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EFFECTIVENESS OF MENTOR TRAINING OF ELEMENTARY COLLEAGUE TEACHERS

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Abstract

This study reports the results of one phase of a project, funded in part by a grant from the National Science Foundation, which was designed to make hands-on science the predominant mode of instruction in the elementary schools of a large metropolitan district. A two-part questionnaire was developed and administered as a pretest/posttest focusing on the effectiveness of mentor/colleague inservice workshops. Results indicated significant changes in teachers' beliefs about teaching science, their understanding of the nature of science, the type of instruction they used in teaching science, and their anxiety toward science teaching as a result of workshop participation.

Introduction

In citing generalizations from exemplary science programs, Yager and Penick (1984) concluded that excellent science programs are designed to be excellent. They involve among other things years of focused, intensive inservice, energetic teachers, a locally developed curriculum, a science supervisor who plays a key role, an emphasis on team teaching, and strong central and building administration support. Although all facets of a science program are important, it is the teacher who plays the vital role. "Teachers are central to education. They serve as models, motivators, and mentors, the catalysts of the learning process" (National Science Foundation, 1991, p. 46646).

It is teachers who can create and maintain change in practices in teaching science, but to do so they must have a role in creating the knowledge to facilitate these changes (Briscoe, 1991). To achieve a level of excellence in teaching science, Fraser-Abder (1989) proposed that "teachers need to feel that they have an adequate knowledge of science, can teach without fear, are comfortable using science equipment in the classroom, and are interested in science and can pass on this interest to their students before they can be classified as good elementary science teachers" (p. 561). It is also posited that attitude toward the subject determines when and if science will be taught (Harlen, 1986). Shrigley (1983) has suggested "that science will be taught to more elementary

school classrooms when teacher attitude and teacher behavior become more positive toward science" (p. 214).

Unfortunately, even positive attitudes and sufficient preparation for teaching science may not result in a change in practice. In a survey of elementary schools, Goodlad (1984) found the textbook to be the major vehicle for teaching science and the supply and variety of instructional materials available at the elementary school level to be extremely limited. Goodlad also concluded that "teachers' stated expectations for students' learning were much closer to the goal expectations we tend to have for science education than were their teaching practices" (1984, p. 214). This disparity between theory and practice was reiterated by college supervisors who reported that there has been an emphasis upon teaching science processes in methods classes, but that observations in schools indicate a gap between what teachers know on a theoretical level and what is actually done in the classroom (Crocker, Shaw, and Reed, 1990).

The goal of professional development in science has been to bring about change in teachers' knowledge of science, change in their beliefs and attitudes toward science, and change in the instructional process. Orlich (1984) proposed that school-based programs taught by teachers tend to be more successful than those conducted off-site by non-teachers, and that the most successful programs allow for active participation rather than passive listening. "They provide hands-on experiences and allow teachers to use concrete teaching material" (Orlich, 1984, p. 35). Recently, there has been an increased emphasis on elementary staff development in science, and many programs have emphasized the use of student hands-on investigations. There have been a variety of approaches used to bring about a change to a more activity-oriented elementary science program, and the various programs have reported positive results. In Tennessee an inservice training program, the Elementary Science Education Institute (ESEI), relied upon the joint training of elementary teachers, principals, and supervisors of instruction as leadership teams to initiate activity-oriented instruction in rural schools. These teams provided subsequent inservice training on hands-on science instructional methods to elementary teachers throughout their school system (Prather, Hartshorn, McCreight, 1988). A later assessment of ESEI participants revealed that more than 70% of the teachers conducted more effective hands-on lessons at the end of the training period (Prather, Hartshorn, Walters, 1990).

This study, supported in part by a National Science Foundation grant, attempted to incorporate many of the ideas which have been successful in other projects and to address some areas which have not

been previously addressed. While the primary focus of the project was the teachers, both mentor and colleague, the principals and central administration personnel were also involved.

Project Description

From the point of inception, the approach taken to gain support for change was to have participants engage in hands-on science, not talk about it. This approach was taken with classroom teachers, principals, and central office administrators. The premise was that having individuals engage in the process of inquiry would be more effective than a persuasive lecture on the importance of hands-on science. Activities were conducted at meetings attended by the central administration and the 14 elementary principals. After experiencing the activities, all administrators, including the superintendent, were receptive to the idea of hands-on science activities in the schools. From a group of teachers nominated by the 14 principals, 28 elementary teachers from grade levels kindergarten through five (K-5) were selected by a committee to be mentor teachers. All selected teachers agreed to participate.

During the 1988-1989 academic year, these mentor teachers were trained in the use of hands-on science investigations. The following summer, the same mentor teachers wrote 72 hands-on science lessons on selected topics to be used by teachers in their respective grade levels. These lessons were designed to use readily available equipment and supplies; to allow students to independently pursue answers to questions; and to challenge students to think further about science concepts. The lessons were compiled into a hands-on science activity book for each grade level.

During the fall of 1989, the mentor teachers made brief presentations to each elementary staff in the district. They shared their training and activity-writing experiences, engaged the teachers in several hands-on investigations, and invited fellow teachers to participate in three Saturday workshops where they would cooperatively perform hands-on investigations designed for their grade. Teachers were informed they would receive Advanced Academic Training (AAT) credit for participation in 20 hours of inservice training and a copy of the hands-on science activity book designed for their grade level. Over 200 teachers voluntarily attended the workshops. These teachers were designated as colleague teachers.

Grade-level workshops were directed by the K-5 mentor teachers on selected Saturdays. All grade levels began their workshops at specified elementary schools within a two-week period in September of 1989.

During the initial workshops, the project director engaged the colleague teachers in an activity focusing on the enhancement of the teachers' understanding of what a scientist does, the tentativeness of science, and the problem-solving process. During the activity, the teachers were encouraged to make observations and draw inferences based on these observations. In subsequent discussions, the director stressed the importance of teachers not telling students "the answer," but allowing them to discover "an answer consistent with observation," just as the teachers had done during the demonstration activity.

During typical grade-level workshops, the teachers were separated into small groups and assigned to stations where they performed selected investigations under the direction of a mentor teacher. The investigations were performed in the same manner that students would later be asked to do. For a brief period after each experiment, the teachers discussed possible problems they might encounter in the classroom and proposed solutions. A rotation process continued until the teachers had performed the investigations at all of the stations. After their first full day of workshop participation, the colleague teachers began implementing hands-on science activities in their classrooms. Subsequent workshops were scheduled at the discretion of the mentor teachers. Some grades completed their workshops by December 1989, while other grades held their final workshops in March 1990.

Subjects

As an evaluation of the effectiveness of the mentor/colleague workshops, a teacher questionnaire was administered to the colleague teachers as a pretest prior to workshop participation and as a posttest upon completion of the final workshop. Although over 200 teachers participated in the project, the final data analysis included 96 K-5 teachers from the 14 elementary schools who completed the pretest/posttest and attended all workshop sessions.

While this indicates a drastic mortality rate of subjects, a rationale is offered. A number of teachers were unable to attend the initial sessions; therefore, they had not completed the pretest. Other teachers had conflicts over the course of the workshops, such as textbook committee meetings or other district inservice meetings. Some teachers also missed portions (one to eight hours) of the workshops. Since the primary aim was to determine the effectiveness of the 20 hours of workshop participation, only those who attended all hours of the workshop were included. It was determined that the 96 K-5 teachers composed a sufficiently large sample to be representative.

Description of the Survey Instrument

A two-part Workshop Evaluation Questionnaire was developed by the researcher for use in this study. Part one consisted of 16 items measured on a five-point Likert scale. The 16 items were categorized into two subsets: (a) beliefs about teaching science, and (b) understanding of the nature of science. For each item on the scale, a rating of 1 indicated strong agreement and a 5 indicated strong disagreement. A Cronbach alpha (.67) coefficient of internal consistency of the items was acceptable for the intended research purposes (DeVellis, 1991). Part two of the questionnaire was a combination of open-ended and numerical scale items. Responses of the total Likert scored items, two subsets, and individual items were analyzed in order to determine what changes might have occurred.

Results

Table 1 contains the results of the total 16-item Workshop Evaluation Questionnaire, Part 1, and the results of the two subsets of items. Paired *t*-tests, used to examine differences between the pretest/posttest means, suggested that the active participation of K-5 teachers in workshops in which they performed hands-on science investigations themselves and then used those same investigations in their classroom resulted in significant teacher change. An analysis of the total Likert scale items on the Workshop Evaluation Questionnaire for workshop participants revealed that attending the workshops significantly changed the overall attitude of elementary colleague teachers in the desired direction toward teaching science. The difference between the total pretest mean of 57.95 and the total posttest mean of 63.07 was significant at the .001 level. Some items were recoded so that a maximum mean score of 80.00 would indicate perfect Likert scale agreement in the desired direction.

Table 1

Workshop Evaluation Questionnaire, Part 1

	Mean		SD			
Indicator	Pre	Post	Pre	Post	*t*-Value	Prob.
Beliefs about teaching science	22.59	24.21	3.23	2.85	5.04*	.001
Understanding of the nature of science	35.36	38.86	4.48	4.78	6.87*	.001
Total	57.95	63.07	5.93	6.19	8.13*	.001

*Sig. p<.001

When the items were categorized into the two subsets, (a) beliefs about teaching science and (b) understanding of the nature of science, the pretest/posttest mean differences for each subset were also significant at the .001 level in the desired direction of change. In responding to items regarding beliefs about teaching science, the teachers' pretest mean was 22.59 with a posttest mean of 24.21. On the items regarding beliefs about teaching science, a maximum mean score of 30.00 was possible.

Replies to items regarding the teachers' understanding of the nature of science revealed a pretest mean of 35.36 compared to a posttest mean of 38.86. A maximum mean of 50.00 would have indicated the desired understanding of science. Both subset mean differences, which were significant at the .001 level, indicated that participation in the workshops affected teachers' beliefs about teaching science and their understanding of science in the desired manner.

Of particular interest were the responses of workshop participants to individual items on the questionnaire. These items were examined independently and the results are reported in Table 2 and Table 3.

Table 2

Workshop Evaluation Questionnaire, Part 1: Beliefs about Teaching Science

	Mean		SD			
Question	Pre	Post	Pre	Post	*t*-Value	Prob.
Teaching content in science is more important than changing attitudes toward science.	3.80	4.15	1.00	1.04	2.80*	.006
Asking questions in science is more important than giving answers.	1.64	1.47	0.78	0.75	-1.94	.055
I enjoy teaching science.	2.09	1.84	0.90	0.60	-3.25*	.002
I am uncomfortable if children ask me questions about science that I cannot answer.	3.17	3.71	1.22	1.14	3.55*	.001
I shy away from topics in science that I know little about.	2.90	3.02	1.08	1.12	1.05	.295
Students must have a strong background in scientific information before they attempt to do experiments.	4.47	4.64	0.66	0.70	2.22*	.029

*Sig. p<.05

Table 3

Workshop Evaluation Questionnaire, Part 1: Understanding of the Nature of Science

	Mean		SD			
Question	Pre	Post	Pre	Post	*t*-Value	Prob.
Our laws of science, especially any developed within the last ten years, are not likely to be changed.	4.27	4.52	0.80	0.77	2.39*	.019
It is impossible to eliminate error and uncertainty from the measurement process, even with the very best equipment.	2.59	2.04	1.06	1.08	-3.98*	.001
When the same experiment is performed any number of times, under exactly the same circumstances, the result is necessarily the same.	3.67	4.14	0.98	0.86	3.99*	.001
Since scientific knowledge is changing all the time, scientific ideas are subject to be being revised or thrown away.	2.32	1.84	1.01	0.76	-4.11*	.001
Science is the true and certain way to solve problems of nature and man.	2.92	3.09	0.98	1.08	1.46	.147
Most laws of nature have been discovered.	3.53	3.83	1.04	0.95	2.75*	.007
New scientific information leads to the development of new laws but does not affect established theories.	3.93	4.14	0.86	0.77	2.17*	.032
Scientific laws can be proven to be true.	2.41	2.61	0.82	1.10	1.75	.084
The results of a single, well-conducted experiment can be trusted.	3.75	4.19	1.11	0.85	4.41*	.001
Scientists expect a well-developed scientific model to be permanent.	3.81	4.22	1.00	0.73	3.86*	.001

*Sig. p<.05

When colleague teachers were asked to respond to the statement, "Teaching content in science is more important than changing attitudes

toward science," mean differences showed that after workshop participation, the teachers placed more importance on changing student attitudes toward science than before the workshops. The difference between the pretest mean of 3.80 and the posttest mean of 4.15 was significant at the .006 level in the desired direction of change. In the past, elementary teachers have expressed reservations about teaching science; therefore, it was notable that when asked to react to the statement, "I enjoy teaching science," significant (.002) pretest/posttest means of 2.09 and 1.84 respectively indicated that following workshop participation, colleague teachers found teaching science to be a more enjoyable experience.

Since previously elementary teachers have expressed concern about teaching science content for which they felt inadequately prepared, it was interesting to find that when asked to respond to the statement, "I am uncomfortable if children ask me questions about science that I cannot answer," the pretest/posttest means of 3.17 and 3.71 respectively were significant at the .001 level indicating that after workshop participation the teachers felt more at ease in believing that it was not necessary to "know all of the answers." In examining the individual items in Table 3 relating to teachers' understanding of the nature of science, eight out of the ten items were significant at least to the .05 level.

The primary consideration of the mentor/colleague teacher workshops was to have the teachers actually perform hands-on investigations as they would have their students perform them in their own classroom. It was hypothesized that the teachers' allocation of instructional time would be indicative of the degree of hands-on workshop success. Part 2 of the Workshop Evaluation Questionnaire included survey items related to time devoted to science instruction and the teachers' anxiety toward teaching science. The results of the four items are reported in Table 4.

An analysis of the responses revealed that attending the workshops and performing the investigations did not significantly increase the total amount of time teachers devoted to teaching science. Both the pretest and posttest means indicated that teachers average approximately 30 minutes a day teaching science. Participation in the workshops did not cause the colleague teachers to devote more time to science instruction; however, participation in the workshops did result in a change in the type of science instruction the students received. For example, prior to the workshops teachers devoted approximately 22 minutes per week to having students perform science investigations, while following the workshops the same teachers reported that they devoted approximately

Table 4

Workshop Evaluation Questionnaire, Part 2: Time Allocated to Science Instruction and Science Anxiety

Question	Mean Pre (Min.)	Mean Post (Min.)	SD Pre (Min.)	SD Post (Min.)	t-Value	Prob.
How much time do you spend teaching science each week?	144.58	147.57	62.67	60.62	.52	.605
How much time do you spend each week having your students do investigations?	22.42	53.42	23.03	42.24	7.27*	.001
How much time do you spend each week doing science demonstrations?	26.95	38.73	21.22	28.07	3.95*	.001
On a scale of 1 to 10 where would you rate your anxiety level relative to teaching science? (1 indicates very low anxiety and 10 indicates very high anxiety)	4.51	3.67	2.37	1.89	-4.03*[1]	.001

* Sig. p<.001
1 Negative indicates decreased anxiety

53 minutes a week to student hands-on investigation. This represents an increase of over 100% in student-conducted investigations.

Coinciding with changing the amount of time devoted to student investigations, the teachers made an additional change. They devoted significantly more time to science demonstrations. Although this change was of less magnitude than the change to more student investigations, it does represent a change from the previous instructional mode. Following the workshops, the teachers averaged nearly 39 minutes of teacher demonstrations each week compared to approximately 27 minutes per week prior to the workshops.

The impact of the workshops on science instruction can be summarized as follows. Prior to the workshops only 34% of the instructional time was devoted to student investigations or teacher demonstrations, whereas, following the workshops, 62% of the instructional time was devoted to student investigations or teacher demonstrations.

Participation in the workshops also reduced the teachers' anxiety toward teaching science. When asked to rate their anxiety level relative to teaching science on a scale of 1 to 10, the pretest mean of 4.51 and the posttest mean of 3.67 were evidence of a significantly (.001) decreased anxiety toward teaching science.

Limitations

The overall positive conclusions regarding the changes which occurred in the colleague teachers' beliefs, understanding, and in their instructional methods must be tempered by the limitations of the study. First, the participants in the study were volunteers and all of the reservations inherent with the use of volunteers must be acknowledged. It is possible that a random sample of teachers from a district might not yield the same results. There is also concern for the attrition rate of the sample, which was noted previously. The Workshop Evaluation Questionnaire also relied upon the teachers' self-report of information. The instrument is only accurate to the degree that the individuals accurately reported the information; however, there are no reasons to believe that the responses were not honestly expressed.

Discussion

The district is currently in its third year of implementing the hands-on approach to science instruction. The mentor teachers and some of the colleague teachers continue to offer workshops to other teachers on the use of the hands-on approach to science instruction. It appears that the participation of teachers in the mentor/colleague inservice training workshops had an impact on the colleague teachers' perception of science, enhanced their understanding of the nature of science, and resulted in a change in teaching practices. Although the total amount of time teachers devote to teaching science has not changed, indicators suggested that the workshops were a success in increasing the teachers' use of student hands-on science investigations in their classrooms. There has also been an increase in the amount of time teachers devoted to science demonstrations.

In assessing the elements which contributed to the success of the project, there are several which are notable. From the point of inception, support was gained for the project at all levels of the school system. An elite group of teachers was selected to be the catalysts for district-wide change. These mentor teachers then used their expertise to impact the other teachers in the district. There was a collective emphasis upon familiarizing teachers with the science processes, conducting appropriate

hands-on activities for teaching those processes, and immediately putting the activities into practice in the teachers' own classrooms. Additionally, the teachers worked with teachers at their own grade level and performed activities which the students would eventually perform. Through this approach the teachers benefitted from the collaborative effort, gained experience through the application of activities in the classroom, and as a result reduced their anxiety toward science.

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