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AUTHOR	Abell, Sandra K.
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ABSTRACT

Teachers are exposed to many varieties of inservice education throughout their careers. It is critical to evaluate the success of such programs. One criterion of success must be the degree to which teachers effectively implement what they have learned. This study examined the effects of an inservice education program emphasizing problem solving on teacher attitudes toward teaching science and on teaching behaviors. Twenty-two middle school science teachers participated in the program and another 22 served as the control group. Before and after the 10-month project, subjects completed attitude surveys and recorded videotapes of themselves teaching science lessons. No difference was noted between the groups on the attitude measure, "The Science Teaching Attitude Scales." A MANOVA performed on the observational data showed a significant difference between the groups, with a greater difference noted after the workshop than before. The experimental teachers appeared to be shifting to more student-centered classrooms. Teachers substantially decreased the percentage of time spent on lecture and procedural talk and increased the time spent observing and listening to students. This study provides evidence that an extended inservice education program can affect the teaching behaviors of science teachers in the middle grades. References and tables are included. (MVL)

THE EFFECT OF A PROBLEM SOLVING INSERVICE PROGRAM ON THE CLASSROOM BEHAVIORS AND ATTITUDES OF MIDDLE SCHOOL SCIENCE TEACHERS

Sandra K. Abell
School Mathematics and Science Center
Purdue University
West Lafayette, IN 47907

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PREFACE

This study is a result of a grant funded by the National Science Foundation (No. TEI-8652312, "Project STEPS - Science Textbook Extensions through Problem Solving), under the direction of Edward L. Pizzini, Science Education, The University of Iowa. The award was effective March 15, 1987 and expires August 31, 1990. This study represents Phase I of the evaluation component of the project. The research described herein, including the interpretations, does not necessarily represent the view of the National Science Foundation.

Introduction

A great potential for impacting student learning in science lies with the classroom teacher. Teaching behaviors such as wait time, praise, and degree of directiveness have been shown to influence student outcomes (Rowe, 1974a & b; Shymansky, 1976; Shymansky & Matthews, 1974; Tobin, 1980; Wise & Okey, 1983). Therefore teacher education directed at changing teaching behaviors is an essential component in the process of improving science instruction.

The knowledge about science and science teaching is ever-increasing and science teachers need to be continually updated. The current teaching force in the United States is composed of a majority of career teachers, creating an inservice teacher population that is more stable than at any other time in this country's past (Lanier & Little, 1986). Yet Weiss (1987) reported that 50% of elementary teachers surveyed had not participated in a science inservice program in the previous year, and another 23% had only been involved in such programs for less than six hours in the previous 12 months. In grades 7-9, 30% of the sample reported no science inservice participation and 22% less than six hours during the previous year. This situation points to a need for the continuing education of science teachers at all levels. The major question that arises is: Are teaching behaviors affected by inservice education? The present study addresses this problem.

Although the body of research on inservice education and teacher change is quite large, there appears to be a scarcity of research that deals specifically with science teacher education programs (Evans, 1987). A number of studies present evidence that training which involves a questioning classification or strategy analysis system can be instrumental in changing the behavior of preservice teachers (Esquivel, Lashier & Smith, 1978; Riley, 1978; Tobin, 1985; Yeany, 1977). Inservice training in specific behaviors such as questioning (Bruce, 1971; Otto & Schuck, 1983) and wait time (Chewprecha, Gardner & Sapianchai, 1980; Swift & Gooding, 1983) can also be effective in changing teacher behaviors. Bartholomew and Podio (1978) found that earth science teachers increased their investigative behaviors (questioning, problem posing, idea accepting and allowing student planning) after studying videotape or written models.

Training in specific programs and instructional strategies has had some degree of success. In a review of the research concerning the Intermediate Science Curriculum Study (ISCS), Howe and Stanback (1985) indicated that inservice training in the program resulted in changes in teacher behaviors and classroom organization. Stronck and Koller (1981) reported that teachers involved in the Science Curriculum Improvement Study (SCIS) showed a significant change in teaching behavior as a result of participation in SCIS workshops. Yet results of science teacher inservice projects are not always so encouraging. In a program aimed at implementing the learning cycle approach in secondary science classrooms, new ideas were not fully adopted by the teachers (Lombard, Konicek & Schultz, 1985). It seems the complexity of using the learning cycle required longer than a one year program to achieve transfer.

What about the effects of science teacher education on teacher attitudes? Halverson (1979) and Bruce (1971) noted little change in attitude resulting from teacher inservice with SCIS. Kyle, Bonnstetter and Gadsden (1988) noted significant attitudinal changes in SCIIS vs. non-SCIIS students, but little difference between teachers in the two groups. In their review of the ISCS research, Howe and Stanback (1985) reported "few reports of attempts to change teachers' attitudes toward science, and no evidence of successful attempts to bring about such a change" (p. 27). There is some evidence that positive science teacher attitudes can be developed among preservice (Piper & Moore, 1977; Sunal, 1982) and inservice teachers (Gabel & Rubba, 1979; Lawrenz, 1984). From the research one can conclude that attitudes toward teaching science are difficult, but not impossible, to change.

Staff development serves three functions according to Schlechty and Whitford (in Smylie, 1988): "establishment" of new programs, technologies and procedures; "maintenance" of routines and operations; and "enhancement" of individual teacher's performance. The enhancement function is often neglected or unsuccessful (Smylie, 1988). Furthermore few studies ha e tried to evaluate the effectiveness of enhancement programs by measuring change in actual teacher performance (Howey &

Vaughan, 1983).

As educators undertake educational change, a three phase cycle is apparent: initiation, implementation, and incorporation as a permanent feature of the system (Gross & Herriott, 1976). In the change literature, few studies are concerned with the implementation stage as compared with the large number of studies concerning adoption, although the situation is changing (Waugh & Punch, 1987). Furthermore, in 1985 only 7% of the body of science education research addressed teacher education at any stage (Gallagher, 1987). The 1986 science education research displays a similar dearth of teacher education studies (Shymansky & Kyle, 1988).

There is an overwhelming need for the inservice education of science teachers at the middle school level, and a concomitant need to document the outcomes through research. The present study fills a void in the research on inservice education of science teachers by examining the effect of a teacher enhancement program on actual classroom practice rather than merely looking at teacher acceptance of a new practice.

Purpose

Teachers are exposed to many varieties of inservice learning experiences throughout their careers: college courses, teacher conventions, summer workshops, and mandatory district inservices. Nationally the annual cost of inservice education is over $2 billion (Gage, 1984), but it is often conducted with questionable results (Waxman, 1985). Since staff development programs are expensive and time consuming, it is vital to document their outcomes. One criterion of success must be the degree to which teachers effectively implement what they have learned (Fenstermacker & Berliner, 1984; Kyle & Sedotti, 1987).

The research described herein examines the effect of an inservice education program on teacher attitudes toward teaching science and on teaching behaviors. Specifically, the research was guided by two principal problems:

1. Do teaching behaviors change after participation in a problem solving inservice program?
2. Do attitudes toward science teaching change after participation in a problem solving inservice program?

Method

Design and Sample. In order to determine whether teaching behaviors and attitudes change as a result of voluntary participation in a problem solving inservice program, a nonrandomized control-group pretest-posttest design was used (Isaac & Michael, 1981). The experimental group was measured before exposure to the inservice program (a spring seminar series of five meetings, a three week summer workshop, and a fall implementation phase with monthly support group meetings) and again after members had an opportunity to implement the problem solving instructional strategies in their classrooms. Concurrently a control group, selected at the same time as the participants, was measured.

The sample consisted of middle school (grade 5-8) teachers with over three years of teaching experience who volunteered to serve as either inservice participants or control groups members. A majority of control group members were teachers who desired to enter the project as participants, but due to scheduling conflicts accepted the alternative role. With attrition, the final number of subjects was 22 in each group.

Members of the two groups were quite similar in terms of gender, teaching status, and educational background. Each group was composed of 55% females and 45% males. The subjects were experienced teachers: 27% of control and experimental subjects had over 20 years of teaching experience, and another 50% had taught for 10-19 years. The teachers were also highly educated. Half of each group held a Master's degree and an additional 30% of each group had at least 15 semester hours beyond their Bachelor's. Yet among this highly educated and experienced group their was a gap of 4 years for over 50% and 8 years for another 25% since their last coursework in science or science education. One difference between the two groups: 68% of the control group taught in elementary schools (vs. middle or junior high schools) compared to 46% of the experimental group.

Treatment. The inservice program design was based on conclusions of several inservice education research syntheses (Evans, 1987; Showers, Joyce & Bennett, 1987; Sparks, 1983; Wade, 1984; Yeany & Padilla, 1986). Agreements regarding best practices for inservice education which were integrated into the program include:

* Training groups involving different levels of teachers (e.g. elementary and junior high) are more effective.

* Inservice is more effective when participants are selected and receive rewards/incentives for attendance.

* Participants will learn best when new experiences are linked to their own knowledge and experience.

* Modeling new teaching strategies is an effective inservice methodology.

* Participants need time to practice new strategies.

* Participants need feedback about their classroom attempts.

* Participants need time to reflect upon practice in small groups.

* Inservice education programs should be directed toward changing teacher behavior rather than student behavior.

The general pattern of instruction was to 1) expose teachers to a new topic or strategy through an activity which modeled effective teaching; 2) analyze the merits of the strategy through reading and discussion; 3) attempt to use the strategy with their own students; 4) discuss results and make revisions. Participants learned an instructional strategy for problem solving--Search, Solve, Create, Share (Pizzini, Abell & Shepardson, 1988)--which involves students in finding and refining a researchable problem, designing and conducting an appropriate study, processing data and sharing conclusions. Participants played a role in developing teaching and assessment strategies conducive to the instructional model throughout the project.

<u>Data Collection</u>. Data were collected in two rounds--one before

and the other one year after the commencement of the inservice project. Demographic and attitudinal data were collected via a questionnaire, containing a 30 item attitude survey, The Science Teaching Attitude Scales, developed by Moore (1973). The instrument consists of scales that rate positive and negative positions on three critical elements of teachers' perceptions about teaching science: emotional attitudes toward teaching science; attitudes toward science content vs. process; and perception of teacher's role.

Subjects were also asked to record videotapes of themselves teaching science lessons which involved problem solving: one before the workshop and two during post-workshop data collection. A coding system, "Teacher Observations during Problem Solving" (TOPS) was developed to describe science classrooms where a problem solving instructional strategy is employed (Appendix). The TOPS system is low-inference and categorical in nature. It is a closed system in that no new categories are added during observation periods (Evertson & Green, 1986). TOPS consists of columns specifying three dimensions of classroom interaction: groupings of students, stages of a problem solving lesson, and teacher behaviors.

Once the system was established, a team of four coders went through a series of training sessions to learn how to effectively use TOPS. As coders proceeded to code tapes, they were unaware of the design of the study or the status of any tape (pre/post, control/experimental). A G-study (Cronbach et al., 1972) was conducted to determine inter-rater reliability of the TOPS instrument. Intraclass correlation coefficients (Lindquist, 1953) were calculated for each code for one and two coders (Table I). Although the TOPS instrument proves more reliable with two coders per observation, considerations of time and expense necessitated the use of a single coder per videotape.

In order to examine possible influences on control group members during the lengthy treatment period, all subjects completed an activity survey that supplied information about involvement in professional activities outside of the problem solving inservice program (coursework, workshops, professional reading). Additionally experimental subjects were asked to keep an implementation log in which they recorded use of the problem solving teaching strategies in their classrooms.

Data Analysis. The results of this study were analyzed as a mixed factorial design in which repeated measurements are used for two independent groups (Feldt, 1984). Videotapes were coded using the Datamyte hardware to record codes and real time. These data were then transformed, via the MACRO5 program (Shymansky, Pruess & Wolcott, 1985) into a frequency distribution. Because the taped lessons were of different lengths, percentage of time figures were used to allow for direct comparisons among the tapes. A multivariate analysis of variance (MANOVA) was employed in analyzing the videotape data to account for possible intercorrelations among the large number of dependent variables.

Table I

Inter-Rater Reliability for One and Two Raters
Using the TOPS Coding System

Setting			Lesson Structure			Teacher Behavior		
Code	R^1_{xx}	R^2_{xx}	Code	R^1_{xx}	R^2_{xx}	Code	R^1_{xx}	R^2_{xx}
1	.95	.97	1	*		01	.26	.41
2	.93	.96	2	**		02	.44	.61
3	.68	.81	3	.16	.28	03	.12	.21
			4	.67	.80	04	.38	.55
			5	.49	.66	05	**	
			6	*		06	*	
			7	.22	.36	07	.52	.68
			8	*		08	.79	.88
			9	.18	.31	10	.57	.73
						11	*	
						12	**	
						13	.77	.87
						14	.68	.81
						15	.65	.79
						16	*	
						17	*	
						18	.37	.54
						19	**	
						89	.80	.89
						99	.48	.65

1. Based on a sample of 5 tapes coded by 5 raters.

2. R^1_{xx} is the reliability coefficient for one rater.

3. R^2_{xx} is the reliability coefficient for two raters.

*Less than 1% of total time on average allocated to this category.

**Calculations yielded negative numbers.

Results

Attitudes. Based on the thirty-item *Science Teaching Attitude Scales* (Moore, 1973) subjects received an attitude score indicating their agreement/disagreement with three elements: emotional attitudes toward teaching science, attitudes toward science content vs. process, and perception of the teacher's role. The highest possible score for each element is thirty, and for the entire instrument is ninety.

Table II reports the means and standard deviations for each subscale and for the combined score. In each case the experimental group mean increased slightly while the control group means decreased slightly from pre to posttest. The combined scores were used as the dependent variable in a repeated measures ANOVA to examine these differences for statistical significance (Table III). The F ratios for interaction and main effects are not significant at $\alpha = 0.10$.

Teaching Behaviors. Teaching behaviors were measured via the TOPS coding system in order to examine the null hypotheses that:

- There is no interaction effect of repeated measures by treatment, i.e. the effect of time is the same for both experimental and control groups.
- There is no difference in behaviors between experimental and control groups.

A multivariate analysis of variance followed by an examination of univariate F-ratios provided information regarding the hypotheses.

Table II

Means and Standard Deviations:
Attitudes Toward Teaching Science

		Total		I		II		III	
Condition	n	$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd
Experimental									
Pre	22	64.18	8.62	24.77	3.28	18.23	3.69	21.18	4.24
Post	22	66.41	9.26	25.14	3.33	19.00	4.47	22.14	3.43
Control									
Pre	22	63.95	8.22	24.64	3.66	18.59	3.54	20.73	4.34
Post	22	63.23	8.01	24.14	4.39	18.41	3.86	20.23	3.87

I: Emotional attitudes toward teaching science.
II: Attitudes toward science content vs. process.
III: Perception of teacher's role.

Table III

ANOVA Summary Table: Attitudes Toward Teaching Science

Source	SS	df	MS	F
Between	5308.62	43	123.46	0.99
Treatment	64.24	1	64.24	0.51
Error	5244.38	42	124.87	
Within	1031.50	44	23.44	1.01
Pre/Post	12.36	1	12.36	0.53
Interaction	47.87	1	47.87	2.07
Error	971.27	42	23.13	

$0.10\ F_{(1,42)} = 2.83$

A two-way repeated measures MANOVA (Table IV) produced an interaction significant at p=0.0539. The main effects were also found to be significant: for the group effect at p=0.0392 and for the time effect at p=0.0001. These results lead to the rejection of both null hypotheses. In order to further describe the interaction, two one-way MANOVAs for the group effect of time were performed (Table V). The results of the pre-inservice analysis were not significant, while the post workshop analysis produced an F significant at p=0.0775. These results indicate a trend in the data: the two groups were more alike on their teaching behaviors before the workshop than after.

To reveal which of the dependent variables contributed the most to the significant results of the MANOVA, univariate F-ratios were calculated for twenty-six variables (some codes were combined for ease in analysis and interpretation). None of the "setting" codes were found to be significantly different. In the "lessons structure" column, two group X time interactions were significant: problem finding plus problem refining (p=0.074) and producing (p=0.091). Two significant differences for the main effect of group were found: data collecting (p=0.018) and sharing/presenting (p=0.002).

Some of the univariate tests in the "teacher behavior" column also produced significant results. Three codes revealed significant group X time interactions: procedural plus lecture (p=0.061), redirecting (p=0.028) and uncodable plus other (p=0.014). The group main effect was significant in five cases:

Table IV

Two-Way MANOVA: Teaching Behaviors of Control and Experimental Groups Before and After Inservice Program

Source	F	PR>F
Group	2.30	0.0392
Time	6.29	0.0001
G X T	2.14	0.0539

$F_{(26,17)}$ based on Wilks' criterion.

Table V

One-Way MANOVAs for Group Effect

Time	F	PR>F
Pre-Inservice	1.02	0.4924
Post-Inservice	1.95	0.0775

$F_{(26,17)}$ based on Wilks' criterion.

procedural plus lecture (p=0.016), managerial (p=0 080), redirecting (p=0.039), wait time (p=0.024) and uncodable plus other (p=0.041). Five significant differences were also found for the time main effect: procedural plus lecture (p=0.012) input (p=0.003), observing plus listening (p=0.005), praise plus criticism (p>0.001) and uncodable plus other (p=0.009). The direction of these differences was discovered through examining the means for each difference (see Tables VI and VII).

Activity Survey. The two groups closely resembled each other in terms of professional activity from May, 1987 to January, 1988: they took similar numbers of college courses, and were involved with mandatory and voluntary inservice to a similar degree. The topics/titles of these course and workshops also closely corresponded. In the area of professional reading, again there was a parallel between the two groups in number and type of journals read. One difference was that more members of the control group attended a teachers conference during the time span.

The last question on the survey asked teachers to reflect on their teaching practice, questioning if their teaching had changed and noting any modifications which were undertaken since May, 1987. One hundred percent of the experimental subject answered affirmatively to the question of change, while only 71% of the control group did. Both groups mentioned modifications such as cooperative learning, altered questioning techniques, and more focus on process science. The experimental group, however,

Table VI

Means by Group and Time for Codes Yielding Significant F-Ratios; Lesson Structure

Group	Time	n	Code 1 & 2	Code 4	Code 6	Code 7
1	1	22	6.12	40.26	0.00	0.57
1	2	22	1.41	43.95	5.89	6.47
2	1	22	3.08	32.51	4.11	4.69
2	2	22	8.42	26.62	2.02	19.58

Group 1 = Control; Group 2 = Experimental
Time 1 = Pre-Workshop; Time 2 = Post-Workshop

Codes:
1. problem finding
2. problem refining
4. data collecting
6. producing
7. sharing/presenting

Table VII

Means by Group and Time for Codes Yielding Significant F-Ratios: Teacher Behavior

Group	Time	N	Code 1 & 2	Code 3	Code 7	Code 8 & 18
1	1	22	35.66	6.33	0.67	16.46
1	2	22	34.11	13.16	1.11	24.30
2	1	22	32.42	9.05	1.42	21.64
2	2	22	22.27	12.25	4.50	28.08

Group	Time	N	Code 10 & 11	Code 14	Code 16 & 17	Code 89 & 99
1	1	22	1.87	0.63	0.40	19.17
1	2	22	0.82	0.81	0.34	7.44
2	1	22	1.82	1.76	1.04	9.49
2	2	22	0.86	0.76	0.55	9.09

Group 1 = Control; Group 2 = Experimental
Time 1 = Pre-Workshop; Time 2 = Post-Workshop

Codes:

1. procedural (lesson-related)
2. lecture/telling
3. input question/statement
7. managerial/discipline
8. observing students
10. praise/positive evaluation
11. criticism/negative evaluation
14. redirecting
16. wait time I
17. wait time II
18. listening to students
89. uncodable/inaudible
99. other

was much more specific in mentioning modifications of their teaching methodologies: increased time on investigative problem solving, increased use of brainstorming, less textbook time, more student-selected research questions, more student-designed investigations.

The Problem Solving Classroom

A compilation of the post-workshop TOPS results for the experimental subjects (Table VIII) can be used to describe the classrooms of these teachers. Almost 60% of the problem solving class time is spent in whole class settings, with another 30% in small groups and the balance working with individuals. During the inservice the instructional team espoused large groups for problem finding and sharing/presenting, but cooperative teams for problem refining, research designing, data collections and analysis, and evaluation. It is thus surprising not to find more small group work in the tapes. One possible reason is that teachers may have chosen settings where videotaping was easier--whole class work.

In terms of lesson structure, the problem solving teachers spent the most class time on data collection, which would be the stage of problem solving that requires the longest to accomplish. They also spent a goodly amount of time defining problems, designing research, analyzing results, and sharing conclusions. Producing and evaluating were infrequently observed, most likely because these stages were taking place outside of class or

Table VIII

Post-Workshop TOPS Results for
Experimental Subjects

Setting		Lesson Structure		Teacher Behavior	
1)	59.05	1+2)	8.42	1+2)	22.27
2)	31.17	3)	12.66	3)	12.25
3)	9.76	4)	26.62	4)	1.66
		5)	8.53	5)	1.77
		6)	2.02	6)	0.44
		7)	19.58	7)	4.50
		8)	0.81	8+18)	28.08
		9)	7.22	10+11)	0.86
				12)	2.50
				13)	3.32
				14)	0.76
				15)	6.44
				16+17)	0.55
				19)	3.96
				89+99)	9.09

n = 22; Figures represent percent of total time.

Codes:

1. whole class
2. small group
3. individuals

1. problem finding
2. problem refining
3. research designing
4. data collecting
5. data analyzing
6. producing
7. sharing/presenting
8. evaluating
9. other

1. procedural
2. lecture
3. input
4. processing
5. output
6. metacognitive
7. managerial
8. observing
18. listening
10. praise
11. criticism
12. acknowledgment
13. repeating
14. redirecting
15. probing
16. wait I
17. wait II
19. informing
89. uncodable
99. other

filming times. About 7% of the taped class time was spent on non-problem solving matters such as review.

The preeminent teaching behavior of the experimental group was observing/listening to students. Problem solving teachers also spent a relatively large proportion of time lecturing/giving procedural information and asking input level questions. Their response mode was dominated by probing for clarification and listening. If these data are compared with Power's (1977) figures on the typical science classroom where the dominant cognitive teacher behaviors are fact-stating (50-60%) and explaining (10-20%), there is much less lecture and procedural talk among the problem solving teachers. From the observing and listening categories one could infer that about 28% of class time was dominated by student talk, an increase from Power's figure of 10-20%. It would be of value to study student behaviors in the problem solving classrooms to see if they initiate talk more often, ask more questions, and ask higher level questions than is typically the case.

Discussion

The results concerning science teaching attitudes showed no significant difference between the treatment groups. This finding is not surprising in light of the body of research which reports little teacher attitude change as a result of inservice education (Bruce, 1971; Halverson, 1979; Hasan & Billeck, 1975; Howe & Stanback, 1985; Kyle et al., 1988). Yet the experimental group's attitude scores did increase in all cases while the control group's did not, even if the the differences were not statistically significant. Perhaps the length of the treatment period was not sufficient for major attitudinal change, or the attitude instrument used in this study was not sensitive enough to the particular attitudes which the inservice indirectly aimed to enhance. It could be that this sample of highly experienced volunteers had fairly positive attitudes originally--their pre-test scores were higher that Moore's (1973) groups--and thus their attitude scores were more difficult to raise. These concerns warrant further study.

One would expect that, after being trained in a problem solving model, teachers would change the structure of their lessons. It was predicted that experimental teachers would spend more time on problem finding and refining, research designing, data analysis, and sharing/presenting than their control counterparts. The results did show an increase in percentage of time allotted to problem finding and refining and sharing/presenting for the experimental group (with a proportional decrease in data collection, although it was still the major activity type). These teachers have come to realize that investigative problem solving is more than "messing about" with equipment; it includes the essential steps of defining a problem and later sharing conclusions (Bransford et al., 1986; Marzano et al., 1988). The increase in problem finding and refining also implies a transfer of responsibility to students (these phases take more time when students are in charge).

Students must be involved with problem finding and refining to experience meaningful problem solving (Freudlich, 1978).

The predictions concerning teacher behaviors were that the experimental group would demonstrate a decrease in the amount of lecture and procedural talk, an increased use of metacognitive talk (Costa & Marzano, 1987) and an increase in higher level questions with a corresponding increase in open responses (Costa, 1985) such as wait time, deferred judgment, and probing. Certain predictions were validated through the study. The experimental group substantially decreased the percentage of time spent on lecture and procedural talk as compared with the control group. Concurrently the experimental teachers spent more time observing and listening to students. They are relying less on teacher talk and more on student behaviors than before the inservice. This shifting the control of learning to the students is essential to developing student thinking and problem solving skills (Marzano et al., 1988). Other predictions, however, were not substantiated. It could be that the treatment failed to produce changes in these behaviors. Yet the teachers themselves reported behavioral change. Perhaps the changes reported by these teachers were not detectable at the reduced level of specific behaviors recorded using TOPS.

The classroom environment is very complex. Attempts to quantify it can be inadequate. Yet the results of the MANOVA indicated that the two groups were more different when measured with TOPS after the inservice than before. Although not all of the predicted behavioral changes were detected, some significant changes did take place. The problem solving teachers appear to be shifting to a more student-centered classroom. This shift in emphasis would have required a concurrent change in teacher role, which is often difficult to achieve (Spector, 1984; First, 1987). Thus the fact of change in itself is significant, but more work will need to be done to detect more specific teaching modifications.

New questions raised in the course of this research remain to be studied. Who is more prone to change regarding an innovation, i.e., what are predisposing characteristics for change? Which components of an inservice program are essential for affecting change? What are elements of philosophical change (regarding the nature of science and pedagogy) that teachers encounter in adopting an innovation? Which teaching behaviors are prevalent at different stages of problem solving? What effect does changed teacher behavior have on student problem solving behaviors, abilities and attitudes? Further research involving extended periods of observation and qualitative methods of data collection and analysis might be fruitful in detecting and describing more completely the effect of inservice experiences on teachers and students.

References

Bartholomew, R. B. & Podio, A. L. (1978). Three-dimensional analysis of verbal interaction matrices. Journal of Research in Science Teaching, 15(5), 307-324.

Bransford, J. D., Sherwood, R., Rieser, J., & Vye N. (1986). Teaching thinking and problem solving: Research foundations. American Psychologist, 41, 1078-1089.

Bruce, L. R. (1971). A study of the relationship between the SCIS teachers' attitude toward the teacher-student relationship and question types. Journal of Research in Science Teaching, 8(2), 157-164.

Chewprecha, T., Gardner, M., & Sapianchai, N. (1980). Comparison of training methods in modifying questioning and wait time behaviors of Thai high school chemistry teachers. Journal of Research in Science Teaching, 17(3), 191-200.

Costa, A. L. (1985). Teacher behaviors that enable student thinking. In A.L. Costa (Ed.), Developing minds: A resource for teaching thinking (pp. 125-137). Alexandria, VA: Association for Supervision and Curriculum Development.

Costa, A. L. & Marzano, R. (1987). Teaching the language of thinking. Educational Leadership, 44(2), 29-33.

Cronbach, L. J., Gleser, G. C., Nanda, H., & Rajaratnam, N. (1972). The dependability of behavioral measurements: Theory of generalizability for scores and profiles. New York: John Wiley & Sons, Inc.

Esquivel, J. M., Lashier, W. S., & Smith, W. S. (1978). Effect of feedback on questioning of preservice teachers in SCIS microteaching. Science Education, 62(2), 209-214.

Evans, T. P. (1987). Guidelines for effective science teacher inservice education programs: Perspectives from research. In B.S. Spector (Ed.), A guide to inservice science teacher education: Research into practice (1986 AETS Yearbook) (pp. 13-56). Columbus, OH: SMEAC Information Reference Center.

Evertson, C. M. & Green, J. L. (1986). Observation as inquiry and method. In M.C. Wittrock (Ed.), Handbook of research on teaching (Third Edition) (pp.162-213). New York: Macmillan Publishing Company.

Feldt, L. S. (1984). Design and analysis of experiments in the behavioral sciences. Unpublished manuscript. Iowa City: The University of Iowa.

Fenstermacker, G. D. & Berliner, D. C. (1984). Determining the value of staff development. The Elementary School Journal, 85(3), 281-314.

First, D. R. (1987). Improvement of science teaching of Native American elementary students through staff development: An ethnographic study. In P.E. Blosser & S.L. Helgeson (Eds.), Abstracts of presented papers. National Association for Research in Science Teaching--60th annual NARST conference (p. 73). Washington, DC: NARST.

Freundlich, Y. (1978). The "problem" in inquiry. The Science Teacher, 45, 19-22.

Gabel, D. & Rubba, P. (1979). Attitude changes of elementary teachers according to the curriculum studied during workshop participation and their role as model science teachers. Journal of Research in Science Teaching, 16(1), 19-24.

Gage, N. L. (1984). What do we know about teaching effectiveness? Phi Delta Kappan, 66(2), 87-93.

Gallagher, J. J. (1987). A summary of research in science education--1985. Science Education, 71(3), 271-457.

Gross, N. & Herriott, R. E. (Eds.). (1976). The dynamics of planned educational change. Berkeley, CA: McCutchan Publishing Company.

Halverson, D. L. (1979). The effectiveness of a televised science in-service model for improving elementary teacher attitudes and concept knowledge. Unpublished Doctoral Dissertation. The University of Iowa.

Hasan, O. E. & Billeck, V. (1975). Relationship between teachers' change in attitude toward science and some professional variables. Journal of Research in Science Teaching, 12(3), 247-253.

Howe, A. C. & Stanback, B. (1985). ISCS in review. Science Education, 69(1), 25-38.

Howey, K. & Vaughan, J. (1983). Current patterns of staff development. In G. Griffin (Ed.), Staff development: Eighty-second yearbook of the National Society for the Study of Education (Part II) (pp. 92-117). Chicago: University of Chicago Press.

Isaac, S. & Michael, W. B. (1981). Handbook in research and evaluation for education and the behavioral sciences. San Diego: EdITS Publishers.

Kyle, W. C., Bonnstetter, R. J., & Gadsden, T. (1988). An implementation study: An analysis of elementary students' and teachers' attitudes toward science in process-approach vs. traditional science classes. Journal of Research in Science Teaching, 25(2), 103-120.

Kyle, W. C. & Sedotti, M. A. (1987). The evaluation of staff development: A process, not an event. In B.S. Spector (Ed.), A guide to inservice science teacher education: Research into practice. (1986 AETS Yearbook) (pp. 101-118). Columbus, OH: SMEAC Information Reference Center.

Lanier, J. E. & Little, J. W. (1986). Research on teacher education. In M.C. Wittrock (Ed.), Handbook of research on teaching. (Third Edition) (pp. 527-569). New York: Macmillan Publishing Company.

Lawrenz, F. P. (1984). An evaluation of the effect of two different lengths of inservice training on teacher attitudes. Journal of Research in Science Teaching, 21(5), 497-506.

Lindquist, E. F. (1953). Design and analysis of experiments in psychology and education. Boston: Houghton Mifflin Company.

Lombard, A. S., Konicek, R. D., & Schultz, K. (1985). Description and evaluation of an inservice model for implementation of a learning cycle approach in the secondary science classroom. Science Education, 69(4), 491-500.

Marzano, R. J., Brandt, R. S., Hughes, C. S., Jones, B. F., Presseisen, B. Z., Rankin, S. C., & Suhor, C. (1988). Dimensions of thinking: A framework for curriculum and instruction. Alexandria, VA: Association for Supervision and Curriculum Development.

Moore, R. W. (1973). The development, field test, and validation of scales to assess teachers' attitudes toward teaching elementary school science. Science Education, 57(3), 271-278.

Otto, P. B. & Schuck, R. F. (1983). The effect of a teacher questioning strategy training program on teaching behavior, student achievement, and retention. Journal of Research in Science Teaching, 20(6), 521-528.

Piper, M. & Moore, K. (1977). The effect of a physics course for elementary teachers on attitudes toward science of preservice elementary teachers. In M. Piper, (Ed.), Attitudes toward science: Investigations. Columbus, OH: SMEAC Information Reference Center.

Pizzini, E. L., Abell, S. K., & Shepardson, D. P. (1988). Rethinking thinking in the science classroom. The Science Teacher, 55(9), 22-25.

Power, C. (1977). A critical review of science classroom interaction studies. Studies in Science Education, 4, 1-30.

Riley, J. P. (1978). Effects of studying a question classification system on the cognitive level of preservice teachers' questions. Science Education, 62(3), 333-338.

Rowe, M. B. (1974). Wait-time and rewards as instructional variables, their influence on language, logic, and fate control: Part one--wait-time. Journal of Research in Science Teaching, 11(2), 81-94.

Rowe, M. B. (1974). Relation of wait-time and rewards to the development of language, logic and fate control· Part II--rewards. Journal of Research in Science Teaching, 11(4), 291-308.

Showers, B., Joyce, B., & Bennett, B. (1987). Synthesis of research on staff development: A framework for future study and a state-of-the-art analysis. Educational Leadership, 45(3), 77-87.

Shymansky, J. A. (1976). How is student performance affected by the one-to-one teacher-student interactions occurring in an activity-centered science classroom. Journal of Research in Science Teahcing, 13(3), 252-258.

Shymansky, J. A. & Kyle, W. C., Jr. (1988). A summary of research in science education - 1986. Science Education, 72(3), 249-402.

Shymansky, J. A. & Matthews, C. C. (1974). A comparative laboratory study of the effects of two teaching patterns on certain aspects of the behavior of students in fifth grade science. Journal of Research in Science Teaching, 11(2), 157-168.

Shymansky, J. A., Pruess, C., & Wolcott, E. (1985). Macro-X user's guide: A computerized system for analyzing observational data. Unpublished manuscript. Iowa City: The University of Iowa.

Smylie, M. A. (1988). The enhancement function of staff development: Organizational and psychological antecedents to individual teacher change. American Educational Research Journal, 25(1), 1-30.

Sparks, G. M. (1983). Synthesis of research on staff development for effective teaching. Educational Leadership, 41(3), 65-72.

Spector, B. S. (1984). Case study of an innovation requiring teachers to change roles. Journal of Research in Science Teaching, 21(6), 563-574.

Stronck, D. R. & Koller, G. R. (1981). Evaluating the effectiveness of an in-service science program through the use of materials. Journal of Research in Science Teaching, 18(5), 403-408.

Sunal, D. W. (1982). Affective predictors of preservice science teaching behavior. Journal of Research in Science Teaching, 19(2), 167-175.

Swift, J. N. & Gooding, C. T. (1983). Wait time and questioning skills of middle school science teachers. Journal of Research in Science Teaching, 20, 721-730.

Tobin, K. G. (1980). The effect of an extended teacher wait-time on science achievement. Journal of Research in Science Teaching, 17, 469-475.

Tobin, K. (1985). Teaching strategy analysis models in middle school science education courses. Science Education, 69(1), 69-82.

Wade, R. K. (1984). What makes a difference in inservice teacher education? A Meta-analysis of research. Educational Leadership, 42(4), 48-55.

Waugh, R. F. & Punch, K. F. (1987). Teacher receptivity to systemwide change in the implementation stage. Review of Educational Research, 57(3), 237-254.

Waxman, H. C. (1986). Improving classroom instruction through staff development: A Review of recent research. Journal of Classroom Interaction, 22(1), 1-30.

Weiss, I. R. (1987). Report of the 1985-1986 National Survey of Science and Mathematics Education. Research Triangle Park, NC: Research Triangle Institute.

Wise, K. C. & Okey, J. R. (1983). A meta-analysis of the effects of various science teaching strategies on achievement. Journal of Research in Science Teaching, 20(5), 419-435.

Yeany, R. Jr. (1977). The effects of model viewing with systematic strategy analysis on the science teaching styles of preservice teachers. Journal of Research in Science Teaching, 14(3), 209-222.

Yeany, R. H. & Padilla, M. J. (1986). Training science teachers to utilize better teaching strategies: A research synthesis. Journal of Research in Science Teaching, 23(2), 85-95.

APPENDIX

Teacher Observations during Problem Solving (TOPS)

<u>SETTING</u>

1 whole class

2 small group

3 individuals

<u>LESSON STRUCTURE</u>

1 problem finding

2 problem refining

3 research designing

4 data collecting

5 data analyzing

6 producing

7 sharing/presenting

8 evaluating

9 other

<u>TEACHER BEHAVIOR</u>

Initiating

01 procedural (lesson-related)

02 lecture/telling

03 input question/statement

04 processing question/statement

05 output question/statement

06 metacognitive question/statement

07 managerial/discipline

08 observing students

Responding

10 praise/positive evaluation

11 criticism/negative evaluation

12 acknowledging w/out judgment

13 repeating/rephrasing

14 redirecting

15 probing/clarifying

16 wait time I (>3 sec)

17 wait time II (>3 sec)

18 listening to students

19 giving information

89 uncodable (inaudible)

99 other