DOCUMENT RESUME

ED 292 686 SE 049 071

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TITLE Breaking Down Barriers to Teaching Primary Science: Did a Summer Science Institute Help?
PUB DATE Apr 88
NOTE 26p.; Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (61st, Lake of the Ozarks, MO, April 10-13, 1988).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Elementary Education; *Elementary School Science; *Inservice Teacher Education; *Institutes (Training Programs); Light; *Primary Education; Science Education; Teacher Education; *Teacher Improvement; *Workshops
IDENTIFIERS Science Education Research

ABSTRACT

This study was designed to determine whether a summer institute for elementary teachers could reduce or eliminate obstacles to teaching science. During summer, 1986, 10 primary teachers (K-3) participated in a month-long training session designed to help them improve their background knowledge of light and shadows and develop, teach, and revise a unit on the topic. During the following school year they taught the unit to their classes under the guidance of the institute director. The teachers' logs, final reports, and post-institute interviews were analyzed and compared with their pre-institute interviews to determine how they felt barriers to science teaching changed during the year. Pre-institute interviews indicated that the greatest obstacles were lack of time to teach science, lack of materials and equipment, lack of assistance in terms of support personnel and the teachers' lack of background knowledge, skills and confidence. The teachers reported that their participation in the institute had helped them improve their science teaching, especially in the areas of how to teach and how to manage a class while teaching science. Several reported a transfer of strategies learned in the institute to other subjects. (CW)

Breaking Down Barriers to Teaching Primary Science: Did a Summer Science Institute Help?

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Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, Lake Ozark, MO, April 1988.

Breaking Down Barriers to Teaching Primary Science:
Did a Summer Science Institute Help?

This study is a part of a larger project, a Summer Science Institute, designed to help primary teachers improve the quality of their science teaching. During summer 1986, the ten primary teachers (K - 3) involved in the Summer Science Institute at the University of Delaware participated in a month long training session. In the following school year, they taught the unit they had developed during the summer session under the supervision of the Institute Director. The purpose of this study was to determine whether the barriers to teaching science these teachers reported before they participated in the Institute changed after their experience in the program.

What Are the Barriers?

In 1984, Congress passed the Education for Economic Security Act (EESA) requiring State education agencies to submit comprehensive needs assessments in order to receive the funding provided by Title II of the Act for improvements in mathematics, science, computer learning, and foreign language instruction. The findings of the needs assessment (Dickens, Pontzer, Shahmirzadi & Schenet, 1987) concluded:

> - The greatest need for improvement in teacher qualifications appears to be in science teaching at the elementary level.
>
> - The picture of weakness in elementary science is reinforced by the needs assessment information on materials and

equipment, which suggests that the greatest need is for materials and particularly for equipment for the elementary science curriculum.

- the description of programs and initiatives in these two subjects indicate that inservice activities have primarily focused on reinforcing content knowledge of teachers at the secondary level. Only a few States have focused specific initiatives on instructional strategies and new approaches to elementary science and mathematics. Similarly, only a small number of States mentioned specific initiatives to deal with the need for science equipment.

The conclusions of the needs assessment reinforce earlier findings about the state of elementary science teaching. That is, science is not given much time in elementary classrooms and when it is taught it is often not done well (Bennett, 1986; Hounshell, 1987; Rosenshine, 1980; Schmidt & Buchmann, 1983, Welsh, 1981). This lack of quality science in elementary schools is due to the following obstacles encountered by teachers: lack of time, lack of support in terms of materials, equipment and personnel, and lack of prerequisite skills and training (Johns, 1984; Schoenberger & Russell, 1986; Stake & Easley, 1978; Stronck, 1986; Weiss, 1978, 1987; Wier, 1987; Zeitler, 1984).

Several studies which addressed barriers to teaching science encountered by elementary teachers, including one on these ten teachers before the Summer Science Institute, indicated that one of the greatest barriers is lack of time for science due to the

high priority given to reading and math by school administrators (Johns, 1984; Schoenberger & Russell, 1986; Weiss, 1978; Wier, 1987).

A second large obstacle is lack of support in terms of supplies/ equipment and personnel. Inadequate science equipment, materials, and facilities were reported by teachers in several studies (Johns, 1984; Teters, Gabel & Geary, 1984; Weiss, 1978; Wier, 1987). Support personnel such as science supervisors and well trained individuals to conduct inservice workshops are often missing in school districts (Stronck, 1986; Weiss, 1978; Wier, 1987).

A further barrier reported by primary teachers is a lack of confidence in teaching science due to inadequate science training in both content and methods courses (Schoenberger & Russell, 1986; Stake and Easley, 1978 Weiss, 1978; Wier, 1987; Zeitler, 1984).

Procedure

The participants in the Summer Science Institute were ten primary teachers from three school districts who were recruited and recommended by their districts for the four-week summer science training program in the College of Education at the University of Delaware. The teachers had from five to twenty-seven years of experience and ranged in age from mid-twenties to mid-fifties.

Prior to the program, the teachers were interviewed at length about their teaching backgrounds, school environment,

problems they encountered in their efforts to teach science, and their knowledge of science content. In a previous study, the interview transcripts were analyzed to determine these teachers perceptions of obstacles to their science teaching (Wier, 1987).

The Summer Science Institute was designed to meet the needs and concerns expressed by primary teachers about science teaching while training them in conceptual change teaching (described in Neale, Smith & Wier, 1987).

Training to provide background knowledge and strategies for a unit on light and shadows was provided in a summer training session and meetings throughout the following school year. The summer training portion of the program was a four week session led by the Institute Director, Debbie Smith. The first week was designed to help the teachers gain a sound background of knowledge on light and shadows. During this week, they read and discussed articles on content and children's thinking about the topic and participated in light and shadows activities. In addition, they conducted interviews on the topic with the children they would teach during the following two weeks in the Summer Science Camp. Working in pairs, they also developed a unit to teach in the Science Camp based on what they had learned about light and shadows and their students' thinking about the topic. During the two weeks of the science camp, the teachers taught their unit to a small group. Each week one of the partners had responsibility for teaching while the other coached her. In addition, one teacher was videotaped for the entire morning. In

the afternoon she viewed the tape, provided feedback through stimulated recall, and was coached by Debbie Smith. During the fourth week the teachers revised their units for use in their classrooms during the following year.

Throughout the following school year, the teachers met monthly with Debbie Smith to continue revising their units, improving their understanding of light and shadows, developing teaching strategies, and discussing problems encountered in teaching their units.

To provide continuing support, the teachers were observed and videotaped while they were teaching several of their light and shadows lessons. After these sessions they met with Debbie for stimulated recall and coaching. With Debbie's support, the teachers also planned and conducted an inservice workshop on light and shadows for other primary teachers in their districts.

The school districts made a commitment to the program by providing Title II funds for several aspects of the program: (1) equipment and materials for the units; (2) stipends and release time for the teachers to meet with Debbie Smith in planning and feedback sessions; and (3) stipends and equipment for other district teachers who attended the inservice workshop conducted by the Summer Institute teachers.

Information about teachers' feelings concerning the Institute, planning and implementing their units, and teaching science in general was collected in several ways. During the

school year, the teachers kept logs on the monthly meetings and on implementation of their light and shadows lessons. In the fall of 1986, each teacher was interviewed on her subject matter knowledge of lights and shadows. After teaching their units, the teachers submitted final reports to the Director. In September 1987, a post Institute interview was conducted in which the teachers were asked to describe whether there had been any changes in the barriers to science teaching they had previously encountered due to their involvement with the Institute or to changes in their districts or schools.

For this study, logs, final reports, and post interviews on subject matter knowledge and "science teaching barriers" of the seven teachers who had been able to complete teaching of the light and shadows unit were analyzed. In addition, the interview responses were compared to the pre Institute interviews to determine what effect participation in the Institute and various changes in district and school environments and policies over the year had on obstacles to teaching science in the primary grades.

Results

The Summer Institute teachers' perceptions of obstacles to teaching science before they participated in the Institute were categorized as follow: lack of time; lack of support of both materials and personnel; and lack of prerequisite skills and training (Wier, 1987). Their perceptions of barriers after their

participation in the Institute will be reported here under the same categories.

Time

The pre Institute interviews indicated that all but two teachers reported that one of the greatest barriers was the lack of time to teach science usually due to the high priority given to reading and math by administrators. Post interviews and discussion in monthly meetings showed that this problem had not eased. In fact, the problem had become worse for two teachers. One who had previously found enough time for science now felt more pressure to cover math and reading because the district had adopted new series for these subjects and appeared to be setting more objectives for teachers to meet. Another who had transferred to an Intensive Learning Center (ILC) for Special Education children had been informed that she was "not expected to teach science." Two other teachers had scheduling changes which resulted in less actual classtime to teach science. But both felt that these changes might allow them to spend a more concentrated effort on science when it was taught and that this could be an advantage in planning and implementing science lessons. In one case, the classes had become "departmentalized" for science and social studies and the teacher believed that this set schedule would "trap" the teachers into teaching science, that is, they could not use the science period for reading or another subject. All seven indicated that regardless of the

limitations, they were going to teach science even if they had to "sneak it in," as at the ILC.

Although most of the teachers still felt pressure to meet the math and reading objectives, two of their districts did seem to be making an effort to place more emphasis on science by revising the science guidelines and distributing them to the teachers. However, the teachers did not know how the districts would determine whether the guidelines/objectives were met.

Support: Supplies and Personnel

Supplies/Equipment/Materials

In their pre-Institute interviews all of the teachers reported that a lack of equipment and materials was considerable obstacle to science teaching. Because Title II funds were used to purchase light and shadows equipment, the teachers had adequate equipment to teach that unit. They all expressed pleasure over this, as one said, "And that was wonderful. It made it [the unit] so much easier to plan and to work with, just to know that all the materials were right there."

As for other science units, the materials were, "Zilch! Zippo!" in the words of one teacher. All seven explained that at that time they had no school funds to purchase materials and they expected that they would continue to buy their own using their own money and time to do so. However, two with new principals indicated that their principals might make some funds available. Two who had received grant money from their districts planned to

submit grants for science related equipment again. One of these knew of additional grant possibilities from the Delaware Teacher Center and the DuPont Company and planned to pursue funds from these sources.

Personnel

District Science Supervisors In the year the Institute began, none of the districts had a science supervisor to assist the teachers. During Summer 1986 one district hired a science supervisor, a secondary science teacher. Two Institute teachers from that district had participated in a summer workshop with the science supervisor previewing kits to be used in the district. They knew that they could borrow equipment from the supervisor. The other two teachers from the district suspected that they could go to the science supervisor for help and equipment but they were not sure.

In another district, a secondary science teacher had extra duty as a science coordinator. One teacher from the district did not feel that she could go to him for help because of his secondary school orientation. The other teacher in the district was not aware that there was a district person she could contact for help. The third district involved in the Institute did not have a science supervisor.

Principals Within their schools, most of the teachers had found their principals interested in their participation in the Institute because it was something new, not necessarily because

it was science. For the 1987-88 school year all seven had new principals due to the reassignment of principals or themselves. Five were not sure what kind of support they would have but they were hopeful. One was sure of support because her principal was a former science teacher; another, the ILC teacher, was sure she would not be supported since she was not expected to teach science.

Other Teachers In the pre Institute interview, several teachers reported that they got ideas and support for science lessons from other teachers. Five now believed that there would be a sharing of the light and shadows unit, especially since they had received rave reviews from teachers at their inservice workshops. Two teachers, however, felt some negative vibrations from their colleagues. One sensed that because she talked about her unit so much the other teachers thought "she had some special talent or skill." But, as she said, "I didn't. It only came from the training."

The ILC teacher had felt support at her previous school because "[there was] a lot of interest, a lot of sharing [among teachers]." Some of this was due to the fact that the school had partitions rather than walls and the teachers heard what others were doing in their classrooms and willing shared ideas and activities. At her new school, however, she felt she would have to "[hide her science] light under a bush" so she would not get into trouble with the other teachers who felt so pressured to teach "reading and reading and reading."

Parents The pre Institute Interviews revealed that parents in all the teachers' schools showed little concern about science teaching. All but one teacher indicated that the parents commented positively about their children's involvement in the light and shadows unit. Parents, however, did not indicate concern about science teaching in general.

Prerequisite Skills/Training and Background Knowledge, Skills and Confidence

In the pre-Institute interview all but one teacher indicated a weakness in either what to teach, how to teach, and how to manage a class while teaching science. All teachers, except the one who felt confident to begin with, reported that their participation in the Institute had helped them improve their science teaching especially in the area of how to teach and how to manage, in one case, "a million times improved." The feeling that several teachers expressed about gaining confidence in implementing activity-based lessons replete with equipment and management problems was expressed by one, as follows:

> After the Institute,I feel I'm more aware of how important it is to have everything right there. I know exactly what's going to happen. Just to have all the materials at hand before you actually start the lesson and know where you want to place the kids and what you want to do. I'm more aware of that and I know I'll have to do that with each lesson.

As for what to teach, three teachers specifically mentioned an increase in knowledge of lights and shadows. Furthermore,

results of Debbie Smith's subject matter interview with the teachers following the summer Institute indicated that all of the teachers' substantive content knowledge of lights and shadows had increased, sometimes dramatically (Smith, 1987). Before the Institute, the teachers' knowledge was fragmented and often included flaws similar to children's misconceptions. In the October post interview, the teachers sometimes felt they did not know answers but when asked to tell what they did know, they worked through the problem and arrived at the correct solution. The teachers made substantial progress in understanding concepts which received the most emphasis during the summer (that is, a mental model of light and understanding shadow phenomena) but were less sure of concepts which had received less time and attention (refraction, absorption, and reflection).

Teachers also indicated a confidence in the "practical" knowledge of what children are capable of and ready to handle. As one teacher explained:

> I think I'm more confident to tackle things. I'm not afraid to say that I'm at a point that I have to stop... I think that they show me where to go and how far to go. I can read their frustrations. But I think I'm also more comfortable with their fill-up level.
> Maybe if I wrote a three week unit [and] after two and one-half weeks they've had enough, why should I force it because they're not going to listen. Maybe I can come back later on and introduce those couple of days or maybe the next teacher that ever bothers to teach them that they'll be ready to listen.
> ... The conceptual age is true. If the kid can't hold a pencil, how can I teach him cursive. Yet,theoretically that's what the school district wants. I'm much more child-directed now than I was...

The overall increased confidence in teaching science implied in several of the teachers' interviews was expressed by one in a quote that suggests science may have been missing in classrooms more because of lack of confidence than because of the other barriers. This teacher ended the interview by saying:

> ...this year when I did my schedule, I included science and I hadn't done that before. I [used to think], "Well, I'll do science when I have time for it." But this year we've done science several times. I have it on my schedule. Mr. Martin (the principal) wanted it scheduled and I put it on there and I'm doing it and I'm not as afraid of it as I used to be.

Conclusions and Implications

The Institute teachers' comments indicated progress toward surmounting barriers which the Summer Science Institute could address directly. The teachers indicated that they had increased confidence in teaching strategies, management, and science knowledge about light and shadows. In addition, they had adequate equipment for teaching the light and shadows unit. They also indicated that because of this increased confidence and support they were putting "science" on their schedules even though some still felt pressured to teach reading and math. Debbie Smith is making further efforts to gain the support of administrators by meeting with them in a series of seminars. During the seminars, the administrators are introduced to conceptual change strategies and they discuss the need for providing support to the teachers in terms of time, equipment, materials, training, and evaluation procedures.

During the post interview, the teachers were asked to describe a program which would help primary teachers teach science well. The feeling of the teachers was that the Institute had been an excellent and worthwhile experience. One expressed it as follows:

> I feel like I've seen the best, I've been through the best and so my hope is for myself that I can try to model and transfer that knowledge of techniques and children to other areas.

The teachers made suggestions about an ideal program to help primary teachers teach quality science based on their Institute experience but tempered with what they felt would be feasible in the real world of their school districts. The following is an outline of a program incorporating their suggestions.

Guidelines for Primary Science Training

The school districts should set guidelines which include only a few topics (3 - 6) and related skills which are to be covered in each grade level. These guidelines would give the teachers a clear and attainable goal.

The teaching materials special units, including the equipment, should be provided to teach the units. If teachers were involved in developing the units, they should be given time to do this in the summer when they are able to focus their attention on the project.

Training

Provide summer training sessions lead by an "expert" (this could be another teacher with expertise in subject). The sessions should include adequate background knowledge about the topic covered, modeling of strategies, and, most importantly, opportunities to participate in activities. Most of the teachers stressed the importance of being involved in the activities. As one teacher put it:

> I learn best if somebody lets me be kid and teaches me as if I were the kid, not to teach me as a teacher but let me do the experiments and fail so I can see what the kids are going to do.

Most felt that working with small groups of children during the summer Institute had been a good way to see how children would react to activities. But they also felt that it was unrealistic and, perhaps, "misleading" when thinking about transferring the activities to a larger classroom so they did not feel that it was a necessary part of the training.

Support

Materials The school districts should provide adequate materials and equipment to teach the units.

Personnel The teachers stressed the importance of a resource person to give them support throughout the year. They felt that the follow up support which had been provided by Debbie Smith had been excellent, but that this type of intensive support was not feasible in their districts.

One teacher suggested a sort of "mentor system" in which a teacher with expertise in certain areas would be paid to be available for support for about 10 teachers who could contact him/her over the year for advice and suggestions.

Recommendations from the Project Director

The Director of the Institute, Debbie Smith, was also interviewed to determine her views on an "ideal" science institute for primary teachers as she reflected back on the original. These are her suggestions:

The Topic

The teachers' views on covering fewer topics and covering them well are supported by Debbie Smith as well as other science educators (e.g. Anderson, 1988).

- The institute would focus on one topic -- one appropriate for the grade levels of the participating teachers and for which there is literature about children's thinking on the topic (for example, lights

and shadows or "weights" and balances for K - 3 teachers).

The Schedule

The time period for the project would be lengthened from one to two years, with the summer institute component increased from four to five weeks. The need for increased time for programs which require drastic changes in styles of teaching such as this one has been indicated by other programs as well; for example, the implementation of a inquiry, activity-based curriculum in Colorado (Hord & Hurling-Austin, 1986). The overall strategy employed by the program would be that of modeling, coaching, fading as proposed by Anderson (1987).

Pre Institute In the spring before the summer institute, each teacher would bring his or her class to the Curriculum Development Lab at the University of Delaware. There the teacher would observe Debbie teaching lessons (modeling conceptual change strategies which work). Next the teacher would team teach with Debbie and be video-taped while teaching. This experience would show the teacher what could be done in a classroom, give them an opportunity to try it with

support (coaching) from Debbie, and get them used to being videotaped.

Summer Institute The summer institute would last five weeks. There would be two preparation weeks prior to the Summer Science Camp (rather than one). During the first week, the teachers would learn about the topic and conceptual change strategies through reading, discussion, and participation in activities.

During the second week, the teachers would interview the children they would teach in the summer science camp about their ideas on the topic and develop lesson plans for the science camp based on the strategies they had learned and the children's preconceptions. (In the original Institute all of this was done in one week.)

- The summer science camp would last two weeks and would provide an opportunity for the teachers to try out the lessons they had developed with small groups of children. (Even though some of the Institute teachers felt that this was an unrealistic situation, Debbie Smith felt that it was an imperative step because it gave the teachers a chance to focus on the teaching of the lessons without the distractions of managing an entire classroom.)

The teachers would work in pairs each teaching for one week while the other coached (as they had for the original Institute). In addition, the coaching teachers would also observe other groups, thereby giving them range of ideas for activities and children's responses to them.

The "teacher of the day" would be videotaped and would meet with the director on an individualized basis for discussion and coaching. (The more structured "stimulated response" would not be conducted as it was in the original Institute because it seemed to interfere with the coaching by the Director.)

During the fifth week the teachers would revise the units they taught during the science camp for use in their classrooms. The director would provide close supervision and support for this task which proved to be very difficult for teachers in the original Institute.

Post Institute

There would be follow-up for two school years rather than one. The additional year would provide the extended coaching or "comfort and caring" found by Hord and Hurling-Austin (1986) to be an important determinate in the success of program.

- During the first year, the teachers would co-teach the unit with the director. The lessons would be videotaped and the teacher and director would use the tapes to review and discuss the lessons.
- Throughout the year, the teachers and director would meet at least once a month to discuss problems, successes, content, and strategies. (The teachers had found these seminars to be very helpful but difficult to fit into their busy schedules. It was suggested that release time could be provided by the districts so that the teachers could attend these during school time.)
- In the second summer, teachers would meet in a seminar to share their teaching experiences, reinforce topic concepts and related skills, and catch up on their own and recent research findings about children's thinking on the topic.
- During the second school year, the teachers would have full responsibility for teaching their units. The director would not co-teach (fading) but would provide coaching.

School District Responsibility

District support in providing materials, rescheduling, release time for training, planning and coaching

sessions, and eliciting parent support is vital for success of a new program (Hord & Hurling-Austin, 1986). Again, the districts would need to provide equipment and materials. An explicit listing would be provided by the director. More release time than was provided for first Institute would be needed for training, planning and coaching sessions, seminars, and workshops with other teachers and parents.

More ways to involve the principals and other administrators in the project would be provided. For example, they could participate in the summer institute to become aware of the strategies and learn how to provide coaching and support in terms of time, materials, equipment, and resource personnel. Seminars to address concerns and problems of the administrators would also be conducted.

Each school involved in the project would have a lead teacher to be the liaison with the director, give support and coaching and maintain the materials and equipment in the schools.

In summary, the Summer Science Institute was successful in helping breaking down some of the barriers to science teaching for these seven teachers. However, for large scale changes to take place toward quality science in primary classrooms

"conceptual changes" must occur for administrators and teachers. Administrators must see the value of quality science in primary classrooms, be shown how such programs can be implemented, and be willing to make a large commitment, as described above, to implement such programs. But, the programs cannot be implemented top down. The teachers themselves must see a need to change, see that it is possible to make the change, have a say in making it, and be supported every step of the way in implementing the change.

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