# Cooperative Learning and Preservice Elementary Teacher Science Self-Efficacy

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## Introduction

In the elementary school setting, a negative teacher attitude can result in little time allotted for science and in poor instruction of the subject (Riggs, 1989; Sunal, 1980a, b; Wilson & Scharmann, 1994). Of greater concern, however, is that of the teacher's attitude affecting students' attitudes (Cannon & Scharmann, 1994; Koballa & Crawley, 1985; Markle, 1978). Koballa and Crawley (1985) found that teachers' subject preference and the time devoted to teaching the preferred subject was positively related to student attitude toward that subject. Furthermore, they commented that preservice teachers often bring their positive or negative attitude toward a subject to their first teaching assignment. Therefore, one goal of an undergraduate science education program should be the development of positive attitudes toward science and science teaching (Gabel, Rubba, & Franz, 1977; Ginns & Foster, 1983; Weaver, Hounshell, & Coble, 1979).

Researchers have investigated a variety of factors that contribute to the effectiveness of the individual classroom teacher (i.e., learning style, wait time, student-centered instruction, etc.). Many of these factors, however, are not universal predictors of beginning teacher success or failure. More recently, one prominent factor related to attitude has been cited often as a consistent predictor of teacher success--teacher self-efficacy.

Self-efficacy is a teacher's belief about her or his own abilities to teach effectively. Indeed, one researcher (Ashton, 1984) commented that "no other teacher characteristic has demonstrated such a consistent relationship to student achievement" (p. 28) and continued by stating that "a potentially powerful paradigm for teacher education can be developed on the basis of the construct of teacher efficacy" (p. 28). Self-efficacy, a construct within Bandura's (1977, 1981, 1982) social cognitive theory of behavior and motivation, is the perceived judgment of an individual about his or her capability to perform in a given activity or situation. The second factor affecting behavior, according to Bandura, is an individual's action-outcome expectancy.

Educational researchers have successfully applied Bandura's theory in both preservice and inservice contexts over the past decade (Cannon & Scharmann, 1994; Czerniak & Chiarelott, 1990; Gibson & Dembo, 1984; Lucas, Ginns, Tulip, & Watters, 1993; Riggs, 1989). Gibson and Dembo (1984), as one example, defined teacher self-efficacy as the belief in the teachers' abilities to positively affect students' behaviors and achievements. Using Bandura's two dimensional approach, the outcome expectancy mode is a teacher's anticipation of the results of effective teaching, while the self-efficacy mode is the teacher's confidence in her or his own teaching abilities (Gibson & Dembo, 1984). Thus, teacher efficacy is based both on expecting behavior to produce certain desirable outcomes (outcome expectancy) and on the individual teacher's belief in his or her ability to perform the behaviors (self-efficacy) (Riggs, 1989). Both self-efficacy and outcome expectancy are independent dimensions of teacher efficacy (Hoy & Woolfolk, 1990; Woolfolk & Hoy, 1990).

Developing teacher efficacy should be an important aim of a preservice teacher program (Ashton, 1984). At the preservice level, the science education literature contains a number of strategies that historically have been implemented in order to decrease the anxiety associated with learning and teaching science among elementary education majors, for example: (a) increase the science content preparation, pedagogical preparation, or both; (b) use mastery learning or programmed learning models; or (c) model the teaching of science through the use of science instructional kits.

Each of these approaches has merit, yet none speaks directly to the question of preservice science teacher efficacy. A notable exception, however, has been the application of cooperative learning within elementary science methods experiences (Cannon & Scharmann, 1994). Czerniak and Chiarelott (1990) reported that science anxiety can be decreased by using a variety of

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social arrangements, including cooperative learning, in the classroom. Denham and Michael (1981) noted that one way in which teacher preparation may affect one's sense of efficacy is through the experience of a shared ordeal. Therefore, grouping elementary preservice teachers to work on a common problem/project (a shared ordeal) could reduce science anxiety, maintain motivation (Ashton, 1984), and increase teacher efficacy (Stalheim-Smith & Scharmann, 1994).

Cooperative learning has further been shown to promote more positive attitudes toward a given subject area when it is utilized directly within that subject, especially for diverse (heterogeneous) student groups (Johnson & Johnson, 1991; Jones & Steinbrink, 1989). It has also been specifically noted that heterogeneous cooperative learning groups promote more positive attitudes toward science among female students when utilized within science classes (Johnson, Johnson, Scott, & Ramolae, 1985). Cooperative learning usually consists of heterogeneous groupings of three to five students working together to help one another accomplish assigned tasks. High, average, and low achievers all seem to benefit in cooperative learning situations (Slavin, 1991).

Explicit in much of the cooperative learning literature is a central premise that achievement should be the preferred criterion upon which to form groups (Johnson & Johnson, 1991). Such a position has been promoted especially when cooperative learning has been utilized in specific subject (i.e., science, mathematics, etc.) learning environments. That achievement, however, should be the best criterion in all contexts has received both increasing scrutiny (Czerniak & Chiarelott, 1990; Stalheim-Smith & Scharmann, 1994) and outright criticism (Dillow, Flack, & Peterman, 1994).

## Purpose of the Study

The work of Dillow et al. (1994) suggests that when cooperative learning is used with female learners in middle schools, great care should be exercised in forming groups. It is our opinion that the same advice should be followed in working with preservice elementary teachers; therefore, rather than make use of achievement, we selected science self-efficacy as the basis upon which to form cooperative groups. The primary intent of this study was to examine the influence of grouping, by means of cooperative learning, on elementary preservice teachers' science teaching efficacy. It was hoped that by comparing the pretest and posttest results obtained from a preservice science teaching efficacy belief instrument and qualitative data gained through participant observation, differences might be ascertained among four laboratory sections of an elementary science teaching methods course. The following questions guided the research process:

1. Does matriculation in an elementary science teaching methods course enhance the science self-efficacy or outcome expectancy of preservice elementary teachers?
2. Are there forms of cooperative learning that are more effective in enhancing science self-efficacy or outcome expectancy among preservice elementary teachers?
3. How do various forms of cooperative learning potentially influence preservice elementary teachers' interest/enthusiasm for learning and/or the quality of their teaching of science?

## Methodology

The subjects participating in this study were 84 preservice teachers (74 females; 10 males) enrolled in an elementary science methods course at a large midwestern land grant university. Data were collected over eight weeks of the course, utilizing a pretest-posttest control group experimental research design (Campbell & Stanley, 1963).

### Independent Variable

Each subject was concurrently enrolled in a common lecture and one of four laboratory sections. The lecture, which met for two 1-hour sessions per week, was taught by an experienced science education professor. Each of the four laboratory sections met for two hours each week and were all taught by the same graduate teaching assistant (GTA). The scope and sequence of instruction used for the laboratory sessions were designed by the science education professor to reflect a learning cycle instructional approach (Lawson, Abraham, & Renner, 1989). The instructional episodes were activity-based and hands-on and utilized a cooperative learning format advocated by Jones (1985). Treatment conditions were randomly assigned to each laboratory section. Two of the four sections were randomly assigned to be the experimental groups, while the remaining two sections were used as comparison groups. The type of grouping each section received served as levels of the independent variable. Grouping was accomplished within each of the laboratory sections during the second meeting of the laboratory portion of the course.

### Dependent Variables

Scores obtained from the pretest and posttest administrations of the *Science Teaching Efficacy Belief Instrument* (STEBI-B) (described below), a Likert-type instrument developed by Enochs and Riggs (1990) which measures preservice science teaching efficacy beliefs, provided the quantitative portion of the data. Qualitative data consisted of the collection of extensive field notes which were acquired through participant observation during eight weeks of science teaching methods laboratory sessions.

To measure science teaching efficacy, Riggs (1989) developed an instrument entitled the *Science Teaching Efficacy Belief Instrument* (STEBI-A). This initial version was constructed and validated for use with inservice teachers. A revision of the STEBI-A instrument resulted in the production of the STEBI-B, which is intended for use with preservice elementary teachers (Enochs & Riggs, 1990; Riggs & Enochs, 1990) and is used in this study.

The STEBI-B consists of 23 statements which yield two subscale scores. Embedded randomly within these 23 statements, 10 items comprise the Outcomes Expectancy Subscale (OE; range of scores = 10-50) and 13 items comprise the Personal Efficacy Subscale (PE; range of scores = 13-65). Each of the 23 statements uses a 5-point Likert-type scale which asks respondents to select, for each statement, one of the following--Strongly Agree, Agree, Uncertain, Disagree, or Strongly Disagree. Scoring is accomplished by assigning a 5 to positively worded items receiving a Strongly Agree response down to a 1 for Strongly Disagree response. Negatively worded phrases require that scores be reversed. Previous work with 208 preservice elementary teachers established reliability coefficients of 0.90 and 0.79 respectively for the PE and OE subscales of the *Science Teaching Efficacy Belief Instrument*. Validity was determined by way of factor analysis. A more comprehensive delineation of the reliability and validity of the STEBI-B can be found in Riggs and Enochs (1990) and Enochs and Riggs (1990).

### Procedures

All 84 subjects were asked to respond to the 23-statement STEBI-B during the first laboratory session of the semester. Based on these scores, cooperative learning groups for the two experimental sections were formed by the lecture professor, acting as a third party. Each experimental section consisted of one high-scoring, one low-scoring, and one or two moderate-scoring individuals, resulting in the formation of heterogenous cooperative learning groups. Cooperative learning groups were also formed in the two remaining laboratory sections serving as comparison groups. In one section, cooperative groups were formed by a random draw, while in the other section, subjects were permitted to self-select their cooperative groups. Each cooperative learning group had at least three members and no group had more than five. The majority of the groups contained four members.

A participant observation approach was used to obtain data for the qualitative portion of this study. Since one of the investigators was unaware of which of the laboratory sections were assigned to what cooperative learning treatment condition, this investigator was able to serve in the participant observer capacity. Weekly observations of planned laboratory activities were conducted for six weeks and included taking extensive notes related to the following variables: (a) number of members within cooperative groups that were involved in laboratory activities, (b) identification of group leader(s) and a science resource individual(s), (c) level of interest/enthusiasm displayed, and (d) use/transfer of science knowledge covered in lecture. In addition, a subsequent two weeks of observation were conducted as each of the cooperative groups prepared and taught a peer lesson. Observational notes that were recorded for peer lessons included: (a) identification of a key instructional leader(s), (b) identification of a science resource person(s), (c) level of pre-planning and rehearsal performed, (d) lesson flow, (e) accuracy of science concepts introduced in the lesson, (f) organization and management of materials, and (g) overall quality of the lesson presentation.

Upon the completion of the combined eight weeks of laboratory sessions and peer presentations, field notes were analyzed and quantified. Independent scores were determined for the laboratory sessions and peer presentation of each cooperative learning group in each treatment condition. A further analysis of all observational data variables resulted in the assignment of a single point value for both the overall level of interest/enthusiasm exhibited during the six laboratory sessions and the overall quality of the peer teaching presentation performed by each cooperative learning group. Six points were awarded for an excellent rating down to one point for a poor rating. Because the unit of analysis is laboratory section (i.e., as intact groups), an average rating was then calculated for each section on the two focal variables: (a) inte⁻⁼st/enthusiasm and (b) peer instructional performance. To assure the reliability of the participant observer ratings, the GTA was requested to independently assess two cooperative groups randomly selected from each laboratory section. When these independent assessments were compared (+/- 1 rating point), there was 100% agreement on the rating of peer presentation quality and 87.5% agreement on the level of interest/enthusiasm exhibited (i.e., seven of eight cooperative groups were consistently rated within one rating point by the GTA and participant observer).

## Results

Likert-type scales, and the totals that result from the administration of them, yield (at best) ordinal level data. Therefore, a more liberal and/or robust parametric analysis is inadvisable even if all other parameters (i.e., normally distributed, random assignment, homogeneity of variance, etc.) for using such statistical procedures can be met or justified. Thus, a more conservative nonparametric approach was adopted to analyze the quantitative data obtained in this study.

After random assignment of the treatment conditions occurred and pretest STEBI-B scores were obtained, a median test was conducted to assess whether the four laboratory sections were equivalent. The median test resulted in a nonsignificant statistic for both the PE ($\chi^2 = 2.77$; $p = 0.43$; $df = 3$) and the OE ($\chi^2 = 4.01$; $p = 0.26$; $df = 3$) STEBI-B subscales, which indicates that all four sections were equivalent at the outset of the study for both the PE and OE measures. Internal consistency reliability, as measured by Chronbach's alpha, was determined for the current population to be 0.84 and 0.73 for the PE and OE subscales respectively. Although marginally less than those reported by the instrument developers (Enochs & Riggs, 1990), these values are still credible. The mean, standard deviation, and median for pretest and posttest PE and OE scores for all laboratory sections are reported in Table 1.

### Self-Efficacy and Outcome Expectancy

Before considering the influence of the independent variable, which consisted of the different forms of cooperative learning employed, it was desirable to determine if enrollment in an elementary science teaching methods course had a positive influence in either the enhancement of science self-efficacy and/or outcome expectancy. In each case, a nonparametric sign test was employed. The results of both of these tests yielded

**Table 1**

*Pretest and Posttest Science Self-Efficacy and Outcome Expectancy Scores by Laboratory Section*

| | | A | | B | | C | | D | |
|---|---|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post | Pre | Post |
| Science | Median | 49.5 | 51.0 | 48.0 | 50.0 | 48.0 | 49.0 | 44.0 | 48.0 |
| Self- | Mean | 49.1 | 50.9 | 45.8 | 49.8 | 47.2 | 47.3 | 45.5 | 47.9 |
| Efficacy | SD | 4.8 | 5.1 | 6.2 | 4.9 | 5.2 | 5.8 | 6.0 | 5.6 |
| Outcome | Median | 37.0 | 37.0 | 37.0 | 37.0 | 36.0 | 37.0 | 36.0 | 37.0 |
| Expectancy | Mean | 36.3 | 37.0 | 36.9 | 36.5 | 36.0 | 36.8 | 35.3 | 37.1 |
| | SD | 3.1 | 3.4 | 3.8 | 3.9 | 2.8 | 4.5 | 4.3 | 3.2 |

Legend: A = Heterogeneous experimental group 1
B = Heterogeneous experimental group 2
C = Random assignment comparison group 1
D = Self-selected comparison group 2

significant statistical outcomes.

The change in subjects' science self-efficacy and outcome expectancy over the eight weeks of this study are reported in Tables 2 and 3 respectively. That such findings resulted in statistical significance might be too easily dismissed as providing evidence for the obvious conclusion that, indeed, formal education should make a difference; however, given the vast historical evidence of elementary teacher avoidance of science, any statistically significant evidence related to elementary teacher confidence where science and science teaching are concerned should not be minimized.

**Table 2**

*Changes in Science Self-Efficacy Among All Laboratory Sections*

| N | Negative | Positive | Ties | Z |
|---|---|---|---|---|
| 84 | 20 | 54 | 10 | 3.84** |

$p < 0.001$

**Table 3**

*Changes in Outcome Expectancy Among All Laboratory Sections*

| N | Negative | Positive | Ties | Z |
|---|---|---|---|---|
| 84 | 28 | 47 | 9 | 2.08* |

$p < 0.05$

## Cooperative Learning

Three forms of cooperative learning served as levels of the independent variable under examination in this investigation: (a) heterogeneous (designated as experimental groups), (b) random (comparison group), and (c) self-selected (comparison group). The educational research literature suggests that heterogeneous cooperative groups should be most effective (Johnson & Johnson, 1991; Jones & Steinbrink, 1989; Slavin, 1991). To test this assumption, a Kruskal-Wallis test of variation in ranks was conducted using posttest STEBI-B scores for self-efficacy and outcome expectancy. Data analysis for differences between the experimental and comparison laboratory sections indicate that no form of cooperative learning was superior to another in enhancing science self-efficacy or outcome expectancy. These results are summarized in Tables 4 and 5.

**Table 4**

*Posttest Personal Science Teaching Self-Efficacy Mean Ranks by Laboratory Section*

| Section | Cases | Mean Rank | $X^2$ |
|---|---|---|---|
| A | 18 | 51.22 | 4.55 |
| B | 23 | 45.30 | |
| C | 23 | 37.04 | (ns) |
| D | 20 | 37.70 | |
| Total | 84 | | |

Legend: A = Heterogeneous experimental group 1
B = Heterogeneous experimental group 2
C = Random assignment comparison group 1
D = Self-selected comparison group 2

**Table 5**

*Posttest Outcome Expectancy Mean Ranks by Laboratory Section*

| Section | Cases | Mean Rank | $X^2$ |
|---|---|---|---|
| A | 18 | 42.92 | 1.01 |
| B | 23 | 44.80 | |
| C | 23 | 38.30 | (ns) |
| D | 20 | 44.30 | |
| Total | 84 | | |

Legend: A = Heterogeneous experimental group 1
B = Heterogeneous experimental group 2
C = Random assignment comparison group 1
D = Self-selected comparison group 2

### Interest/Enthusiasm and Quality of Teaching Science

The qualitative observational field notes were reduced to single data values, as previously described, for both interest/enthusiasm and quality of overall peer teaching performance. Although this reduction eliminates potential rich description, it can, nonetheless, yield meaningful patterns undiscernible prior to the reduction. In the present study, a superficial reading of the field notes revealed many positive and negative behaviors to remark upon; however, it was only after a reduction (through quantification) was performed that any pattern of differences among laboratory sections began to emerge. Since the investigator serving as participant observer was unaware which laboratory sections were experimental and which were comparison, any conclusions reached about the effectiveness of cooperative groups comprising a given laboratory section (i.e., representing a level of treatment condition) were considered to be credible.

The mean ratings for interest/enthusiasm and for overall quality of peer instructional performance are summarized in Table 6. The mean ratings for both of these variables are higher in both of the experimental sections than for either of the comparison groups. This is especially evident in the case of the quality of peer teaching performance. It should be also noted that the self-selected cooperative groups laboratory section had the lowest mean level of enthusiasm and the poorest overall quality of peer teaching performance.

**Table 6**

*Mean Level of Interest/Enthusiasm and Peer Instructional Performance by Laboratory Section*

| Section | Interest/ Enthusiasm | Instructional Performance |
|---|---|---|
| A | 3.60 | 4.20 |
| B | 3.33 | 5.00 |
| C | 3.17 | 2.86 |
| D | 2.86 | 2.86 |

Legend: A = Heterogeneous experimental group 1
B = Heterogeneous experimental group 2
C = Random assignment comparison group 1
D = Self-selected comparison group 2

### Discussion and Implications

Attempts to identify the cause(s) associated with specific results are often difficult in educational research. In this study, however, a conscious effort to separate the potential influence of cooperative learning forms from the influence of the course itself was made. The fact that the course itself provided sufficient experiences to enhance the development of science teaching self-efficacy is a source of modest satisfaction, especially since the forms of cooperative learning were an integral component of the course. If one examines the main effect of the form of cooperative learning, however, no statistical significance is found. Does this mean that the form of cooperative learning doesn't matter? The answer to this question cannot be found through the use of post hoc statistical procedures, however tempting they may be to employ, because a nonstatistically significant result should prevent looking in this direction in the first place. Instead, the answer needs to be sought through an examination of the qualitative observations undertaken.

If the results reported in Tables 4 and 5 were to have practical consequences rather than statistical meaning, it might appear that letting students select the cooperative learning group they want to work within might not be too detrimental (as opposed to randomly or heterogeneously grouping them). It is also a finding from this investigation that the experimental (heterogeneously formed) cooperative groups had no more statistical significance (despite possessing higher mean ranks) than the comparison forms of cooperative learning in producing enhanced self-efficacy or outcome expectancy. If that finding is valid, then certainly allowing students to choose their own cooperative groups is more convenient than taking the time to group them randomly or on the basis of some artificial construct. Such a conclusion would be inconsistent with both the extant body of literature on cooperative learning and the personal experiences of the lecture professor for this course. Are there other factors operating here that a set of questionnaire scores (such as the STEBI) cannot detect?

The observational data shed some light concerning the practical significance of the form of cooperative learning employed. A thoughtful reaction to the results reported in Table 6 provides evidence that both experimental laboratory sections (heterogeneously formed cooperative groups) exhibited more enthusiasm during the planned laboratory activities and lesson planning sessions, while the comparison sections (especially the self-selected cooperative groups) showed the least. This may be because the preservice teachers felt freer to display their feelings/attitudes with friends in self-selected cooperative groups, while students in the experimental laboratory sections felt more inhibited to do so. Furthermore, when those feelings/attitudes displayed by peers were negative, an impediment to the enhancement of self-efficacy within individual cooperative groups was engendered. To the contrary, which occurred more often in experimental laboratory sections, the tacit inhibition about displaying feelings/attitudes produced less overall group anxiety, which thus resulted in greater opportunities for individual enthusiasm to influence the attitude of the other less efficacious group members. Such a finding is more in harmony with the cooperative learning literature and the personal experiences of the lecture professor.

Observational data regarding the quality of the peer teaching presentations exhibit the same trend (see Table 6). The two experimental laboratory sections showed the highest quality, while the comparison sections showed the least. The higher quality presentations generally exhibited a better flow, were more organized, and provided more accurate delineations of the science concepts presented. Finally, while all cooperative groups in all laboratory sections had at least one identifiable group leader, not all groups possessed an evident science resource person. The randomly formed and self-selected laboratory sections had fewer groups with science resource persons. Certainly, since neither of these arrangements necessarily possessed a highly efficacious individual, at least where science is concerned (as identified through STEBI scores), the presentations organized and conducted by such groups may have suffered.

## Implications

A reflective consideration of the data analyzed and presented in this article has led us to conclude that a well-designed and sequenced science teaching methods experience can enhance the development of science teaching self-efficacy and outcome expectancy among preservice elementary teachers. If the development of a preservice teacher's self-efficacy is as absolutely crucial as its advocates claim, it follows that any curricular innovation that enhances this development should be sought and implemented.

The literature suggests that cooperative learning, as a curricular innovation, promotes both self-efficacy development and the use of social skills, especially when employed in a heterogenous manner (Johnson & Johnson, 1991; Slavin, 1991). Through this research effort, the relative superiority of heterogeneous cooperative learning has been confirmed; however, while we endorse heterogeneous grouping, we differ with the classic literature, since we do not promote achievement as the best criterion upon which to determine heterogeneity among preservice elementary teachers.

We conclude this study with a more pronounced respect for the consequences of using specific forms of cooperative learning in science methods classes. The implication of this research effort is that science methods instructors should not leave self-efficacy development to chance. Too often, if cooperative learning is employed in methods courses, we permit students to self-select their partners or cooperative groups. Instead, we should take a more active role in modelling how cooperative groups should be formed and why they should be formed in more systematic ways. The reason for condoning self-selection may be unawareness of consequences, convenience, or the notion that anxiety will be reduced if students work with those peers with whom they are most comfortable. The observational data obtained and analyzed in this study does not support any of these reasons. Therefore, methods instructors need to take a more active role in:

1. establishing cooperative learning groups based on criteria more specific to the targeted group(s) of students (i.e., self-efficacy for preservice elementary teachers),
2. explicitly modelling the behaviors expected of students participating in cooperative learning exercises,
3. communicating a rationale for heterogeneously forming cooperative learning groups, and
4. recognizing when cooperative learning is most effective and when it is least effective.

Essentially, the above suggestions mirror the work of Dillow et al. (1994) when they concluded:

> *The potential benefits of cooperative learning on female achievement are encouraging. Students gain confidence in their abilities, learn to work together effectively, and build a greater sense of self-esteem. Cooperative learning is a tool. Educators need to understand fully the consequences of the use of that tool on females as individuals, as well as its influence on students in general, if the best results are to be obtained. (p. 51)*

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