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Increasing Student Mathematics Self-Efficacy Through Teacher Training

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Why are some students eager to learn and willing to tackle new challenges while others seem uninterested or unmotivated? Why do some students demonstrate high levels of confidence in their abilities, while others seem unsure of themselves? Self-efficacy theory may provide the answer to these questions. Self-efficacy, one of the most consistently defined motivational constructs (Murphy & Alexander, 2001), refers to an individual's judgment about being able to perform a particular activity. It is an individual's "I can" or "I can't" belief. Bandura (1977) first introduced the construct of self-efficacy in the late 1970s. Research during the past 30 years has revealed a positive relationship between self-efficacy beliefs and academic performance and persistence (Martin & Marsh, 2006; Multon, Brown, & Lent, 1991; Skaalvik & Skaalvik, 2004). The relationship exists across a wide variety of subjects, experimental designs, and assessment methods. Those with high self-efficacy are not only more likely to attempt new tasks, they also work harder and persist longer in the face of difficulties (Bandura, 1986; Lyman, Prentice-Dunn, Wilson, & Bonfilio, 1984; Multon et al., 1991; Schunk, 1981).

summary

Teachers can modify their instructional strategies with minimal training and effort, and this can result in increases in their students' self-efficacy. Self-efficacy judgments are based on four sources of information: an individual's own past performance, vicarious experiences of observing the performances of others, verbal persuasion that one possesses certain capabilities, and physiological states. Individuals use these four sources of information to judge their capability to complete future tasks. Teachers who capitalize on the influence of the strongest of these sources—past performances, observations of others as models, and verbal persuasion—produce more confident students.

The following instructional strategies increase student self-efficacy:

- Reviewing lesson accomplishments from the previous day, posting the current lesson's objectives prior to instruction, drawing attention to the lesson objectives as they are covered, and reviewing the lesson objectives at the end of the lesson.
- Asking students to record each day on a calendar something new they learned that day or something at which they excelled.
- Prompting students who perform poorly to attribute their failures to lack of effort and encouraging them to try harder.
- Drawing students' attention to their growth and complimenting them on their specific skills.
- Using student models early to demonstrate some aspects of a lesson to remind them that other students like themselves are mastering the material and therefore they can master it also.

Teachers who use these strategies on a daily basis produce students who are more confident in their academic skills.

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The purpose of this study was to determine whether teachers who received staff development on classroom self-efficacy strategies would effect changes in students' mathematics self-efficacy. This study differed from previous studies on self-efficacy in four ways. First, it attempted indirectly to influence students' self-efficacy through teacher training. Previous studies traditionally involved researchers working directly with students (Skinner, Wellborn, & Connell, 1990). Second, the instructional modifications suggested for teachers in the treatment groups in this study occurred in whole-classroom environments with all students. Prior studies often focused on laboratory settings or pullout situations involving subgroups of students (Schunk, 1989b). Third, this study implemented a package of instructional techniques that had been found to influence self-efficacy. Finally, an attempt was made to increase students' self-efficacy and subsequently, student achievement, not merely to establish a relationship between self-efficacy and academic performance. Therefore, the problem addressed in this study was whether training teachers in ways to enhance self-efficacy could influence students' mathematics self-efficacy and mathematics achievement. Both Bandura's theory of self-efficacy and research on school staff development provided the theoretical framework for this study.

Theoretical Framework

Self-Efficacy Theory

Self-efficacy refers to the belief or perception that one is capable of organizing and executing the actions necessary to succeed at a given task (Bandura, 1997). Stevens, Olivárez, and Hamman (2006) reported that self-efficacy and the sources of self-efficacy described below were stronger predictors of mathematics achievement than general mental ability. Zarch and Kadivar (2006) found that while mathematics ability had a direct effect on mathematics performance, it also had an indirect effect via mathematics self-efficacy judgments. Self-efficacy judgments are based on four sources of information: an individual's own past performance, vicarious experiences of observing the performances of others, verbal persuasion that one possesses certain capabilities, and physiological states (Bandura, 1986). These four sources have been found to influence both academic and self-regulation efficacy beliefs (Usher & Pajares, 2006).

Past performance is the single greatest contributor to students' confidence and their ability to achieve in school. If students have been successful at a particular skill in the past, they probably will believe that they will be successful at the skill in the future (Bandura, 1993). The old adage, "Nothing breeds success like success" certainly is true when it comes to developing self-efficacy. While the relationship between past performance and self-efficacy is well established, Stevens, Olivárez, Lan, and Tallent-Runnels (2004) found the relationship between prior mathematics achievement and self-efficacy was stronger for Hispanic students than for Caucasian students.

The second source of self-efficacy information is observing others similar to one's self succeed or fail at a task. By observing others like themselves perform tasks, individuals make judgments about their own capabilities (Schunk, 1989b). Unlike the self-efficacy beliefs derived from past experience, self-efficacy gained through observation is less stable. As Schunk (1989b) found, once strong self-efficacy is developed from one's own personal successes, an occasional failure may not have negative effects; however, self-efficacy based on observing others succeed will diminish rapidly if observers subsequently have unsuccessful experiences of their own.

A third source of information is verbal persuasion. Although hearing teachers say, "You can do this!" can increase a student's confidence to do a task, self-efficacy research indicates that verbal persuasion does not impact self-efficacy as much as an individual's own experiences or vicarious experiences (Bandura, 1986). The short-term effects of persuasion need to be coupled with actual successes. The persuader's credibility is also an important factor with verbal persuasion (Schunk, 1989a). Students experience greater gains in self-efficacy when they are told they are capable by someone they believe is trustworthy.

Self-efficacy beliefs are also impacted by physiological cues. Physical symptoms such as sweaty palms, a rapid heartbeat, or a dry mouth are signs of nervousness (Bandura, 1986). These signs may undermine a person's confidence that he or she can succeed at a particular task. Conversely, feeling relaxed or excited before confronting a new situation may increase a person's sense of efficacy toward the task he or she faces.

Strategies to Increase Self-Efficacy

Individuals use the four sources of information mentioned above to judge their capability to complete future tasks. Teachers can design instructional presentations and interactions that capitalize on the influence of these sources (Margolis & McCabe, 2006; Schunk, 1989a). Extensive research in the late 1970s and 1980s found that modifying instructional techniques increased self-efficacy (Bandura & Schunk, 1981; Dweck, 1975; Kazdin, 1975; McAuley, 1985; Meece, Blumenfeld, & Hoyle, 1988; Meichenbaum, 1971; Schunk, 1985; Schunk & Hanson, 1985; Schunk & Rice, 1984; Wood & Locke, 1987).

The teacher training developed for this study provided specific instructional strategies using three sources of self-efficacy information: past experiences, observations of others as models, and verbal persuasion. The training specifically focused on teacher feedback, which included teachers complimenting students on their abilities and the skills they acquired; goal setting, which included activities designed to draw students' attention toward their successful performances; and modeling, which involved students observing fellow students successfully completing similar tasks.

Teacher Feedback. With certain types of feedback, teacher talk can have a significant effect on students' perceptions of their own effort and ability (Schunk, 1984). According to attribution theory, effort and ability are both internally perceived causes

(Weiner, 1979), and the teacher's role can be to help students understand the relationship between effort and ability (Good & Brophy, 1994). Researchers increasingly find that feedback has many boundary conditions (Dweck, 1975, 2000; Mueller & Dweck, 1998; Schunk, 1989a). Feedback is not as simple as either "you-get-it" or "you-don't-get-it." Instead, the style and content of feedback are also important. Schunk (1984) found that successful students who received feedback that complimented their ability rather than their effort developed higher self-efficacy and learning. Schunk's studies suggest that teachers encourage students to use effort as an explanation for failure, and ability as an explanation for success. This feedback is more effective if it is provided early in the student's performance (Schunk, 1984, 1989a).

Zimmerman and Martinez-Pons (1990) suggested that when teachers offer unsolicited advice or help, students believe this help signals low ability. Graham and Barker (1990) found that not only do the students being helped think of themselves as less capable, but other students watching come to the same conclusion. Graham and Barker also learned that expressions of sympathy following a substandard performance, or praise after an easy task, function in the same way. Even first graders attach importance to teacher feedback styles. First graders believe, for example, that teachers watch low achievers more and scold those they believe could do better (Office of Educational Research and Improvement, 1992).

Boys more often attribute their successes to ability and their failures to lack of effort (Nicholls, 1975), whereas girls often attribute their successes to luck (Reis, 1987) or to effort (Rimm, 1991) and their failures to lack of ability (Licht & Shapiro, 1982; Nicholls, 1975; Reis, 1987). The academic self-efficacy of young males is enhanced because they attribute success to their ability, and it is maintained during failures because they attribute failure to lack of effort. However, young females may tend to accept responsibility for failure but not for success (Felton & Biggs, 1977). Boys report higher self-efficacy than do girls in mathematics and science, whereas girls show higher self-efficacy in language arts (Junge & Dretzke, 1995; Meece, Glienke, & Burg, 2006; Siegle & Reis, 1998; Terwilliger & Titus, 1995). Schunk and Lilly (1984) found that gender differences in mathematics self-efficacy disappeared when girls received clear performance feedback, and a recent study reported no gender differences in mathematics self-efficacy (Kenney-Benson, Pomerantz, Ryan, & Patrick, 2006).

The research on teacher feedback suggested that teacher planning could improve the delivery and effectiveness of feedback, and that, for optimum effects, teachers should:

- Help students to practice lack-of-effort explanations when they perform poorly.
- Call attention to student ability when students succeed at meaningful and reasonably difficult tasks.
- Be careful about offering unsolicited help, and especially, only targeting low achievers for assistance.

Goal Setting. Sometimes students are unaware of their abilities or the progress they are making. Goals provide a standard against which students can gauge their progress, and setting goals can have a substantial impact on student self-efficacy and achievement (Bandura, 1986, Schunk, 1989b). When children can easily gauge their progress against a goal, their perception of improvement enhances their self-efficacy.

Goals that include specific performance standards are more likely to increase self-efficacy than more general goals. Progress toward an explicit goal is easier to evaluate. More general goals, such as, "Do your best," are difficult to measure and ineffective (Schunk, 1989a). When a student goal contains a clear performance standard, it eliminates guesswork about where to aim. Rosswork (1977) found that not only did specific goals lead to higher levels of performance than nonspecific goals across a variety of incentive conditions, but that the students who were given specific goals maintained those higher levels even when incentives were withdrawn.

Dweck and Leggett (1988) proposed a model in which individuals' implicit theories of intelligence orient them toward learning or performance goals. Individuals who view intelligence as malleable tend to set learning goals. These individuals are concerned with increasing their competence and view greater effort on their part as manifesting more ability. In contrast, individuals who view intelligence as stable set performance goals. These individuals are concerned with gaining favorable judgments of their competence and they view effort and ability as inversely related. For them, high effort that results in success or failure implies low ability, and low effort that results in success implied high ability. More recent studies (Gutman, 2006) have shown that mastery goal orientation positively increases mathematics self-efficacy.

The research on goal setting suggests that teachers can improve student self-efficacy by helping students establish and measure goals. For optimum effects, teachers should:

- Let students help decide how to break up larger goals into smaller, attainable ones.
- Seek advice from students about how personally challenging teacher-set goals are. When students seem over- or underchallenged, teachers should consider new ways to align the goals with student interests.
- Try to state, and have students state, goals in terms that are sufficiently clear so that later progress is unambiguous.

Modeling. Modeling is a type of social comparison that has an important influence on children's self-efficacy during skill acquisition (Schunk & Hanson, 1985). Children who observe a model they perceive as similar to themselves are likely to believe that they can perform as well as the model and thereby experience higher self-efficacy (Bandura, 1982). Although a variety of types of models are effective, perceived similarity of the learner to the model can increase the model's effectiveness in increasing self-efficacy and behavior change. Models who are similar or slightly higher in competence provide the best opportunity for students to assess their self-efficacy (Schunk, 1989a). Teachers are important models, of course; however, Schunk and Hanson (1985) found that other students can be at least as effective. The superiority of peer models is particularly significant for remedial students who may believe they are more capable of learning when they observe a peer successfully solve a problem (Schunk, 1989b).

A new line of research that maximizes perceived similarity is called *self-modeling*. In self-modeling, a videotape is made of a learner performing a desired behavior while undesired or unsuccessful behaviors are edited out (Bray & Kehle, 2001; Kehle, Bray, & Chafouleas, 2001). Schunk and Hanson (1989) found self-modeling can be effective when elementary children viewed videos of their own mathematics work; they showed better achievement than those who were taped but did not see their tapes, or than those who were not taped at all. Viewing tapes of peer models was not as useful as viewing oneself, but it resulted in greater skill acquisition than viewing no models at all. Videotape feedback showing one's own skillful performance conveys to students that they have made progress, and it increases their self-efficacy for that skill.

The research on modeling suggests several teaching strategies for improving learning and self-efficacy:

- Teachers should try to choose models who can successfully perform skills to be learned. At first, this will likely be the teacher, but soon other students who catch on quickly may be used as models. Tasks can be broken into smaller sections so peer models can be used as early as possible in a lesson.
- Teachers should consider a variety of ways to use models. Videotaping is effective but time consuming, and self-modeling is even more so because someone must edit the tapes. Peer tutoring, work groups, and class demonstrations can help to exploit the power of models.

Research on School Staff Development

Joyce and Showers (1982) proposed four elements of in-service training that "virtually guarantee the successful implementation of almost any approach" (p. 5). These elements are:

- study of the theoretical basis or rationale of the teaching method;
- observation of demonstrations by persons who are relatively expert in the approach;
- practice and feedback in protected conditions (such as trying out the strategy on each other and then on children who are relatively easy to teach); and
- coaching one another as they work the new approach into their repertoire and providing one another with ideas and feedback.

They found that the first three, when they are of high quality, are sufficient to enable teachers to implement an approach appropriately. When the last element is included, nearly all teachers will begin using the approach.

The key factor in maintaining any change in instructional practices is demonstrated student learning, according to a model proposed by Guskey (1986). In his model, teachers change their beliefs and attitudes about an instructional modification only after they observe positive changes in student learning outcomes as a result of changes in the teachers' classroom practices. Some studies have shown that teachers with higher efficacy toward teaching are more likely to value, adopt, and implement new innovations (Cousins & Walker, 2000; DeForest & Hughes, 1992; Stein & Wang, 1988).

Starko and Schack (1989) reported that teachers were not likely to teach students a thinking skills strategy, even when they knew the strategy was useful to the students, unless the teachers felt competent performing the strategy themselves. They noted that the teachers' self-efficacy can be raised through practicing the activity in real or simulated situations or through observing others modeling the desired behavior. Sparks (1986) found that peer observation training was more powerful at changing teachers' behavior than coaching or workshop-only activities.

In a study conducted by The National Research Center on the Gifted and Talented, Reis et al. (1993) found that elementary teachers could successfully implement a curriculum modification technique with which they had no familiarity with as little as two 30-minute in-services using videotape instruction and an explanatory book about the technique. This study also found, however, that the best implementation of the technique occurred when teachers were provided with higher levels of training and peer coaching. Sparks (1986) also found that teachers can make desirable changes in their teaching under certain conditions and in a relatively short period.

The teacher training developed for this study was based on the first three elements of Joyce and Showers' (1982) staff development model. It included a handbook and videotape describing the rationale for the strategies the teachers were expected to use, observation of a peer modeling each of the strategies via a videotape, and feedback from the researchers on the teachers' understanding and application of the strategies through an Efficacy Awareness Form. The questions on the Efficacy Awareness Form provided teachers with an opportunity to reflect on the specific teaching situation they were being asked to implement. This opportunity for reflection influences teacher self-efficacy, according to Ashton (1984).

Methods

Subjects

The study used a cluster-randomized pretest/posttest design. Schools that volunteered to participate in the study were randomly assigned to either the treatment condition or the control condition. The sample included 872 fifth-grade students (n = 435 males; n = 432 females; n = 5 gender not provided) from 10 school districts with a total of 15 schools and 40 fifth-grade classrooms. The 10 school districts were located in 6 states across the Midwest, Central, South, and East. School participation in each district was voluntary; however, all of the fifth-grade mathematics teachers were required to participate in the study if the school

Table 1

Data on Participating Districts

District	State	Community Type	Number of Schools	Number of Classrooms	Number of Students
1	MI	Rural	1	5	122
2	NC	Rural	1	3	80
3	MI	Suburban	1	1	30
4	MA	Suburban	2	4	82
5	MD	Suburban	1	4	88
6	MT	Urban	5	11	206
7	MT	Suburban	1	6	138
8	MI	Suburban	1	2	59
9	NE	Rural	1	3	61
10	MT	Rural	1	1	6

elected to participate. Of the students, 92% were Caucasian and 23% were enrolled in special programs.

The largest district was located in a Midwestern city of 100,000 with 11 classrooms and 206 fifth-grade students. The smallest district was located in a rural Midwestern town of 150 with one fifth-grade class of 6 students. Class size ranged from 6 students to 30 students and the mean class size was 21 students. A summary describing the school districts is provided in Table 1.

Each of the 15 schools was randomly assigned to either the treatment or the control group. Eight schools, with a total of 19 classrooms and 442 students, were assigned to the control group and 7 schools, with a total of 21 classrooms and 430 students, were assigned to the treatment group. One control group teacher taught the mathematics for the three classes in her school. Students in both the experimental and control group classrooms completed the Student Mathematics Survey and the Math Achievement Test both prior to and after receiving instruction on the mathematics measurement unit.

Procedures and Materials

This study consisted of two phases. In the first phase, the treatment group teachers were trained in the self-efficacy construct and self-efficacy strategies to use in their classroom. In the second phase, the treatment group teachers implemented the self-efficacy strategies while teaching a 4-week mathematics unit in measurement that was developed by the researchers. The control group teachers taught the same 4-week mathematics measurement unit; however, they did not receive self-efficacy training.

Phase One: Treatment Group Teacher Training

The teachers assigned to the treatment group received approximately 2 hours of training. The training was based on the first three elements of Joyce and Showers' (1982) staff development principles. The material for the treatment group training consisted of a 35-page handbook developed by the researchers and a 1-hour training videotape, which included material from the handbook in a workshop format and filmed segments of a classroom teacher implementing the self-efficacy strategies. The handbook contained a rationale and supporting research for the strategies the teachers were expected to use. The teachers were able to observe another teacher on the videotape implement the strategies with her students. The teachers read the handbook individually prior to watching the videotape as a group. Following the training, the teachers completed a questionnaire to assess their understanding of the strategies they were expected to implement. The teachers indicated on the questionnaire how they would apply the strategies in various situations. Upon completion of the questionnaire, they received feedback from the researchers on their responses. The teachers answered eight questions related to their training.

The treatment group training focused on teaching strategies in three areas: goal setting, which included activities designed to draw students' attention toward their successful performances;

teacher feedback, which included complimenting students on the specific skills they had acquired; and modeling, which involved students observing fellow students successfully implementing learning tasks. Previous research reported that self-efficacy was most strongly influenced by past performances, vicarious experiences, and verbal persuasion (Bandura, 1986); therefore, the treatment condition used these strategies.

Phase Two: Student Mathematics Measurement Unit

The curricular content in this study consisted of a 4-week mathematics unit on measurement. The unit was based on measurement concepts covered in fifth-grade mathematics textbooks. The unit contained 20 days of 30-minute lessons. The first 10 days' material was developed with the assistance of a university mathematics specialist. These lessons encompassed the concepts of inches, feet, yards, miles, and Fahrenheit temperature measurement units; reading rulers and thermometers; and map scale and ratios. The final 10 days involved the first four of eight activities developed by The Middle Grades Mathematics Project (Shroyer & Fitzgerald, 1989). This material covered surface area and volume.

All of the participating teachers received instructions for each lesson, as well as all of the necessary materials and handouts for their students. The first 2 weeks of the unit consisted of daily instructions attached to classroom packets of materials. The instructions for the treatment group also included suggestions for integrating self-efficacy strategies into the lessons. The control group's lesson plans did not include self-efficacy strategies. Each day, the treatment teachers recorded which of the eight self-efficacy strategies they used during instruction onto a researcher-provided checklist (see Table 2). The last 2 weeks of the unit consisted of The Middle Grades Mathematics Project's instructions for each of four activities. The teachers extended the four activities of this math project across the last 10 days of the study. No special self-efficacy instructions were included with the last four activities; however, the treatment group teachers

Table 2

Summary of Self-Efficacy Strategy Implementation by Treatment Teachers

Strategy	Percentage of Days Successfully Implemented
Goals	
1. Reviewed previous day's goals	92
2. Posted today's goals	94
3. Reviewed success of today's goals	92
4. Students recorded daily progress on calendars	92
5. Reviewed students' daily progress calendars	75
Feedback	
6. Complimented class four times on specific skills	88
7. Complimented five students on specific skills	83
Models	
8. One student successfully demonstrated (modeled) the skill during the lesson	76

were reminded to continue applying the self-efficacy techniques they had been using during the first 2 weeks.

Data Sources

Two student instruments were constructed to assess the impact of the teacher training. The first, the Student Mathematics Survey, was developed to assess students' self-efficacy related to their ability in measurement. It consisted of 35 statements, and students judged their self-efficacy on a 7-point scale ranging from *not good* to *super good*. The same version of the instrument was administered prior to and after completion of the instructional unit. The Cronbach alpha internal consistency reliability estimates for the pre- and posttest self-efficacy instruments were .96 and .97, respectively.

The second instrument, the Math Achievement Test, consisted of 32 questions and was designed to assess mathematics achievement in measurement. Two versions of the test were developed. Separate versions were used for pre- and posttests, and both versions tested the same concepts. The K-R 20 reliability estimates were .78 and .83, respectively. Panels of five content experts evaluated the content validity of both instruments.

In addition, prior to beginning the study, the classroom teachers rated their students' mathematics skills on a scale from 1 = *poor* to 7 = *superior*. This ability assessment was used as a covariate in all of the analyses of the pretest and posttest data.

Analysis

To analyze the effectiveness of the self-efficacy intervention, we conducted a series of multilevel regression analyses using HLM 6.03. The responses of students within a school are not independent of each other. Further, the 15 schools were randomly assigned to either the treatment (n = 7) or control (n = 8) group. Therefore, we elected to evaluate the responses of students nested within schools. We analyzed the impact of the treatment on two separate dependent variables: math self-efficacy and achievement. For the purposes of the analyses, level 1 was the student level, and level 2 was the school level. We estimated all models using restricted maximum likelihood estimation, given the small level-2 sample size (N = 15). For the analyses of each of the dependent variables (self-efficacy and achievement), we used a model building approach (Raudenbush & Bryk, 2002). First, we estimated the unconditional model to assess the degree of between school variance in the dependent variable. Then we estimated a level-1 model, which included three independent variables: gender (coded 0 for males and 1 for females); ability, which was grand mean centered; and the pretest score, which was also grand mean centered. We allowed the slopes of the intercept and the three level-1 slopes to vary. Next, we estimated a full level-2 model, with group as a predictor of the intercept and the three level-1 slopes, resulting in the estimation of three cross-level interactions. For the final model, we eliminated any level-2 random effects that were not statistically significant, and we compared this simpler, less parameterized model to the full model, using a chi-square difference test. If the chi-square test suggested that the simpler model with fewer random effects provided no worse fit to the data than the more parameterized model, then the simpler model was retained.

Analysis of the Teacher Training

Phase One: Teacher Training

The treatment group teachers demonstrated a clear understanding of the self-efficacy strategies and expressed confidence in their ability to implement the strategies during the study. The mean responses, based on the 7-point scale (1 = *very little confidence*; 7 = *extremely high confidence*), for the two subscales, confidence in using the self-efficacy strategies with students and confidence in using the self-efficacy strategies in the classroom, were 5.1 and 5.7, respectively. Based on this information, the teacher-training component of this study was considered effective.

Phase Two: Teaching the Measurement Unit

The second phase of the study investigated how often the teachers implemented the self-efficacy strategies and what impact the strategies had on student mathematics self-efficacy and student mathematics achievement. The treatment group teachers indicated on a Daily Strategy Form which of the eight self-efficacy strategies they used each day during the instruction of the measurement unit. Table 2 contains the percentage of sessions in which teachers reported using the various self-efficacy strategies.

Table 3

Final HLM for Pre-Self-Efficacy Scores

Fixed Effects	Coefficient (*SE*)	*t* (*df*)	*p*
Model for intercept (β_0)			
Intercept (γ_{00})	4.39 (.20)	21.52 (13)	< .001
Group (γ_{01})	-.47 (.28)	-1.66 (13)	.120
Model for GENDER slopes (β_1)			
Intercept (γ_{10})	.09 (.11)	.83 (13)	.42
Group (γ_{11})	.35 (.15)	2.29 (13)	.04
Model for ABILITY slopes (β_2)			
Intercept (γ_{20})	.12 (.04)	2.73 (13)	.02
Group (γ_{21})	.04 (.06)	.65 (13)	.53
Random Effects (Variance Components)	**Variance**	**χ^2(*df*)**	***p***
Var. in intercepts (τ_{oo})	.247	83.62 (13)	< .001
Var. in MALE slopes (τ_{11})	.005	8.30 (13)	> .50
Var. in ABILITY slopes (τ_{22})	.004	16.80 (13)	.208
Var. within schools (σ^2)	1.116		

Analysis of Student Data

Preassessment Data

To establish the equivalence of the two groups at pretest, and to examine preexisting differences among subgroups of students, we first developed a hierarchical linear model using student gender, treatment or control group membership, and teachers' rating of the student's mathematical ability as predictors of students' student mathematical self-efficacy (Table 3) and students' mathematical achievement (Table 4) at pretest. The results of the analyses of the preassessment data indicated that there were no statistically significant main effects of treatment group on either math self-efficacy or math achievement.

Table 4

Final HLM for Pre-Math-Achievement Scores

Fixed Effects	Coefficient (SE)	t (df)	p
Model for intercept (β_0)			
Intercept (γ_{00})	39.02 (2.63)	14.86 (13)	< .001
Group (γ_{01})	-1.08 (3.63)	-.30 (13)	.77
Model for GENDER slopes (β_1)			
Intercept (γ_{10})	4.11 (1.09)	3.76 (13)	.003
Group (γ_{11})	.41 (1.52)	.27 (13)	.79
Model for ABILITY slopes (β_2)			
Intercept (γ_{20})	5.28 (.58)	9.09 (13)	< .001
Group (γ_{21})	-.60 (.81)	-.74 (13)	.47
Random Effects (Variance Components)	**Variance**	**χ^2(df)**	**p**
Var. in intercepts (τ_{oo})	43.72	128.47 (13)	< .001
Var. in GENDER slopes (τ_{11})	.31	6.84 (13)	> .50
Var. in ABILITY slopes (τ_{22})	1.34	34.04 (13)	.001
Var. within schools (σ^2)	112.96		

Not unexpectedly, teachers' rating of students' ability was a statistically significant predictor of both pretest math self-efficacy (see Table 3, γ_{10} = .12) and pretest math achievement (see Table 4, γ_{10} = .053). Further, there were statistically significant gender differences in math achievement at pretest (see Table 4, γ_{20}= .041), favoring males. While math self-efficacy did not differ by gender at pretest, the cross-level interaction between group and gender was statistically significant (see Table 3, γ_{20}= .041). In other words, the gender difference in pretest self-efficacy scores was larger in the control group (group = 1) than in the treatment group (group = 0).

Mathematics Self-Efficacy

First, we estimated a random-effects ANOVA model to compute the intraclass correlation for post self-efficacy. The intraclass correlation was .11, indicating that approximately 11% of the variance in post-self-efficacy scores was between schools. Then we estimated three additional models: a model that included only the level-1 predictors, a full level-2 model with all random effects, and a final level-2 model, constraining all nonstatistically significant random effects to be 0. Table 5 reports the results of these three models of post self-efficacy. After controlling for gender, math ability, and pre self-efficacy, the average math self-efficacy in treatment schools was .52 points higher than it was in control schools. This represents a Cohen's *d* effect size of .46 standard deviation units. After controlling for the other variables in the model, ability was still a statistically significant predictor of post math self-efficacy ($\gamma_{20} = .16$), as was pre math self-efficacy ($\gamma_{30} = .39$). Gender was not a statistically significant predictor of self-efficacy, and there was not a statistically significant cross-level interaction between gender and group at posttest. The predicted post-self-efficacy value for males in the treatment group who scored at the overall mean on pre math self-efficacy and ability was 5.68. Similar males in the control group had an average score of 5.16 on the post-self-efficacy assessment. Holding math ability and pre-math self-efficacy constant at their means, the expected value for females in the treatment group was 5.58. The expected value for comparable females in the control group was 5.14.

Significant between-school variability remained to be explained in the intercepts, the ability slopes, and the pre-self-efficacy slopes. In other words, our final model failed to completely explain the between-school differences (variability) in math self-efficacy, the effect of math ability on math self-efficacy, or the effect of pre math self-efficacy on post math self-efficacy. However, the variance component for the gender slope was not statistically significant. Therefore, the random effect for this slope was fixed to 0 in the final model. To compare the fit of this more parsimonious

Table 5

Post Self-Efficacy

	Model A Level-1 Model	Model B Full Model	Model C Final Model
Fixed Effects			
Intercept			
Intercept γ_{00}	5.41 (0.10)*	5.69 (0.10)*	5.68 (0.09)*
Group γ_{01}		-.053 (0.14)*	-0.52 (0.13)*
Gender Slope			
Intercept γ_{10}	-0.07 (0.07)	-0.12 (0.09)	-0.10 (0.09)
Group γ_{11}		0.10 (0.13)	0.08 (0.12)
Ability Slope			
Intercept γ_{20}	0.14 (0.03)*	0.16 (0.04)*	0.16 (0.04)*
Group γ_{21}		-0.03 (0.06)	-0.03 (0.06)
PreSE Slope			
Intercept γ_{30}	0.49 (0.05)*	0.40 (0.07)*	0.39 (0.07)*
Group γ_{31}		0.17 (0.10)	0.17 (0.10)
Variance Components			
τ_{00} (intercept)	0.106*	0.036*	0.030*
τ_{11} (gender slope)	0.010	0.008	
τ_{22} (ability slope)	0.006*	0.006*	0.006*
τ_{33} (PreSE slope)	0.028*	0.023*	0.021*
σ^2 (w/ in schools)	0.691	0.692	0.695
Deviance (REML)	2035.07	2035.23	2036.49
Number of estimated variance components	11	11	7

model (Model C) with the more parameterized model (Model B), we conducted a chi-square difference test. The chi-square difference between the two models was 1.26 with 4 degrees of freedom. This difference was not statistically significant, which suggested that the more parsimonious model (Model C) provided no worse fit than the more parameterized model (Model B). Therefore, Model C represents our final model.

Mathematics Achievement

We also developed a hierarchical linear model using student gender, treatment or control group membership, teacher rating of student mathematical ability, and pre student mathematical achievement as predictors of post student mathematical measurement achievement. Achievement was measured as the percentage of correct answers on a measurement skills test. First, we estimated a random-effects ANOVA model to compute the intraclass correlation for posttest math achievement. The intraclass correlation was .177, indicating that approximately 17.7% of the variance in posttest math achievement was between schools. Then we estimated three additional models: a model that included only the level-1 predictors, a full level-2 model with all random effects, and a level-2 model constraining all nonstatistically significant random effects to be 0. Table 6 reports the results of these three models of posttest math achievement.

After controlling for the other variables in the model, group membership (control or treatment) was not a statistically significant predictor of posttest math achievement. In addition, after controlling for the other variables in the model, students' math ability level was not a statistically significant predictor of posttest math achievement, nor was there a statistically significant cross-level interaction between math ability level and math achievement by treatment group. However, gender was a statistically significant predictor of posttest math achievement. On average, male students correctly answered 61% of the questions. After controlling for other variables in the model, females' scores were 2.48 percentage points lower than males' scores. In addition, math pretest scores were statistically significant predictors of math posttest scores. For each percentage increase on the math pretest, the posttest score was approximately .64 points higher.

Table 6

Post Achievement

	Model A Level-1 Model	Model B Full Model	Model C Final Model
Fixed Effects			
Intercept			
Intercept γ_{00}	58.99 (1.54)*	61.21 (2.10)*	61.14 (2.15)*
Group γ_{01}		-4.43 (2.91)	-4.41 (2.98)
Gender Slope			
Intercept γ_{10}	-1.69 (0.69)	-2.83 (1.30)*	2.48 (1.14)*
Group γ_{11}		2.32 (1.80)	1.95 (1.57)
Ability Slope			
Intercept γ_{20}	2.57 (0.54)*	1.73 (0.78)*	1.65 (0.84)
Group γ_{21}		1.67 (1.07)	1.66 (1.14)
PreACH Slope			
Intercept γ_{30}	0.60 (0.04)*	0.62 (0.06)*	0.64 (0.06)*
Group γ_{31}		-0.06 (0.08)	-0.06 (0.07)
Variance Components			
τ_{00} (intercept)	29.84*	26.13*	27.60*
τ_{11} (gender slope)	2.89	2.68	
τ_{22} (ability slope)	3.20*	2.64	3.20*
τ_{33} (PreACH slope)	.002	0.0030	
σ^2 (w/ in schools)	114.42	114.54	115.37
Deviance Statistic	6094.43	6086.13	6090.34
Number of variance components estimated	11	11	4

Significant between-school variability remained to be explained in the intercepts and the ability slopes. In other words, our final model failed to completely explain the between-school differences (variability) in math posttest achievement and the effect of ability on math achievement. However, the variance components for the gender slope and the preachievement slope were not statistically significant. Therefore, the random effects for these two slopes were fixed to 0 in the final model. To compare the fit of this more parsimonious model (Model C) with the more parameterized model (Model B), we conducted a chi-square difference test. The chi-square difference between the two models was 4.21 with 7 degrees of freedom. This difference was not statistically significant, which suggested that the more parsimonious model (Model C) provided no worse fit than the more parameterized model (Model B). Therefore, Model C represents our final model. The level-1 model, the full model, and the final model with nonsignificant predictors are shown in Table 6.

To examine the relationship between posttest self-efficacy and posttest achievement after controlling for prior math ability and prior math achievement, we estimated a final multilevel model, in which ability, preachievement, and post math self-efficacy were predictors of posttest achievement. Treatment group was entered as a cross-level moderator of these effects. Table 7 contains the results of this model. After controlling for ability and prior math achievement, post self-efficacy was a statistically significant predictor of posttest achievement. After controlling for the other variables in the model, a one-point increase in post math self-efficacy resulted in a corresponding 2.49 percentage point increase on the math achievement posttest. Treatment group was not a statistically significant moderator of this effect.

Finally, an examination of the relationships between pre- and postassessments revealed similar relationships for control and treatment students except for one pair. The relationship for posttest achievement and posttest self-efficacy was stronger for the treatment students than for the control students (see Table 8).

Educational Importance of the Study

This study demonstrated that teachers can modify their instructional strategies with minimal training, and this can result

Table 7

Final HLM for Post-Achievement Scores Using Pre-Achievement, Ability, and Post Self-Efficacy

Fixed Effects	Coefficient (*SE*)	*t* (*df*)	*p*
Model for intercept (β_0)			
Intercept (γ_{00})	59.10 (1.97)	30.03 (13)	< .001
Group (γ_{01})	-2.48 (2.72)	-.91 (13)	.38
Model for ABILITY slopes (β_1)			
Intercept (γ_{10})	1.50 (.75)	2.00 (13)	.07
Group (γ_{11})	1.74 (1.01)	1.72 (13)	.11
Model for POST SELF-EFF slopes (β_2)			
Intercept (γ_{20})	2.49 (.65)	3.85 (13)	< .001
Group (γ_{21})	-1.36 (.82)	-1.67 (13)	.10
Model for PRE-ACH slopes (β_3)			
Intercept (γ_{30})	.58 (.06)	10.17 (13)	< .001
Group (γ_{31})	-.03 (.07)	-.35 (13)	.73
Random Effects (Variance Components)	**Variance**	**χ^2(*df*)**	***p***
Var. in school means (τ_{oo})	24.11	134.37 (13)	<.001
Var. in ABILITY slopes (τ_{22})	2.20	43.07 (13)	.001
Var. within schools (σ^2)	113.74		

in increases in students' self-efficacy. These results suggest that the intervention was effective for students of varying ability levels and students of both genders. The effect size for this treatment was almost .50 standard deviation units, which certainly is a nonnegligible effect. Most importantly, these increases can be achieved during a short period of time with minor changes in instructional style.

Table 8

Correlations Between Variables

	Pre Self-Efficacy		Post Achievement		Post Self-Efficacy	
	Control	Treat	Control	Treat	Control	Treat
Pretest Achievement	.307	.278	.666	.699	.346	.402
Pretest Self-Efficacy			.189	.276	.607	.521
Posttest Achievement					.330	.528

*** All correlations were significant at the 0.01 level (two-tailed).*

Teacher Training

Several factors contributed to the success of the teacher-training module used in this study. The training followed Joyce and Showers' (1982) suggestions and provided a rationale for the strategies, gave participants the opportunity to observe a teacher implementing the strategies on videotape, and provided feedback from the researcher under protected conditions. It also provided an opportunity for teachers to observe changes in student behavior. The treatment group students recorded daily accomplishments on student calendars, which the teachers reviewed individually with them. By requiring the treatment teachers to continually review the student calendars with the students, the teachers were constantly being bombarded with positive feedback from their students about their students' progress. The training also prompted the teachers to expect that the strategies would produce useful outcomes. The handbook and videotape featured positive outcomes from a variety of previous self-efficacy research studies.

Teaching Strategies

The goal strategies were designed to draw students' attention toward their progress. The strongest source of efficacy information is past experience (Bandura, 1993), and the activities in this study provided opportunities for students to see the progress they were making. Each day, the treatment group teachers reviewed goal accomplishments from the previous day, posted the current lesson's goals prior to instruction, and reviewed the daily goal accomplishments at the end of the current lesson with their classes. Although many teachers were aware that sharing objectives was an "instructional set" to help students organize their learning, many of the teachers were not cognizant that this activity also provided an opportunity for students to evaluate their growth. The student calendar writing used in this study resembles the popular practice of journal writing, which also allows students to reflect on their academic growth. Students recorded on a calendar each day something new they had learned or something at which they had excelled.

The second set of self-efficacy strategies involved teacher feedback. Teacher feedback can function as verbal persuasion. For example, teachers can prompt students to attribute their failures to lack of effort and encourage students to try harder. Teacher feedback also functions as past performance awareness. Drawing students' attention to their growth and complimenting students on their specific skills were major emphases of the teacher-training component. Middleton and Spanias (1999) noted that students should be encouraged to attribute their successes to a combination of ability and effort and their failures to lack of effort or to confusion or reliance on inappropriate strategies.

Another salient feature of the teacher feedback entailed the specificity of the compliments. Just as specific goals are more effective (Rosswork, 1977; Schunk, 1989a), specific compliments are more effective at drawing students' attention to their skills, and subsequently, their past performance. A comment such as, "Good work!" provides a student with very little information about his or her ability. However, a compliment such as, "You're getting good at using a ruler" lets the student know what skill he or she has developed. Such a comment gives the student more information to cognitively appraise his or her progress. Pajares and Miller (1995) found that self-efficacy specific to a mathematics task was more related to later performance in that task than general mathematics self-efficacy was.

The third strategy involved using student models. The treatment group teachers were instructed to use student models early in the lessons that they conducted. This demonstrated to students that other students like themselves were mastering the task and therefore they could master it also. Additionally, the model provides the student observer with the vicarious experience of completing the task.

The nature of the lessons encouraged teachers to organize the students into groups, which may have actually decreased self-efficacy differences between the treatment and control students. Group work may have increased students' self-efficacy because it provided students with an opportunity to observe a variety of peer models. With the group work, both treatment and control group students benefited from student modeling.

Some earlier research involving attempts to increase student self-efficacy through successful completion of projects reported no increase in self-efficacy (Schack, 1986; Starko, 1986). Although these studies provided students with successful experiences, they did not incorporate a key factor in self-efficacy theory, which is the cognitive appraisal of the performance. Students who successfully complete a very difficult project may not report higher self-efficacy if they fail to recognize the skills they have developed and mastered during the successful process, or if the amount of effort necessary to complete the project overshadows the skills they developed and used in the process. In this study, students' academic progress was continually being drawn to their attention.

Limited Achievement Differences

The lack of difference that was found on mathematics measurement achievement tests between treatment and control students may be due to the length of the study or the variety of topics covered during the study. A wide variety of measurement topics were covered in the 4-week unit. Most of the topics were limited to 1 or 2 days of instructional time. Using this format, increases in self-efficacy would have had a limited opportunity to influence achievement. High self-efficacy contributes to achievement through additional effort and persistence on the students' part. The students in this study were not presented with additional tasks beyond those found in the initial lesson, which would have required the perseverance associated with high self-efficacy. If one or two concepts had been explored for several weeks, achievement differences may have emerged.

This study also found a significant relationship between self-efficacy and achievement. This supports the large body of research revealed from meta-analysis (Multon et al., 1991) that positive, significant relationships exist between self-efficacy and achievement. Further, students whose teachers were trained in self-efficacy showed a stronger relationship between posttest self-efficacy and posttest achievement than students of teachers who were not trained.

Suggestions for Further Research

This study needs to be replicated with a more culturally diverse population. Although the students in this study benefited from feedback complimenting their skills, students from other cultural backgrounds may not. In addition, replication of this study over a longer time frame could help to determine whether increases in self-efficacy could lead to eventual increases in academic achievement. Additionally, variations on goal orientation (Dweck, 2000; Lodewyk & Winne, 2005) should be included into the design of future studies of this nature.

In conclusion, this study demonstrated that teachers can implement new instructional strategies with minimal training. Further, significant increases in student self-efficacy can be achieved during a short time period with minor changes in instructional style. Accordingly, professional development should expose teachers to self-efficacy theory, as well as teaching the rationale for, and the benefits of, these self-efficacy strategies. Educators need to be aware that students of all abilities can benefit from a learning environment where growth and progress are recognized.

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