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AUTHOR	Henriques, Laura
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ABSTRACT

Science: Parents, Activities and Literature (Science PALs) was a four-year systemic reform effort collaboratively undertaken by the Science Education Center at the University of Iowa and a local school district. This paper summarizes the research base for effective inservice and shares additional features of Science PALs' inservice most responsible for success. Data was collected from teachers (N=16) during their first 1.5 years in the project. Data relating to teachers' beliefs and perceptions of teaching were compared to their actual teaching. Demographic information, survey responses, and interview and written responses to scenarios were among the data collected as source variables. Results indicate that newer teachers were more likely to implement the Science PALs model. Teachers reported much higher levels of implementation than their teaching performance indicated. Contains 77 references. (Author/ASK)

Maximizing the Impact of Your Designing the Inservice and Selecting Participants

by
Laura Henriques

Maximizing the Impact of Your Inservice: Designing the Inservice and Selecting Participants

Laura Henriques, Science Education, California State University, Long Beach, California

Introduction

This study took place within the context of the Science: Parents, Activities and Literature (Science PALs) Project. Science PALs was a four year systemic reform effort collaboratively undertaken by the Science Education Center at the University of Iowa and a local school district. Key features of Science PALs included the use of children's literature as a springboard into inquiry based science investigations, activities to increase parents' involvement in children's science learning and extensive inservice opportunities for elementary teachers. The overarching goal of this elementary science teacher enhancement project was to move teachers towards an interactive-constructivist model of teaching and learning.

What can be learned from Science PALs to inform other inservice projects? This paper summarizes the research base for effective inservice and then shares additional features of the Science PALs inservice most responsible for success. The selection of participants along with a cascading model of leadership is shared as finding participants who show early signs of success enhances the likelihood of project success.

History of Reform

The last large-scale science education reform occurred in the 1960's. This post-Sputnik reform effort included the release of multiple curricula, millions of dollars spent on teacher inservice sessions related to the new curricula and a call for Americans to move forward in science instruction to meet a perceived future crisis for scientists and engineers. Many of the curricula created in that era were highly regarded, several have had a long market life, still being sold in the 90's (e.g. SCIS III and Delta Science - ESS). Good curricula, inservice efforts and a national call for reform seem to be an ideal combination. Why, then, were not these reform efforts wider spread and longer lasting? What lessons can be learned from the failed efforts of past reforms to inform the leaders of current reforms?

The 1960's curriculum development efforts resulted in materials which were to be 'teacher proof' (Hall, 1992; Yager, 1992). Science curricula were produced that promoted hands-on discovery activities. Although the curricula included effective activities for learning science, teachers did not know what to do with them. Studies show that the curricula were generally more effective than traditional programs but they did not get into classrooms (Sivertsen, 1993). It is now known that 'teacher proof' curricula is a misnomer. If excellent teachers with excellent curricula do not always produce the desired results (e.g. Smith & Anderson, 1984), uninformed teachers with good curricula cannot be expected to have positive results. Teachers need to have knowledge of the content they are teaching (content knowledge) supplemented with general teaching knowledge (pedagogical knowledge) and content specific teaching knowledge (content-pedagogical knowledge). Students differ, which means that teachers must tailor lessons to meet the needs of diverse learners. This can only be done when the teachers have an understanding of the curricula they are using and the curricula are sensitive to the cognitive needs of the students.

The post-Sputnik reforms tried to help teachers gain an understanding of the new curricula so that they could be successfully implemented. Massive inservice efforts were mounted to help teachers learn both the curricula and appropriate teaching methods. At the height of the post-Sputnik effort, equal money was spent for curriculum development and teacher workshops and institutes (Yager, 1992), increasing likelihood of lasting change (Hall, 1992).

The lack of clearly stated, known and agreed upon goals is but one reason the reform effort of the 60's failed (Yager, 1992). Reform efforts and changes are most successful when the policy makers, practitioners and researchers share goals, and are partners who all meaningfully contribute to the same effort (Hall, 1992; Linn, 1986). Teachers were not stakeholders in the reform effort nor did they fully understand the project's goals. As a result, they had little incentive to implement the reforms.

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The Current Reform Movement In Science Education

A Nation at Risk (1983), *Educating Americans for the 21st Century* (1983) and other reports investigating American education spawned several standards documents, including the creation of standards for science education K-12 (American Association for the Advancement of Science [AAAS], 1993; National Research Council [NRC], 1996) and for teaching (National Board for Professional Teaching Standards [NBPTS], 1990, 1993, 1994, 1996). These standards describe the content and concepts to be taught at various grade levels; they describe how teachers should teach; they give guidelines for professional development and professional standards for teachers. The need for better qualified science teachers who meet high performance standards is imperative (AAAS, 1993; NBPTS, 1993, 1994, 1996; NCTAF, 1996; NRC, 1996). The teacher's professional quality and performance, is the single best predictor of, and most important contributor to, a child's performance (NCTAF, 1996). In order to help the masses of teachers perform better massive change must occur.

Numerous studies have been undertaken to investigate the nature of school reform and the role of teacher as a change agent (e.g. Berman & McLaughlin, 1976; Fullan & Eastabrook, 1973; Fullan & Stiegelbauer, 1991; Hall, 1992; Hall & Hord, 1987; Sarason, 1990). Among the findings are the need for teachers and administrators to work together; a school climate conducive to change; teachers willing to serve as change agents; and understanding that change takes time.

Teacher Inservice Programs

Just as current reform efforts can learn lessons from the failures of past reforms, inservice planners can gain insight by comparing features of successful and unsuccessful professional development efforts (Kirst & Meister, 1985). A failure to learn from the past will result in millions of dollars spent in vain, thousands of hours of teachers' time wasted and millions of students leaving school with missed opportunities to learn (Sarason, 1995).

Teacher inservice, staff development, professional development, or continuing professional education consists of ongoing, systematic growth processes for teachers to improve their in order to benefit students (Burke, 1994; Dillon, 1978). The length and duration of inservice activities vary, depending upon the goals of those who planned the inservice. Teacher roles within the inservice activity vary as well. "It is still widely accepted that staff learning takes place primarily at a series of workshops, at a conference, or with the help of a long-term consultant" (Lieberman, 1995, p. 591). Generally accepted as necessary, inservice programs are often viewed as a waste of time by the teacher participants (Bradley, 1996a; Sparks & Loucks-Horsley, 1990).

Elements Of Successful Inservice

Current professional development begs for reform if lasting changes are to take place (Pogrow, 1996). Most efforts are not successful at implementing long term change (Sykes, 1996). Few reforms have considered the support needed by teachers to fully understand the reform and to substantiate the innovation (NCTAF, 1996; NRC, 1996). There are, however, several components common to successful inservice programs which can be used to improve the likelihood of program implementation. This section discusses these components.

Time Duration

Professional development projects must be of sufficient length and duration to allow for: acquisition, practice, feedback, follow-up, and maintenance (Burke, 1994). Change does not take place if participants cannot become adequately acquainted with the innovation and its implementation (Showers & Joyce, 1996). Once they understand the basic tenets and goals of the project they must try them out, revise their understanding and collectively redefine goals (Burke, 1994; Fullan & Pomfret, 1977; Lieberman, 1995). This cannot occur in a one-shot inservice program. Ball (1996) argues for "a stance of critique and inquiry" within inservice; a shift from rote implementation of the innovation towards a constructivist emphasis of adaptation and generation of new knowledge. Teachers need to test suggested approaches in their classrooms, modify and adapt them for their own needs and then share their results with other concerned teachers. This verification approach allows teachers to act as researchers, something called

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for by various standards (NBPTS, 1990, 1993; NRC, 1996; Sivertsen, 1993).

This idea of inviting teachers to be involved, having them take part in articulating and evaluating the goals, incorporating the changes in their classes and revisiting goals with colleagues only occurs when there are follow-up meetings, long term support and shared understanding of desired change (MacGilchrist, 1996). When substantial amounts of time are spent meaningfully sharing ideas and generating knowledge teachers view their peers as partners and they see themselves as part of a professional learning community (Lieberman, 1995). It should be noted that simply increasing the time allotted to inservice efforts does not guarantee that the innovation will be implemented, but without long term efforts the likelihood is reduced (Hall, 1992).

Reflection

More and more educators are espousing the value of reflective practice within the confines of professional development (Ball, 1996; Darling-Hammond & McLaughlin, 1995; Lieberman, 1995; Muscella, 1992; Russell, 1992; Schifter, 1996; Schön, 1982; Wilson, Peterson, Ball & Cohen, 1996). Teachers seeking to enhance students' metacognitive skills are themselves rarely given the time to reflect on their own learning, thinking and understanding. Time ought to be allocated for reflection when a new innovation is being introduced (Johnston, Guice, Baker, Malone & Michelson, 1995; Russell, 1992). This reflection allows teachers and institutions to assess the significance of the innovation and to plan, monitor and regulate strategies for implementation. It also provides time for internalization and self-articulation of goals and beliefs (Duckworth, 1987, 1991; Johnston, *et al.*, 1995; Muscella, 1992; Russell, 1992). Constructivist practices dictate that learners be provided time to reflect on their emerging ideas (NRC, 1996; Sivertsen, 1993). The time set aside for reflection promotes reflective practices by allowing teachers to think about their own learning as a springboard to thinking about their teaching practices. This juxtaposition between teacher and learner is a critical element of reflection (Muscella, 1992). Assigning priority and time on the inservice agenda for reflection underscores to participants its importance.

The Modeling Of Exemplary Practices

Inservice programs and reform efforts are ways to introduce teachers to new pedagogical approaches. Unfortunately, the common 'do as I say, not as I do' method of instruction is counter-productive. Teachers learn in ways similar to students (Ball, 1996; Lieberman, 1995; Shymansky, 1992; Wilson et al., 1996) yet they are not taught in ways which recognize them as being students. In most cases teachers are passive recipients of information about which they have no familiarity (Darling-Hammond & McLaughlin, 1995). The constructivist methods of teaching are ones that the teachers themselves have never seen and likely a manner in which they have not been taught. In these cases, the leaders are trying to construct situations in which teachers 'unlearn' common practices as they develop a need for new ones (Darling-Hammond & McLaughlin, 1995). Teachers with little or no experience with a new practice are well served by experiencing examples of the espoused approaches (Ball, 1996). Modeling is more effective than telling teachers how to teach. The modeling of ideal behaviors is important if teachers are going to see the merits and technical issues involved in teaching in a new way. By recognizing the teachers in the role of students the teachers become better able to implement the strategy with their own students (Schifter, 1996). Just as modeling is an approach that works well with students (Good & Brophy, 1991), it also works well with teachers-as-learners (Bailey & James, 1978; NRC, 1996; Shymansky, 1992).

Not all aspects of an inservice program lend themselves to an inquiry based or active approach on the part of the learner. Some information must be told. This format should be used on an as needed basis. While telling is not teaching, the telling part of an inservice should be clear, concise and include concrete examples (Ball, 1996; Sparks, 1983). In other words, the didactic aspects of teaching ought to be well modeled, too.

Opportunities For Networking And Team Building

Effective professional development involves teachers working together in communities of effective practitioners. This varies from the traditional model in that it requires teachers to be active, communicate with each other, and collaborate. In order for teachers to successfully facilitate children's science learning they must get support from their teaching colleagues and the greater professional community (NRC, 1996; Sivertsen, 1993). Too often, teachers are isolated. They teach behind closed doors and rarely discuss pedagogical issues with each other. According to Darling-Hammond and McLaughlin (1995), there must be a collaborative effort, involving the sharing of knowledge among educators with a focus on teachers' communities of practice rather than on individual teachers. When teachers are members of learning communities they learn, develop and grow with each other (Duke, 1993; NCTAF, 1996; Raizen & Michelsohn, 1994). As part of a learning community, teachers have a network which acts as a support mechanism. This provides a place to share ideas, problems and concerns in a non-threatening environment (O'Brien, 1992; Richardson, 1996). Working together the teachers help each other with the difficulties that arise when implementing a new teaching approach. The results include a decrease in the amount of teacher isolation, new opportunities for growth and reflection, and the development of an environment that is conducive and supportive of change (Lieberman, 1995; Richardson, 1996). The format for the networking can include peer mentoring, electronic mail communications, two-way interactive video cameras, computer bulletin boards, and regularly scheduled meetings. The common denominator is that teachers are involved in substantive discussions about their practice (Darling-Hammond & McLaughlin, 1995; Lieberman, 1995; NBPTS, 1994; NCTAF, 1996; Richardson, 1996; Showers & Joyce, 1996). These communities of practitioners empower each other to personalize innovations and provide objective, creditable analysis and feedback (NRC, 1996).

Inservice Project Goals

Without clearly articulated and agreed upon goals chaos is likely to occur (Burke, 1994; Wood, McQuarrie & Thompson, 1982) and little or no long term change will be effected (Cornett, 1995; van Lakerveld & Nentwig, 1996; Sparks & Loucks-Horsley, 1990). In order to maximize the impact of an inservice effort teachers, leaders and administrators must have a common vision (Burke, 1994; Darling-Hammond, 1996; Dillon, 1978; Sarason, 1995). Unsuccessful inservice projects often have goals which are imposed by administrators. Successful programs have goals based on teacher input, needs assessments and evaluative information from previous inservice efforts (Ball, 1996; Darling-Hammond & McLaughlin, 1995; Dillon, 1978). These data are used to construct desired goals or target concepts and to establish an indication of current states. The difference, if any, between current state and desired state identifies the magnitude and direction of the required change (Ford, Yore & Anthony, 1997). Frequently the required change must be achieved by several smaller achievable increments rather than one large change (MacGilchrist, 1996; Schmoker, 1996)

The suggested small, easily attainable goals along the way to large scale reform efforts allows all involved to feel a sense of accomplishment and provide a way to reduce stress (MacGilchrist, 1996; Schmoker, 1995). When goals are reached and hard data collected to prove the goal's attainment everyone feels a sense of achievement. Smaller goals within the realm of the larger goal allow teachers and administrators to consolidate gains and continually reexamine their priorities and methods for reaching the larger goal. As teachers begin to implement an innovation their understanding of the project changes. The project and its goals must be flexible enough to allow for the refining and revising that accompanies implementation attempts (Burke, 1994; MacGilchrist, 1996; Schmoker, 1996; Sparks, 1983). The shift is from rote implementation towards an emphasis of adaptation and generation of new knowledge (Ball, 1996). Teachers must assess the desirability of the original innovation and redirect the innovation if needed. This practice supports the guidelines suggested in the *National Science Education Standards* (NRC, 1996) regarding professional development.

Program Evaluation

When innovations are to be implemented into a school there needs to be some way to monitor change. Too often the evidence used to monitor such implementation is anecdotal. While the 'trust us' or 'take my word for it, we say it is good' method may convince some teachers about the innovation it is not likely to impress many (Schmoker, 1996; Shanker, 1995). Data which have been purposefully and systematically collected work better.

Ongoing assessment of project impact, teacher change, and student performance is the feedback loop needed for effective change implementation (Burke, 1994; NRC, 1996). It is the mechanism that provides for mid-project changes and adjustments based on informed considerations not just on belief. This would allow reforms to be redefined or redirected.

The ongoing assessment serves many purposes. First and foremost, it informs and guides the ongoing inservice efforts. Problems and concerns can be addressed when they are known about. Without some form of ongoing assessment inservice projects would flounder. While most inservice leaders do informal needs assessments throughout the project, they are missing opportunities by not participating in a more systematic data collection process. While most teachers do not want to have their performance assessed it is critical to have some form of formal, systematic evaluation taking place (Cornett, 1995). One way to collect data in a way that teachers find valuable is through action research. When teacher participate in reflective practice and action research projects they focus on 'good practices' as learned in the inservice. Through their reflection they are defining the innovation as they implement it and monitoring their growth towards the defined goals (Schmoker, 1996). This method is suggested because it helps focus teachers' reflection and implementation while serving as a measurement for project implementation (NRC, 1996).

Role of Administrators, Teachers and Leaders in Successful Inservice Endeavors

Successful inservice programs have participants playing different roles (Showers & Joyce, 1996; van Lakerveld & Nentwig, 1996). Traditional roles are changed so that teachers and administrators work together towards commonly accepted and agreed upon goals (Darling-Hammond, 1996). The changes in roles within the organization are considered as part of the planning process (Fullan & Pomfret, 1977).

The restructured roles represent a team approach (van Lakerveld & Nentwig, 1996). The triad of administrator, teacher and leader working together is synergistic as they move towards a common set of goals. Together they are more powerful and ultimately more successful than any of the individuals working alone (Darling-Hammond, 1996; van Lakerveld & Nentwig, 1996).

The administrator's role in today's school is ideally one of supporting change. The alteration in power relationships is necessary but not sufficient for change to take place (Sarason, 1995). Teachers and administrators working together are able to define and address needs better than one group alone (AFT, 1995; Bradley, 1996b; MacGilchrist, 1996; Sparks & Loucks-Horsley, 1990). When teachers are involved with administrators and project leaders from the start they are more likely to 'buy-in' than if the innovation is created from without (Fullan & Eastabrook, 1973; Sparks & Loucks-Horsley, 1990).

The Leaders of Successful Inservice Efforts. Successful leaders are ones who are trusted by the teachers. Often the leaders are teachers themselves. This is important to many teachers as they want to know that the leaders understand the day-to-day realities of their world. This leads to trust and a greater likelihood of an immediate buy-in to the ideas presented (Dillon, 1978). Their role is that of a facilitator rather than a leader. They work alongside the teacher-participants helping them achieve their goals. Good inservice facilitators model the innovations they are espousing (Darling-Hammond & McLaughlin, 1995; NRC, 1996; Rudolph & Preston, 1995). This serves two purposes. It demonstrates to teachers what the innovation looks like and it gives the leaders/guides increased credibility. When it comes time for the lecture or 'telling' part of an inservice the leaders should be able to clearly describe the innovation or content, they should be experts in their field (Rudolph & Preston, 1995). The leaders should be able to provide feedback and assistance to teachers who request it (Sparks & Loucks-Horsley, 1990).

The Administrator's New Role. Principals' or administrators' support of an innovation and the subsequent degree of implementation are correlated (Fullan & Pomfret, 1977). Administrative support is *the* major factor affecting success of staff development programs (Sparks, 1983).

The new role as a 'facilitator of change' requires administrators to be involved in goal setting and goal reaching alongside their teachers. Small, easily attainable goals within the long term project goals ought to be articulated (Schmoker, 1996). The new role includes data keeping and coaching (Schmoker, 1996; van Lakerveld & Nentwig, 1996). When starting a new initiative records should be kept so that growth and change is documented, monitored and reported to the teacher teams (Dillon, 1978; Schmoker, 1996). In this way, small increments of change are noted, teachers feel that progress is being made and they are more likely to remain enthusiastic about the long term project.

In this role, the administrator must offer formative evaluation, feedback, and facilitation not simply summative information. This is a new way for teachers and administrators to work therefore it is important for the shift to take place if meaningful change is to take place (Schmoker, 1996). This collaborative environment of problem solving and decision making promotes professional growth and development. The administrator helps this process by providing feedback and the teachers utilize the feedback to reflect on practices. It is important that the feedback and evaluation be used to help the teacher grow and not for punitive purposes (Seldin, 1991; Seldin & associates, 1993).

The administrator who wants the initiative to be implemented and lasting must provide a climate conducive for change (Showers & Joyce, 1996). This is a school climate that promotes risk taking, expects failures along the way to moving forward, and rewards innovation. Administrators who provide effective leadership through collegiality and communications are more likely to have a climate conducive for change. Their schools have a better chance that innovations will be well received and implemented (Sparks & Loucks-Horsley, 1990). One way to augment change is for administrators, and their schools, to set aside time for teachers to network, share ideas and concerns; value and encourage a long term, on-going relationship between project leaders and teachers; provide feedback to teachers; revisit and revise project goals; and share results of progress to date (Fullan & Pomfret, 1977; Fullan & Eastabrook, 1973; Miles, 1977; Schmoker, 1996; Showers & Joyce, 1996; Sparks & Loucks-Horsley, 1990; van Lakerveld & Nentwig, 1996).

It is suggested by many that the ultimate goal of any inservice effort or long term professional growth project be improvement in student achievement (Burke, 1994; MacGilchrist, 1996; Joyce & Showers, 1995; Schmoker, 1996). This goal has the added benefit of supplying data that is easier to collect and monitor change, since teachers are reluctant to have their own performance evaluated and monitored but are willing to use student data as a substitute (Cornett, 1995; Schmoker, 1996; Shymansky, 1995b).

The Teacher's New And Expanded Role. Traditional teacher enhancement programs have an external expert telling teachers what they need to know and do. Regardless of the participating teachers' needs, the experts tell them how to fix their problems. The new ideas about professional development take a different tack. After doing a needs assessment, there may not be a problem that needs to be fixed, but rather teachers' desire to become more effective and enhance already successful practices. In these newer approaches, teacher-participants no longer sit passively, they are actively involved in identifying their visions, defining these visions, and addressing their needs (Darling-Hammond, 1996; Darling-Hammond & McLaughlin, 1995; Fullan & Eastabrook, 1973; Fullan & Pomfret, 1977; Sparks & Loucks-Horsley, 1990). Teachers should be involved in the articulating, refining, planning, and decision making of an innovation from the start. When teachers have a voice that is listened to, their needs are met. When the inservice programs and innovations are meeting a need, participants are more engaged and more likely to view the experience positively.

Factors Affecting Implementation Of Science Innovations

Teacher-related variables which have been found to influence level of implementation are: number of years experience (Burry-Stock & Oxford, 1994; Mahmoud & White, 1980; Nelson & White, 1975; White, 1970; Zuzovsky, Tamir & Chen, 1989); academic preparation - degrees earned, number of science and science education classes taken (Burry-Stock & Oxford, 1994; Mahmoud & White, 1980; Nelson & White, 1975; White, 1970; Zuzovsky et. al, 1989); extent to which the teacher has been involved with other professional development activities (Burry-Stock & Oxford, 1994; Nelson & White, 1975; White, 1970); the perceived costs and benefits of the innovation (Doyle & Ponder, 1977; Fullan & Pomfret, 1977); the extent to which participating teachers understood the innovation, were familiar with the ideas and had philosophical congruence with the ideas presented (Czerniak & Lumpe, 1997; Doyle & Ponder, 1977; Fullan & Eastabrook, 1973; Fullan & Pomfret, 1977; Guskey, 1988; Mohlman, Coladarci & Gage, 1982); and the teachers' reasons for joining the project (Shokere & Wright, 1995).

Factors relating to the school which have been found to impact levels of implementation are: how much and how often science is taught (Burry-Stock & Oxford, 1994; Nelson & White, 1975; White, 1970); number and type of students in the class (Burry-Stock & Oxford, 1994; Mahmoud & White, 1980; Nelson & White, 1975; White, 1970; Zuzovsky et. al, 1989); the level of support from administrators (Fullan & Pomfret, 1977); the political structure and climate of the school (Fullan & Eastabrook, 1973; Fullan & Pomfret, 1977); the extent to which the voice of the teacher is listened to during the reform process and curricular changes (Fullan & Pomfret, 1977); and whether or not the teacher is viewed as an expert by his or her colleagues (White, 1970).

Factors examined which have yielded inconclusive results include the strategies employed by the teacher, school size, make-up of the student body, the amount of time spent disciplining students, the percentage of time spent on various tasks during a lesson, and the age of the curriculum (Doyle & Ponder, 1977; Fullan & Eastabrook, 1973; Fullan & Pomfret, 1977; Mahmoud & White, 1980; Mohlman et al., 1982; Nelson & White, 1975; Shokere & Wright, 1995; White, 1970; Zuzovsky et. al, 1989).

Context

This study took place within the Science PALs project. Science PALs was funded by the National Science Foundation (NSF) and the Howard Hughes Medical Foundation. The partnership between university and school district began in 1994 with the induction of 16 teachers, one from each of the elementary schools in the district. Along with the teachers' growing understanding of constructivism, other project goals included enhancing teachers' science content understanding; learning new strategies for involving children's literature in the classroom and at home; and involving and including hands-on activities, discussions, debates and investigations which support and challenge students' understanding of science content. The project was based on the findings of the Focus on Children's Ideas in Science Project (FOCIS), a previous NSF grant (Shymansky, 1987). The FOCIS project found that teachers increase their own science content knowledge while addressing their students' ideas about science and while honing their science-pedagogical skills (Shymansky, 1992; Shymansky, et al, 1993).

The structure and design of the Science PALs project was carefully planned using the results of FOCIS, planned change literature and continuing professional education research. Its format was congruent with recommendations for teacher professional development activities (America Federation of Teachers [AFT], 1995; Darling-Hammond, 1996; Darling-Hammond & McLaughlin, 1995; Goodlad, 1994; Lieberman, 1995; Rudolph & Preston, 1995; Showers & Joyce, 1996; Shulman, 1987). The Science PALs project called for: an interactive-constructivist approach to teaching and learning science; collaborative, long-term involvement shared by school district and university personnel; teacher input and ownership; personalization of project goals; on-going support; and a cascading leadership structure to transfer responsibilities and administrative duties. These were anchored in the reality of classroom teaching, giving the project ecological validity.

Another important feature was that the interactive-constructivist teaching and learning which took place during the teacher enhancement meetings were consistent with project goals giving philosophical and strategic alignment (Darling-Hammond, 1995; Lieberman, 1995; Shymansky, 1992; Shymansky et al., 1993). The overarching goal of the project was a shift in classroom science instruction towards interactive-constructivism. As a result, teachers were themselves learners in a constructivist context. Project leaders and 'science expert' facilitators did not 'tell the teachers what they needed to know'. Instead, the teachers interactively worked through curricula and activities as they sought to construct answers, find new problems and craft new questions.

Methods

Data was collected from teachers during their first 1.5 years in the project. Data relating to teachers' beliefs and perceptions of teaching were compared to their actual teaching. Demographic information, survey responses, interview and written responses to scenarios were among the data collected as source variables. These were scored using a professional growth matrix designed to measure interactive-constructivist practices in science teaching (Shymansky & others, 1995, 1997). Field notes generated by project staff at inservice sessions, classroom observations and individual teacher-staff meetings were also used to record change and implementation. These were also scored using the professional growth matrix. Videotapes of science teaching and revised science curricula were collected as output variables and scored using the ESTEEM (Burry-Stock, 1995) observational rubric and the project developed rubric.

In order to ascertain the validity of using the ESTEEM classroom observational rubric external rankings of the teachers were collected. The rankings from four experts knowledgeable with the project and the teachers were averaged and compared to the rankings obtained with ESTEEM. There is excellent agreement between ESTEEM and external rankings for the top and bottom quartile, and reasonable agreement for the middle group (Henriques, 1997).

A purposeful sample of teacher, top and bottom quartile, was examined to gain further insight into differences between implementors and nonimplementors. Data collected from these teachers and staff generated field notes highlight differences between the groups.

Interviews with project staff and Science PALs teachers gave insight into aspects of the inservice deemed most important to the project's success. Comparisons between Science PALs and other inservice efforts were made by participants to further illuminate those features.

Discussion

Results from Science PALs data indicate that newer teachers were more likely to implement the Science PALs model ($r= -.621$, $p= .013$ years of experience versus level of implementation). This can be interpreted in different ways. One scenario is that the newer teachers would adopt anything as they search for successful teaching strategies while the more experienced teachers have already found successful ways to teach. The more experienced teacher, therefore, can afford to be more critical of an innovation and slower to adopt. Another interpretation is that the more tenured teachers are less likely to implement an innovation because they are comfortable with where they are professionally. Unless the innovation appears to be a drastic improvement over current practices it is not worth the effort to change.

Those teachers who were philosophically aligned with project goals prior to project involvement were also more likely to implement ($r= .335$, $p= .241$, self-reported level of philosophical congruence). Data show that teachers reported much higher levels of implementation than their teaching performance would indicate. There is a negative, non-significant correlation between self reported and actual levels of implementation ($r= -.120$, $p= .893$).

Science PALs had an extremely high staff to teacher ratio during the first year. There were only 16 teachers in the first cadre to join the project. On staff there were three science education faculty or staff, a district level science coordinator, six science education graduate students and miscellaneous science content faculty from the university. As such, Science PALs teachers had access to frequent visitations to their classroom in addition to the monthly inservice sessions. Since the first round of teachers to join the project were district level 'science advocates' they had additional monthly meetings without Science PALs staff present. The frequent inservice sessions and advocate meetings enabled teachers to develop extensive networking systems with each other and with project staff. High school science teachers eventually joined the project as the science experts, replacing the graduate students and university faculty. This enabled another layer of networking and connections to be built. Not all Science PALs teachers wanted project staff to visit their classrooms. While they were required to permit some visits, the frequency of visits varied greatly among teachers. Visitation data from spring semester 1995: range 3-37, mean ≥9.3 visits, median = 7.5 visits (Shymansky, 1995b). The correlation between visitation by project staff and subsequent levels of implementation is almost zero ($r= -.054$, $p= .854$). This could be an argument for NOT having a high staff to teacher ratio (even though teachers cite this ratio as a positive factor in their implementation). More likely, it represents the differences in styles and personalities of the teachers and graduate students in their rooms.

Some pairs were very effective and others less so. Teachers who were implementing would welcome the graduate student as a function of their relationship. Those struggling to implement would welcome anyone to help them. No formal instruction was given regarding peer coaching or mentoring. Additionally, some teachers did not view the graduate student staff as a coach, mentor or peer.

With the top and bottom quartile of teachers a significant correlation between the number of graduate student visits and the teacher's initial philosophical congruence with Science PALs was found($r= .819$, $p=.024$). The correlation between initial congruence and subsequent teaching performance was also positive ($r= .503$, $p=.250$). The degree to which graduate students' visits to classrooms impacted teaching performance, however, is questionable. Virtually no correlation between the number of visits and subsequent teaching performance was found ($r= .080$, $p= .864$).

There are at least two possibilities that might explain the pattern of graduate student visits to classrooms. Teachers who were initially aligned with the project philosophically might have been more open to having visitors in their classroom. They might be more confident in their ability to implement the project because it matched what they already valued in education. Their open door policy could have lead to more visits. If they were aligned philosophically they would have been more likely to want feedback and suggestions about how to implement the Science PALs model.

Another possibility is that project staff were more likely to visit classrooms where Science PALs was taking place or accepted. This bias would have resulted in staff making more visits to teachers who embraced project goals. In this way, project staff would be surrounding themselves by teachers who were at least talking about the virtues of Science PALs even if they were not implementing it well.

Another possibility is that project staff were not consistent in documenting visits to classrooms. Those staff members who were more conscientious about recording visits may also have been more conscientious about helping Science PALs teachers implement.

The fact that graduate student visits to the classrooms were virtually unrelated to how well a teacher implemented the model is a significant finding on its own, and it contradicts earlier findings related to use of staff to help teachers implement (Mahmoud & White, 1980). There are two possible explanations for this finding. The first is that simply sending graduate students or coaches to classrooms makes no difference. The second is that the quality of the visit is what is important, not the quantity. The field notes kept by graduate students visiting the classrooms are insufficient to make judgments about what occurred between the teacher and the graduate student. If project staff visiting the classroom acted as science experts, telling students the answers, the time was not spent modeling project goals appropriately. If project staff worked with the teacher, demonstrating interactive-constructive teaching strategies, the time would presumably be more valuable to the teacher. The nature of the relationships between project staff, in this case graduate students, and Advocates varied greatly. In some instances the relationship could be classified as partners, coaches or mentors. In others, the lack of teaching experience by some graduate students paired with highly experienced teachers hindered a respectful partnership. Data do not allow a conclusion to be reached at this point.

Teacher willingness or ability to relinquish control seemed to be an overriding difference in the groups. Those teachers that were best at implementing Science PALs were the ones who were confident enough in their abilities to change lesson midstream. They took advantage of the teachable moments, knew their students and what would work with them. These teachers had sufficient content and content-pedagogical knowledge to be able modify lessons on the fly, offer alternative explanations and ask probing, thought provoking questions. Many of these teachers cite the intensive, ongoing inservice provided by Science PALs as the source of their increased content and content-pedagogical knowledge. The changes these teachers made 'on the fly' are documented in videotaped lessons and field notes.

Features of Science PALs which facilitated implementation were discovered. Among the most important features were: elements of time, teacher reflection, teacher input, teachers as leaders and project leaders' modeling of advocated practices. A method to transfer leadership and ownership of the project will help enhance the longevity of the innovation. Teachers having a strong voice in the direction of the project was also viewed as an important aspect of success. Respecting the teacher as a professional was regularly cited as a contributing factor to project success.

Science PALs had a ten day summer inservice followed by monthly day-long inservice workshops during the school year. In addition to the inservice sessions there were classroom visits and district level "advocate" meetings. This cycle repeated each of the four years of NSF funding (although classroom visits decreased each year). The fact that teachers were forced to revisit ideas throughout the project enabled them to try out various aspects of the project one at a time rather than trying to change everything at once. The revisitation of ideas also forced participants to reflect and modify their own understanding of the project. The inservice sessions were of sufficient length (two-week intensive sessions and full-day workshops) and lasted over a long enough time (four years) to allow teachers to try the innovation, reflect on what worked, modify, try again, reflect, etc.

Teachers in the Science PALs project had a very loud voice. Their ideas were sought for agenda items and then used. Evaluations of individual inservice sessions provided direction for future meetings. Teachers repeatedly mentioned that they were willing to spend time critiquing inservice sessions and giving suggestions because they knew their ideas would be listened to. Whenever a change was to teaching resources the teachers were given updated copies immediately. It was, therefore, worth their time to make changes because they would be implemented promptly. Teachers in this project compared their experiences with Science PALs to other long term, large scale projects in which they had participated. The recurring theme is that they were treated as professionals in Science PALs. Their ideas and input were sought and used. As much as the teachers hated to be out of the classroom, they loved Science PALs inservice days because they left rejuvenated, more informed and feeling as if they'd contributed to the project. Graduate students and a half-time field coordinator were largely responsible for the prompt updating and dispersal of materials. Time and money was committed to this purpose from the start.

Science PALs utilized a cascading leadership model. In the first phase of the project the sponsors were in charge. In this type of model, leadership, responsibility and ownership ultimately resides with the 'targets', the Advocates and Lead Teachers. In this way, those responsible for maintaining and encouraging change after funding expires are within the school district and in the schools. The original sponsors, who instigated change, are able to help ease the Advocates into leadership positions while project funding still exists. The roles of teachers evolve as the locus of control shifts from project leaders to Advocates, to Lead Teachers and to teachers. The flow of power, responsibility and ownership in the Science PALs project can be seen in the flow chart in Figure 1. This cascading leadership model not only transfers power, responsibility and ownership, but it allows the innovation to be customized to reflect input and perspectives of each new level of involvement.

INSERT FIGURE 1.

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Figure 1. Model of Cascading Leadership within the Science PALs Project.

Sponsors	Principal Investigator, District Curriculum Coordinator
↓	
Project Leaders	Inservice Director, District Science Coordinator, Field Coordinator
↓	
Advocates	First round of teachers to join the project - one from each school
↓	
Lead Teachers	Second round of teachers to join the project
↙ ↓ ↘	
Change Targets	Remaining teachers in the school - those who joined in final year and those who never joined

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	E-Mail Address: lhenriqu@csulb.edu	Date: 1-9-98

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