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An In-Service Teacher Education Program's Effect on Teacher Efficacy and Attitudes

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Abstract

Changes in teacher efficacy and attitudes toward teaching were examined throughout a teacher education program as teachers worked to integrate new skills into their science curriculum. Correlation coefficients were calculated for the changes. Positive correlation was observed between changes in attitude and self-efficacy. Negative correlation was observed between changes in self-efficacy at the beginning of the school year and changes in self-efficacy at the end of the program.

The concept of teacher efficacy has been researched and discussed in teacher education literature for nearly 30 years. Tschannen-Moran, Hoy, and Hoy (1998) published an extensive review of the concept of teacher efficacy and various instruments to assess it. They noted that efficacy, as applied to teachers, has two distinct roots in the behavioral psychology research literature. Rotter (1966) described a concept of locus of control—the process by which individuals acquire expectancies of internal or external control over desired outcomes. Bandura (1977) described the concept of self-efficacy as an individual's beliefs about his or her ability to successfully perform the task that produces a desired outcome. Both ideas describe a cyclical process by which individuals use previous knowledge and other information to form expectations and perceptions about their ability to perform successfully at specific tasks. Though these two ideas share many similarities, they are very different. For example, Rotter's concept of locus of control described the perceived relationship between an action and an outcome, whereas Bandura's self-efficacy described the perceived ability to produce a desired action. Tschannen-Moran et al. (1998, 211) described the relationship between Rotter's locus of control and Bandura's theory of self-efficacy concisely: "An individual may believe that a particular outcome is internal and controllable ... but still have little confidence that he or she can accomplish the necessary actions."

Thus, Tschannen-Moran et al. (1998) proposed a new model for teacher efficacy that integrated the ideas of both Rotter (1966) and Bandura (1977) and described the cyclical nature of the creation and maintenance of teaching efficacy. In their model (Tschannen-Moran et al. 1998, 233), teacher efficacy represented the teacher's "belief in their capability to organize and execute courses of action required to successfully accomplish a specific teaching task in a particular context." Teacher efficacy, then, is composed both of teachers' beliefs about and confidence in their teaching ability—or teacher self-efficacy (beliefs about internal factors)—and their beliefs about the necessity and availability of teaching resources—or teaching context beliefs (beliefs about external factors).

Correlates of High Teacher Efficacy

Research has shown that high teacher efficacy scores correlate with numerous positive teacher attitudes and behaviors. For example, educators with high teacher efficacy scores are more willing to try new teaching methods and technologies (Guskey 1988) and display more enthusiasm toward teaching (Guskey 1984). According to Schriver and Czerniak (1999), teachers with high efficacy scores:

- spend more time teaching science;
- teach in an inquiry-based, student-centered classroom;
- use open-ended questioning and discussion;
- take personal responsibility for student learning;
- choose lessons effectively; and
- manage the classroom in an efficient manner.

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Teachers with high teacher efficacy scores also are less prone to problems of teacher burnout (Brouwers and Tomic 2000). Teachers who experience burnout tend to avoid dealing with academic concerns, experience high levels of emotional exhaustion, feel a sense of depersonalization toward students, and withdraw to deal with their emotional distress (Chwalisz, Altmaier, and Russell 1992).

The Development of Teacher Efficacy

Though research has succeeded in delineating the attributes of highly efficacious teachers, the mechanisms by which teachers acquire or improve their teacher efficacy are still unclear. Ramey-Gassert and Shroyer (1992) showed that science-related experiences outside of the classroom can increase the teacher efficacy of preservice science educators. Johnston (2003) documented an increase in teacher efficacy scores of preservice science teachers after active learning experiences in a science course. The process by which preservice teachers develop and maintain a high level of teacher efficacy may be different than the process for in-service teachers.

Duran and Duran (2005) demonstrated that in-service science teacher efficacy scores could be increased through professional development emphasizing collaboration and inquiry learning. Duran and Duran examined the teacher efficacy of early childhood educators before and after a year-long professional development program during which teachers created and implemented an inquiry-based science unit in their classrooms. The year-long experience had a significantly positive effect on the participants' teacher efficacy, but because only pre- and post-measurements were discussed, little insight was gained into the mechanisms responsible for the observed gains in teacher efficacy. The study reported in this article sought to clarify the process by which high teacher efficacy is created and maintained by examining science teachers' attitudes and beliefs throughout a year-long professional development program.

In this study, changes in teacher efficacy in participants in a year-long, in-service teacher education program were examined. The view of teacher efficacy discussed by Tschannen-Moran et al. (1998) was adopted: teacher efficacy is composed of two related concepts—self-perception of teaching competence (similar to Bandura's 1977 conception of self-efficacy) and beliefs about the teaching context. These two components of teacher efficacy were assessed and analyzed separately so that relationships between the two components of teacher efficacy could be explored.

The Standards-Based Integrated Science Instruction Program

Science educators, classroom teachers, school administrators, scientists, and outreach educators affiliated with a large, midwestern university worked together to develop the Standards-Based Integrated Science Instruction (SISI) program. This program sought to increase science teacher efficacy by

- introducing teachers to the constructivist model of learning;
- modeling inquiry teaching methods;
- improving science content knowledge;
- aiding teachers in the development and use of integrated, standards-aligned science curriculum;
- encouraging teachers to take on active learning roles;
- helping teachers prepare grant applications to fund teaching resources needed;
- providing educational opportunities, along with self-assessment possibilities; and
- providing an atmosphere where instructional related successes and frustrations could be shared.

SISI Program Activities

The SISI program targets in-service, middle-level science teachers (Grades 4–9) in the state of Indiana and includes a two-week summer workshop during which the participants use science content and processes to solve a fictional crime. Participants work in small groups to scientifically analyze evidence as it pertains to an individual suspect. The evidence is then presented and explained during an activity in which participants hold a trial for each fictional suspect. During this time, participants are learning new science content and process skills to use and apply in their classroom. SISI staff members include master middle-level science teachers, scientists, science outreach specialists, and science educators. Staff members model constructivist-teaching methods and encourage inquiry learning throughout the program. Participants discover integrated science concepts while actively participating in activities that are problem focused and encourage the development and use of critical thinking skills. Participants then design a science unit for their classrooms that addresses the Indiana and National Science Education standards while incorporating inquiry-based learning. The participating teachers work throughout the following school year to successfully implement this science unit in their classrooms. SISI staff members are available for support via e-mail, telephone, or in person.

Participants return for a one-day meeting in October during which they update their peers on the progress of their science unit's implementation. The teachers also participate in a half-day, inquiry-based science activity to refresh and reinforce their knowledge of constructivist pedagogy and inquiry teaching methods. The results of their implementation are presented at the Hoosier Association of Science Teachers' meeting in the spring. In addition to the program's focus on increasing inquiry knowledge for teachers and inquiry-based teaching in classrooms, the SISI program emphasizes the importance of grant writing skills, leadership skills, and teacher collaboration for the effective integration of inquiry-based science into the curricula.

The SISI Program's Role in Creating Teacher Efficacy

Tschannen-Moran et al. (1998) represented the development of teacher efficacy as a cyclical process. Teachers' experiences serve as sources of data that are then used by the teacher to create his or her perception of the influence of both internal and external factors on their ability to teach successfully. Bandura (1977) categorized four types of teacher experiences that play a role in the formation of teacher efficacy:

- mastery experience;
- physiological arousal;
- vicarious experience; and
- verbal persuasion.

> *The development of teacher efficacy is an iterative process occurring on multiple scales.*

Positive experiences of these types generally contribute to the formation of high teacher efficacy, whereas negative experiences generally contribute to the formation of low teacher efficacy. Before affecting efficacy, however, these experiences are cognitively processed by the teacher. The processing of the experience—not the experience itself—ultimately contributes to the creation of teacher efficacy. Therefore, what is seen as a failing experience by others may be assessed by the teacher as a positive learning experience. In these instances, both existing teacher efficacy and attitude play a role in the development and maintenance of higher teacher efficacy scores. The SISI program strove to provide teachers with experiences that contribute positively to teacher efficacy. Experiences in all four domains described by Bandura (1977) were provided for the teachers during the year-long program.

Mastery experience. Opportunities are provided for teachers to master science content knowledge and process skills, constructivist pedagogy and inquiry-based teaching knowledge, and the application of this knowledge and these skills to the education of children in their school. During the two-week summer portion of the program, participants demonstrated mastery of the science concepts covered and critical thinking skills by using their knowledge to solve a crime. Participants displayed their mastery of the science concepts by clearly communicating both the science and the reasoning behind their decisions during the trial. At the culmination of the summer session and at each subsequent group meeting, participants gave presentations detailing their plans for incorporating inquiry-based learning into their classroom. These experiences provided them with valuable opportunities to display their mastery of constructivist pedagogy and inquiry-based teaching knowledge. During the course of the professional development year, participants implemented the inquiry-based unit in their home school. This teaching experience provided them with information about their mastery of teaching inquiry-based science.

Physiological arousal. Bandura (1977, 198) stated, "Stressful and taxing situations generally elicit emotional arousal that, depending on the circumstances, might have informative value concerning personal competency." Opportunities to acknowledge stressful situations and develop techniques to manage or use stress to one's advantage provide important information for developing teacher efficacy. The summer portion of the SISI program provided participants opportunities to acknowledge and manage stress in a supportive environment by challenging them to reach beyond their comfort zone. Participants were challenged to master many science concepts, teaching skills, leadership skills, and communication skills in a short amount of time. They were then challenged to use these skills to change their teaching methods and behaviors. Throughout the year-long program, participants were given opportunities to recognize, attribute, and develop techniques for managing stress in an environment full of enthusiasm and excitement for science content and for teaching science. By dealing with stress in a positive environment, participants were encouraged to process physiological arousal in a manner that developed high teacher efficacy.

Vicarious experience. The SISI program attempted to provide numerous opportunities for participants to view model teachers. While participating teachers were learning new science concepts, SISI staff members modeled inquiry-based teaching. The participants had the opportunity to observe model teachers from a new perspective. Previous SISI participants who have been successful in teaching inquiry-based science act as mentors to current participants.

Verbal persuasion. SISI staff members not only provided participants with the physical and mental resources needed to successfully teach inquiry-based science, but they also gave the emotional support, feedback, and encouragement that is necessary for success. SISI staff members and participants created a large support network for each individual teacher that could be tapped for advice, moral support, and enthusiasm.

Participants

Applicants to the SISI program were required to submit an application that included a curriculum vita, a statement describing their interest in the SISI program, and a letter of support from their school administrator. All applicants were screened based on:

- grade level they teach (fourth grade through ninth grade is the focus);
- subject(s) taught (preference is given to science teaching);
- stated goals and objectives (i.e., do they have a clear goal and plans for integrating the information and techniques learned during SISI into their classroom);
- enthusiasm;
- leadership potential; and
- administrative support.

SISI staff members also attempt to maximize the diversity of participants and the number of different Indiana communities represented by SISI participants. All applicants were independently assessed by at least three staff members. Individual assessments were combined to determine the top candidates for selection to the program.

The SISI program enrolls 30 participants per year. During the year studied, the majority of the participants were science teachers (76 percent), with 10 percent classifying themselves as science / mathematics teachers and 10 percent as "other." The SISI program is designed for middle level (Grades 4–9) science teachers. Thirty-seven percent of the participants had taught for more than 15 years, 13 percent had taught for 11–15 years, and 23 percent had taught for 6–10 years. Twenty-four percent of the participants had taught for five years or less, and 37 percent had been teaching their current subject for five years or less.

Instruments

Three quantitative instruments were used in this study to obtain information on different aspects of teacher efficacy. The Science Teacher Efficacy Belief Scale was adapted from the Teacher Self-Efficacy Scale developed by Friedman and Kass (2002) to measure teachers' beliefs about and confidence in their teaching ability (beliefs about internal factors impacting successful teaching). Teachers' beliefs about the necessity and availability of teaching resources (beliefs about external factors impacting successful teaching) were measured by the Beliefs About the Science Teaching Context instrument. This instrument was developed by Lumpe, Haney, and Czerniak (2000) to measure science teachers' beliefs about environmental factors that influence their teaching. The Attitudes Toward Teaching and Teaching Science (Bratt 1973) instrument was used to assess the attitudes of teachers as they develop science teacher efficacy. The inclusion of attitude assessment is important to fully understanding the development of teacher efficacy because attitudes often affect the way teachers process information from

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their experiences.

Science Teacher Efficacy Belief Scale. The Science Teacher Efficacy Belief Scale (adapted from Friedman and Kass 2002) was used to measure teachers' perceptions of their abilities to organize, execute, and perform in their science and math teaching. This instrument is a seven-item measure that asks participants to rate each statement (e.g., "I see myself as an interesting and motivating science and/or math teacher.") on a 6-point Likert scale ranging from 1 (never) to 6 (always). Five of the seven items from the efficacy scale developed by Friedman and Kass were used. Two additional items were added to assess teachers' beliefs about their influence on students' academic achievement. Reliability statistics for the seven-item scale derived from pre- and posttest measurements ranged from .68 to .76. This instrument was administered four times during the SISI program.

Beliefs About the Science Teaching Context. The Beliefs About the Science Teaching Context instrument (adopted from Lumpe et al. 2000) was administered to assess participants' perceptions of the influence of external factors on their teaching as they implemented the standards-based science unit created during the summer portion of the program in their classrooms. The instrument lists external factors that may influence the participants' success in teaching the new unit and asks for them to rate the degree to which each factor would enable them to teach successfully and the degree to which that factor would be present during their teaching experience.

Participants were asked to rate the enabling ability of each external factor such as support from other teachers, including coaching, advice, mentoring, modeling, and informal discussions, on a five-point scale ranging from 1 (strongly agree) to 5 (strongly disagree) and the perceived availability of the factor on a 5-point scale ranging from 1 (very likely to occur) to 5 (very unlikely to occur). This measure was administered three times during the professional development year to assess the barriers that participants encountered throughout the professional development process. The measure was not administered prior to the first SISI meeting (pre-summer session) because it was specific to factors affecting participants' ability to successfully apply new skills learned during the SISI program. Reliabilities for the beliefs and barriers subscales ranged from .83 to .89 at pre- and posttest intervals. Construct validity for this instrument was established by Lumpe et al. (2000) during its development.

Attitudes Toward Teaching and Teaching Science. The Attitudes Toward Teaching and Teaching Science instrument (Bratt 1973) is a 60-item scale that assesses individuals' attitudes toward teaching and teaching science and beliefs about how science should be taught. Participants are asked to rate each statement (e.g., "One fact children should learn is that the air is approximately 20 percent oxygen.") on a four-point scale ranging from 1 (if you agree strongly) to 4 (if you disagree strongly). There are 12 subscales for this measure:

1. The idea of teaching science is attractive to me; I understand science and can teach it.
2. I do not like the thought of teaching science.
3. There are certain processes in science that children should know.
4. There are certain facts in science that children should know.
5. Science teaching should be guiding or facilitating learning.

6. Science teaching should be a matter of telling students what they are to learn.
7. In education and teaching, the needs of the students and teacher should be more important than the subject matter.
8. In education and teaching, covering the subject matter should be more important than the needs of the students.
9. Educational programs should find students and teachers working together so that both learn something.
10. Teachers should be the authority in the classroom. They ought to be there to teach and the students should be there to learn from them.
11. Students and teachers alike are responsible for the learning that takes place in the classroom. Students should have as much to say about their learning activities and evaluations as the teachers.
12. The teacher should be the sole determiner of the activities. They should plan and evaluate each day's work.

The preceding subscales represent attitudes toward science and science teaching. The odd-numbered subscales represent positive attitudes toward science teaching; the even-numbered subscales represent negative attitudes.

Overall reliability statistics for the measure at pre- and posttest ranged from .74 to .85 in this study. The instrument's author (Bratt 1973) performed test-retest reliability while developing the instrument and found the overall reliability to be .87. A factor analysis was performed by Bratt that validated eight of the instrument's 12 subscales. This instrument was administered four times during the SISI program.

Data Collection

When participants arrived on site for the summer portion of the program, they completed the Science Teacher Efficacy Belief Scale and the Attitudes Toward Teaching and Teaching Science instruments. These two instruments and the Beliefs About the Science Teaching Context instrument were administered at the conclusion of the summer portion of the program and during the fall and spring meetings. Table 1 displays the schedule of the measures administered during the year-long SISI program.

Data Analysis

Paired t-tests were performed to test the significance of changes in attitude and teacher efficacy between each measurement point. Pearson correlation coefficients were then calculated to show relationships among changes in the three measured variables. Table 2 includes statistics for the three instruments used. Calculations for the paired t-tests are discussed in the text that follows.

Paired t-Tests

Science Teacher Efficacy Belief Scale. The data indicated that the participants' level of science teacher efficacy increased significantly during the SISI program, $t(24) = -4.10$, $p < .001$. All measurements after the beginning of the program (post-summer program, fall meeting, spring meeting) showed that participants were significantly higher in science teacher efficacy ($p < .05$) than before attending the summer session (Table 2). The largest

Table 1. Description of Instruments

Measure	Summer Program Pre	Summer Program Post	Fall Meeting	Spring Meeting	Focus of Measure	Major Findings
Assessment Strategies and Major Findings						
Science Teacher Efficacy Belief Scale	X	X	X	X	Confidence in ability to effectively teach science and mathematics, adapt to new and challenging situations, and get positive teaching results.	Significant increase after the first segment of the program followed by decrease during the middle of the program and a rebound at the end of the program.
Beliefs About the Science Teaching Context		X	X	X	Belief in the enabling power of external factors and the perception of the availability of these enabling factors in the school environment.	After implementing inquiry in the classroom, perceived barriers to the teaching of inquiry science decreased and belief in the enabling power of external factors decreased. Perception of availability of external factors was unchanged.
Attitudes Toward Teaching and Teaching Science	X	X	X	X	Attitudes toward teaching and teaching science and beliefs about how science should be taught.	Large increase after the first segment of the program followed by steady decline back to pre-program levels.

jump in science teacher efficacy was during the period from the pre-summer to post-summer program. High science teacher efficacy levels were maintained after the end of the summer session through the spring meeting (Figure 1 on p. 56).

Beliefs About the Science Teaching Context. Teachers' perceived barriers were calculated by summing the two subscales of the measure (the perceived enabling power of external factors and the perceived availability of external factors). The enabling power subscale was scored so that a strongly enabling factor was scored high (5). The availability subscale was scored so that a very unavailable factor was scored high (5). Therefore, a factor perceived as enabling, but not available, had a high total score. A high total score indicated that the factor was perceived as a barrier to effective science teaching. Perceived barriers were unchanged from the end of the summer institute to the fall meeting and decreased significantly between the fall meeting and spring meeting (see Table 2), $t(18) = 4.553$, $p < .001$. Figure 2 on p. 58 displays the decrease in teachers' perceived barriers

Table 2. Attitudes, Efficacy, and Context Beliefs: Mean Scores and Standard Deviations.

Quantitative Data Collected during the SISI Program

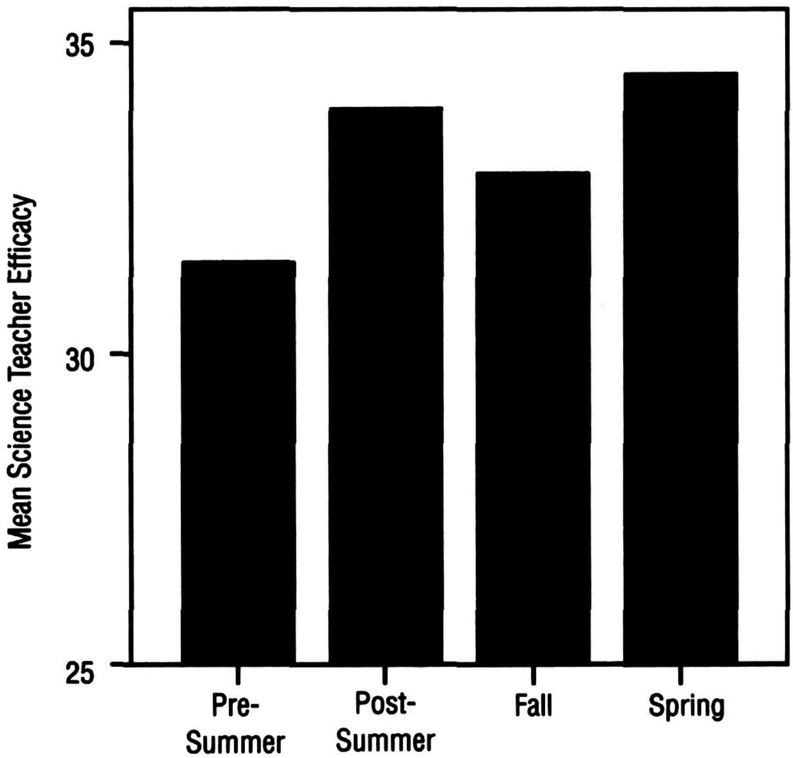
Measure	Summer Program						Fall Meeting			Spring Meeting		
	Pre			Post								
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Science Teacher Efficacy Belief Scale	27	31.67	2.73	27	34.52*	3.37	26	33.46*	4.01	25	34.60*‡	3.35
Beliefs About the Science Teaching Context				26	178.13	19.02	29	181.53	14.82	25	166.93*‡	15.00
Attitudes Toward Teaching and Teaching Science	30	122.83	14.15	30	136.10*	11.19	27	132.18*	12.91	29	129.45	16.94

*Change from the previous time of measurement is significant at the $p < .05$ level.
‡Net change over the entire SISI program is significant at the $p < .05$ level.

to successful teaching during the school year. As the mean score increased, participants' perceived barriers decreased. Figure 2 on p. 58 shows that between the fall and spring meetings, participants' perception of barriers to successful teaching declined. Perceived barriers are composed of the perceived enabling power of a factor and its availability—a factor that is perceived as highly enabling, but not available, scores high as a barrier. Participants' beliefs about the availability of external factors or resources stayed constant throughout the SISI program. Their beliefs in the enabling power of those factors declined significantly after the fall meeting, $t(25) = 4.037$, $p < .001$. This contributed to the decline in perceived barriers during the SISI program.

Attitudes Toward Teaching and Teaching Science. Participants showed a significant increase in positive attitude at the end of the summer session, $t(29) = -5.29$, $p < .001$. Table 2 displays the mean and standard deviation of participants' attitudes throughout the program. Increased scores indicate increased positive attitude toward teaching science. A small but significant drop in attitude was observed between the end of the summer session and the fall meeting, $t(26) = 2.09$, $p < .05$ (Figure 3 on p. 59). The decline in positive attitude after the summer session negated any overall impacts of the program. The mean total attitude scores were not significantly different at the spring meeting compared to the scores prior to the summer session.

Figure 1. Participant science teacher efficacy (internal factors) throughout the SISI program.



Pearson Correlations

Table 3 displays the Pearson correlation coefficients for the changes in efficacy, context beliefs, and attitudes between the three points at which all three variables were measured. Changes in efficacy are positively correlated with changes in attitude between the end of the summer session and the fall meeting ($r = .428, p = .033$). However, changes in attitudes are not significantly correlated with context beliefs. Changes in efficacy during the period from summer to fall were negatively correlated with changes in efficacy from fall to spring ($r = -.453, p = .026$).

Discussion

The goal of the study described in this article was to examine changes in participants' science teacher efficacy and their attitudes toward science throughout a year-long professional development program. Though research has succeeded in delineating the attributes of highly efficacious teachers, the mechanisms by which teachers acquire or improve their teacher efficacy are still unclear. The model of teacher efficacy proposed by Tschannen-Moran et al. (1998) represented the formation of teacher efficacy as a cycle in which teachers glean information from experiences, process this information, and use it as a basis to assess the influence of both internal and external factors on their ability to teach successfully. Self-perception of teacher efficacy has consequences for motivation, planning, persistence, enthusiasm, and effort toward teaching. The development of teacher efficacy is,

Table 3. Pearson Correlation Coefficients

Summer–Fall		Efficacy Summer–Fall	Attitudes Summer–Fall	Context Beliefs Summer–Fall	Efficacy Fall–Spring	Attitudes Fall–Spring	Context Beliefs Fall–Spring
Efficacy	Pearson Correlation	1	.428*	.030	−.453*	−.006	.096
	Sig. (two-tailed)	—	.033	.890	.026	.979	.662
	n	26	25	24	24	24	23
Attitudes	Pearson correlation	.428*	1	.129	.148	−.134	−.214
	Sig. (two-tailed)	.033	—	.528	.489	.513	.303
	n	25	27	26	24	26	25
Context beliefs	Pearson correlation	.030	.129	1	.024	.085	.166
	Sig. (two-tailed)	.890	.528	—	.915	.688	.428
	n	24	26	26	23	25	25

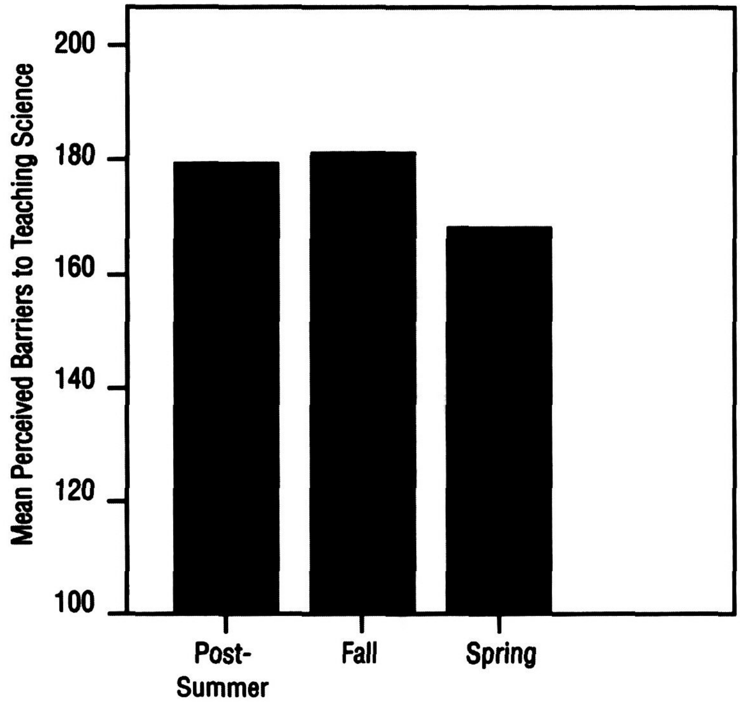
**Correlation is significant at the 0.05 level (2-tailed).*

therefore, an iterative process occurring on multiple scales—one cycle may take a few days, whereas another may take an entire year. Examinations of teacher efficacy and changes in teacher efficacy have focused on a linear view of the formation of efficacy—measuring it at the beginning and end of the professional development process. This view does not allow for insight into the complex process of the formation of teacher efficacy during professional development experiences. This study attempted to examine teacher efficacy and teachers' attitudes at multiple points in the professional development process to provide insight into the process of teacher efficacy formation rather than the end result.

Science Teacher Efficacy Belief

Teachers' perceptions of their internal abilities to teach successfully as measured by the Science Teacher Efficacy Belief Scale increased twice and declined once during the year-long program. The first increase in positive perceptions occurred at the end of the summer program and corresponded to a large increase in positive attitudes toward teaching. The second increase occurred between the fall and spring meetings and corresponded to a slight, but not statistically significant, decrease in positive attitudes toward teaching. The decline in teachers' perceptions of their internal abilities to teach successfully occurred between the end of the summer program and the fall meeting and corresponded to a slight, but not statistically significant, decline in attitudes toward teaching. The fact that the largest jump in efficacy was accompanied by a significant increase in attitudes highlights the role that teachers' attitudes toward teaching may have on efficacy development. However, this occasion was the only time when statistically significant increases in efficacy corresponded with statistically significant increases in attitude. The two other efficacy changes occurred during times of statistically constant attitude.

Figure 2. Participant beliefs about the science teaching context (external factors) throughout the SISI program.

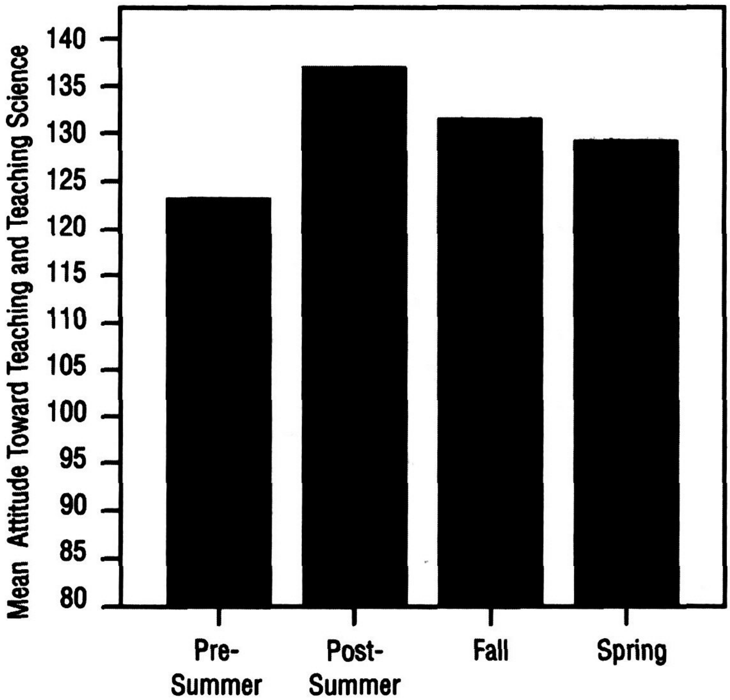


Beliefs About the Science Teaching Context

Perceived barriers to effectively teaching science were largely unchanged from the end of the summer program to the fall meeting and decreased significantly during the time between the fall and spring meetings. This change was due to a decline in participants' belief in the enabling power of external factors, rather than an increase in their perception of the availability of teaching resources. Teachers' perceptions about external factors changed only after they had implemented the new teaching methods in their classrooms. This may indicate that mastery experience has an effect on how teachers perceive their teaching environment. In this case, however, teachers' reliance on outside factors to assist them in their teaching decreased.

The number of factors perceived as barriers by the teachers decreased between the fall and spring meetings, leaving only three barriers. The impediments were course teaching load, requirement to cover a large amount of content, and class size. Though belief in the enabling power of external factors decreased over the year-long program, the three persisting barriers did not follow this pattern. Belief in the enabling power of a smaller course teaching load, reduction in the amount of content that is required to be covered, and smaller class size remained the same, whereas the perceived likelihood of these things occurring increased. More investigation of the individual factors or groups of factors is needed to understand why teachers perceived them differently.

Figure 3. Participant attitudes toward teaching and teaching science throughout the SISI program.



Attitudes Toward Teaching and Teaching Science

The overall importance of assessing participants' attitudes was to measure the impact of the SISI program on attitude change and development. As previously discussed, participants experienced a significant positive increase in their attitude toward teaching science at the end of the summer session, followed by a decline in attitude that negated the previous gain (see Table 2 and Figure 3). The significant drop in attitude could be attributed to a number of factors, such as an emotional high at the completion of the two-week session or a feeling of stress as the school year began and implementation projects got underway. More investigation is needed to determine what was behind the decline back to pre-SISI attitude levels.

Relationships Between Efficacy, Context Beliefs, and Attitudes

During the year-long program, changes in attitudes toward teaching science and science teacher efficacy beliefs were correlated only during the time period between the end of the summer program and the fall meeting. During this time, participants were getting ready for the school year and preparing to integrate new skills and ideas learned during the summer session into their science curriculum. Both attitudes and efficacy exhibited negative mean changes during this time. The changing role of attitudes in the development of a teacher's confidence in his or her assessment of internal abilities to teach successfully may be attributed to the types of experiences on which teachers can draw. During the summer session, teachers experienced mastery, persuasive, vicarious, and physiologically arousing experiences. As the program continued, most of the experiences that required the involvement of others (vicarious and persuasive) were not present. Between meetings, teachers returned to their individual schools and had relatively little contact with SISI staff members or fellow participants. Confidence from vicarious experiences, verbal persuasion, and physiological arousal that occurred during the summer portion of the program was quick to fade. By the end of the program, however, the teachers had encountered mastery experiences that may have led to an increase in perceived efficacy.

Computation of Pearson correlation coefficients indicated that changes in efficacy between the summer and fall meetings were negatively correlated with changes in efficacy between the fall and spring meetings. This result indicates that a possible periodic model of efficacy could be created. Figure 1 shows that perceived efficacy increased during the two-week summer portion of the program, declined between the end of the summer program and the fall meeting, and increased again during the fall and spring meetings. Participants whose perceived efficacy decreased between the summer and fall meetings experienced an increase in perceived efficacy between the fall and spring meetings. This change could be the result of teachers' tendencies to underestimate their abilities while preparing for the school year (corresponding to a decrease in perceived efficacy) and, subsequently, finding that the act of integrating their new knowledge was not as difficult as they had expected (leading to a rebound in perceived efficacy).

It is interesting to note that the context beliefs of participants were not correlated with any other variables. In the integrated model of teacher efficacy used in this study, context beliefs were expected to correlate with both perceived efficacy and attitudes toward teaching science. Two factors comprised the scale used to measure science teaching context beliefs in this study. Only one of these factors—the belief in the enabling power of resources—showed any significant changes during the year-long program. This may indicate that these two factors need to be examined separately in future studies.

Suggestions for Further Research

The concept of teacher efficacy was described previously as both teachers' beliefs about and confidence in their teaching ability (beliefs about internal factors) and their beliefs about the necessity and availability of teaching resources (beliefs about external factors). The results of this study point to a significant role for mastery experiences in the development of science teacher efficacy. As a result of mastery experiences, teachers' confidence in their teaching ability improved significantly. This positive result was not immediate, however. Participants struggled when first confronted with their teaching tasks. As they returned to their schools, confidence in their internal ability to teach successfully and their attitude toward teaching and teaching science dropped significantly. As they completed their teaching tasks, however, confidence in their abilities increased and the perceived need for help from external factors decreased significantly. A more in-depth case study approach may be necessary to fully understand the dynamics of this process. In addition, more complex statistical analyses of the individual external factors or groups of similar factors are needed to better understand how teachers' perceptions of different types of factors change while they undergo professional development.

Meaningful relationships among attitudes toward teaching and teaching science, confidence in teaching abilities, and types of available experiences were observed. Large increases in attitude and confidence in teaching ability corresponded to the availability of experiences during the summer portion of the program. Confidence changes without accompanying significant attitude changes corresponded to those times when mastery experiences and physiological arousal were more available and vicarious and persuasion experiences were less available. This study could examine only those experiences that were part of the SISI program. A case-study approach would be necessary to examine a broader range of teacher experiences. Deeper understanding of the relationships among confidence in teaching ability, beliefs about the necessity of external factors to assist in teaching, and attitudes toward teaching will require more powerful statistical analyses than those employed in this study. Structural equation modeling would be a good tool for exploring these relationships in greater detail.

The development of science teacher efficacy by SISI participants was a dynamic process involving changes in both attitudes and beliefs as a result of teacher participation in a wide range of mastery, vicarious, persuasive, and physiologically arousing experiences. An integrated model of teacher efficacy is essential for capturing the complex relationships among the attitudes and beliefs of teachers about their teaching abilities and teaching environment.

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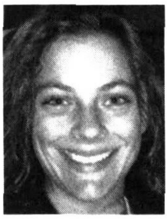

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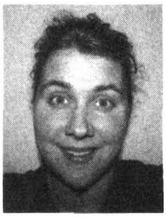

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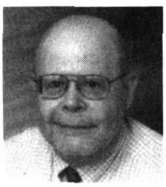

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