	41.79	13.57	1.24	.220
	post	25		37.84	9.37		
Personal Efficacy	pre	29	53	37.00	8.96	-2.91	.005
	post	26		45.8	6.98		

Table 6 t-test for STEBI for Douglas County

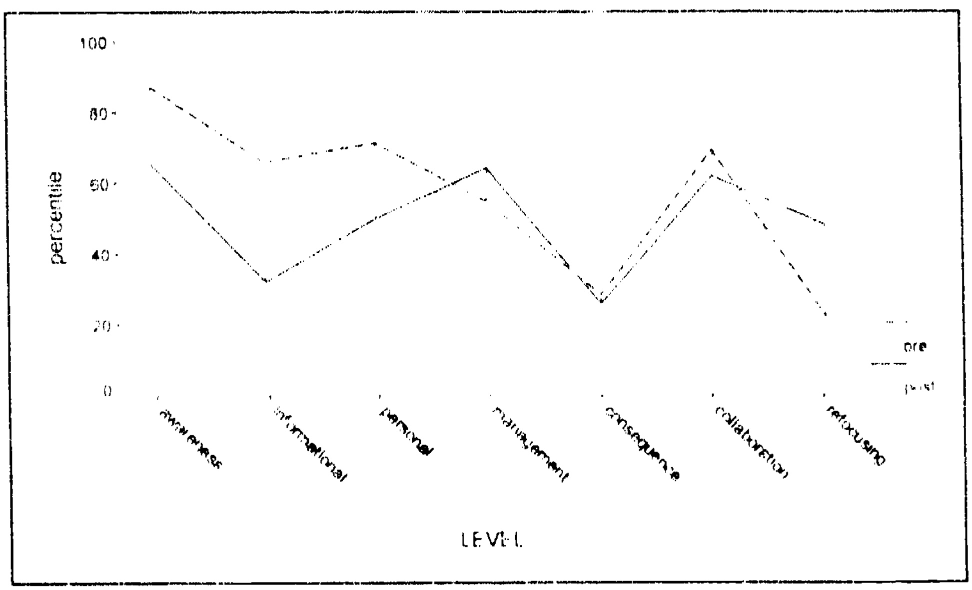

Figure 8 SoCQ profile for Douglas County

6.6.5 Plans for sustaining the program. District-level administrators in Douglas County indicate that they intend to continue the program beyond the funding provided by NSF. They are considering the possibility of beginning a second CO-STEP cohort next year before the first group finishes, because they want to expand the project to teachers in schools that have not participated in CO-STEP. Douglas County administrators also indicate that they intend to expand the masters program that the University of Colorado Denver established in collaboration with the CO-STEP Program.

7.0 Conclusions

Overall, the project is progressing well. Each of the six Centers is providing a quality professional development program in science education for a group of elementary school teachers. The participants are changing in their beliefs about their ability to teach science and their belief that all students can learn science. The participants are improving what they teach, how they teach, and how they assess learning in science. They are progressing through the process of changing their science program following the pattern supported by the research from the Concerns Based Adoption Model. They are becoming leaders in school science improvement in their schools, their districts, and their state. They are influencing the way their colleagues in their schools and districts are teaching science. Our judgment is that at its half-way point, CO-STEP is a success.

Saying that CO-STEP is a success is not the same as saying that there are no problems or unresolved issues. The focus of the evaluation in the middle of the project has been on obtaining formative feedback to guide improvements. We have identified the following as areas for improvement.

1. *Summative evaluation.* We plan to strengthen the evaluation plan for the summative evaluation of the project. We need to collect data to assess the nature of the classroom learning environment. We need to assess the change in teachers' knowledge about science. We need to collect additional information using multiple methodologies to assess the changes in classroom practices of the teachers. To the extent possible, we need to investigate changes in student learning resulting from the project. We need to document the effect that participants are having on changing the teaching of their colleagues. Much of the data must be collected through observation, interviews, and analysis of artifacts of teachers, students, and administrators. We will ask the Center staff to assist in collecting and analyzing these data for the summative evaluation.
2. *Unit planning.* The nature of the unit planning task varies among Centers more that we would like. We want to continue to encourage and support Center staff in facilitating participants in developing their unit plans. The focus of unit planning should be on adapting extant curriculum materials for the local goals, objectives, environment, and culture. At Centers where unit planning has been accomplished well, we have found that it is the keystone to teachers' reconceptualization of their vision of good science teaching.
3. *Action research.* The quality of the action research that participants conduct varies significantly from site to site. We are learning that action research is a powerful strategy to focus teachers on gaining control over their own professional development. We believe that by developing the research skills of teachers that they can and will use disciplined inquiry as lifelong learners of science education.
4. *Sustaining the network.* The Center staff uniformily agree that a major benefit of the project is the collaboration and sharing among themselves during our regular state-wide meetings of Center staff and informally between staff members from different sites. In a state where local control of education is the law and teacher education is delegated to only a few of the institutions of higher education, a project like CO-STEP, which has as its purpose to build a collaborative network for the improvement of elementary school science programs throughout the state, faces many challenges. However, with the recent establishment of the Colorado Systemic Initiative (CONNECT project) whose primary purpose is to coordinate science and mathematics education throughout the state, CO-STEP now has an umbrella organization that serves to unify all levels of the state education infrastructure around a common purpose. A major focus of CO-STEP during the last two years of NSF support will be (1) to strengthen the collaboration among the CO-STEP Centers, (2) to institutionalize the CO-STEP program at each Center, and (3) to strengthen the ties among CO-STEP, CONNECT, and all other individuals and institutions involved in the improvement of science and mathematics education in Colorado.

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