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Effects of Self-Correction Strategy Training on Middle School Students' Self-Efficacy, Self-Evaluation, and Mathematics Division Learning

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Historically, mathematics teachers have focused on teaching academic content. However, students continue to use maladaptive learning methods because their effects are not understood or are hard to discern. There is concern about the quality of American students' achievement in mathematics. A recent report by the National Mathematics Advisory Panel (2008) observed that success in mathematics education is of critical importance to individual citizens because it improves their college and career options. Moreover, the growth of jobs in the mathematics-intensive science and engineering workforce has outpaced overall job growth by a 3:1 ratio. However, American employers have had

summary

Teachers need to monitor students' self-efficacy judgments, as well as their mathematics learning, to provide optimal instruction. First, inaccuracies in self-judgments appear to be a major liability for elementary and middle school children. Classroom practice must cultivate the knowledge to succeed and should nurture the belief that one can succeed. Second, accuracy training can be incorporated in a curriculum. After students solve the problems, teachers can show them how well they judged their capability to solve the problems. Students who can assess what they know and do not know will become better self-regulated learners. Third, strategy training in mathematics is very important. Students learn various strategies in school to solve mathematics problems, but they may not apply the strategies if they do not see their value. Teachers need to show the connection between strategy training and self-efficacy judgments and how these psychological variables relate to better mathematics performance. Students who utilize strategies in problem solving will develop higher efficacy compared to those who do not utilize them. Fourth, accurate self-reflection is important to students' success in math. Teachers can help students to hone this invaluable self-regulatory skill by giving them frequent opportunities to evaluate what they have learned or where they erred after completing a task. Students' self-efficacy is strengthened with tangible indicators of progress. Finally, unrealistically low self-efficacy beliefs and not lack of ability or skill may be responsible for avoidance of challenging academic courses such as math. Teachers will have to identify these inaccurate judgments and design and implement appropriate interventions to change them.

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difficulty finding qualified applicants for these positions and often have to search for suitable applicants from abroad. What can be done to increase American students' achievement in mathematics to make them competitive internationally?

What is missing is a necessary additional component of the learning process: self-regulation. Self-regulated learning is conceptualized as a self-controlled cycle of processes designed to enhance a student's goal attainment and sense of agency. Research indicates that self-regulatory skills improve students' academic performance (Zimmerman, 2002; Zimmerman & Kitsantas, 2005). More specifically, *self-regulation* refers to the processes people use to activate and sustain their thoughts, behaviors, and emotions to attain learning goals. It encompasses processes such as setting goals, using strategies to solve problems, self-evaluating one's performance, seeking assistance when needed, and satisfaction with one's efforts (Pintrich & De Groot, 1990; Zimmerman, 1994). The present study examined whether students' use of a self-correction strategy to check their answers improved their self-efficacy, self-evaluation, and math performance and whether students who are trained to use self-correction strategy displayed higher self-efficacy and self-evaluative calibration.

Self-Regulation of Learning

An important motivational aspect of self-regulation is students' self-efficacy beliefs. Research reveals that self-efficacy beliefs influence students' academic achievement in addition to their prior math knowledge and skill (Pajares, 2008; Schunk & Ertmer, 2000; Zimmerman, 2002). *Self-efficacy* is the belief in one's capability to organize and perform a set of activities necessary to complete a task at a specified level of competency (Bandura, 1986, 1997). It is a predictive measure of one's capability to perform on a future task. Bandura (1997) hypothesized that self-efficacy beliefs increase one's motivation and ultimately one's success on challenging tasks. When self-efficacy judgments are made specific to the task, they predict performance better than self-concept measures (Pajares, 1996).

Along with self-efficacy beliefs, self-regulatory processes play a vital role in promoting mathematics learning and academic achievement. Zimmerman (1998, 2001) developed a model of self-regulation that involves three cyclical phases. During the *forethought phase*, self-regulatory beliefs and processes prepare one for learning to occur. For example, strategic planning and self-efficacy beliefs are forethought precursors to learning or performance (Zimmerman & Schunk, 2008). The *performance phase* involves processes, such as the implementation of learning strategies and metacognitive monitoring. Finally, in the *self-reflection phase*, learners react to their efforts by self-evaluating their progress and adjusting strategies as necessary for subsequent cycles of learning (Schunk & Zimmerman, 2007; Zimmerman, 2001).

Self-evaluation is a key self-regulatory process that involves setting and using standards to judge the quality of one's performance. To be effective, evaluations of one's functioning must be reasonably accurate (Zimmerman, 1998). Schunk (1996) found that when students self-evaluate their capabilities or progress in learning a particular task, they develop a higher level of competence, which in turn strengthens their forethought self-efficacy beliefs, thereby completing Zimmerman's cyclical model of self-regulation.

Schunk and Ertmer (2000) reviewed numerous correlational and intervention studies on various self-regulatory processes and found that students' self-regulatory competence can be improved through systematic interventions that teach skills and raise students' self-efficacy. As mentioned earlier, self-efficacy is a measure of perceived competence on a future task. Students with high levels of self-efficacy set higher goals, use more effective self-regulatory strategies, monitor their work more efficiently, persevere when faced with challenging academic tasks, and evaluate their performance more accurately compared to students with low levels of self-efficacy (Schunk & Meece, 2006; Zimmerman & Schunk, 2008).

Calibration Achievement

Although the strength of students' self-efficacy beliefs enhances their academic performance, recent research indicates that accuracy of these judgments also is important for effective functioning and academic success (Bandura, 1986, 1997; Chen, 2003; Chen & Zimmerman, 2007). When students' self-judgments of efficacy align with their actual performance on the accompanying task, they are described as well-calibrated (Schunk & Pajares, 2004). *Calibration* is a metacognitive judgment of one's performance with the actual performance on that task (Garavalia & Gredler, 2002; Schunk & Pajares, 2004). Students who overestimate their capabilities may attempt challenging tasks and fail, which would decrease their subsequent motivation. Those who underestimate their capabilities may avoid challenging tasks, thereby limiting their potential development of necessary skills (Schunk & Pajares, 2004). As a result, inaccurate judgments of one's capabilities can diminish subsequent motivation and learning.

Researchers report that students often are inaccurate in judgments of their capability on a task or test (Chen, 2003; Hacker & Bol, 2004). A significant disparity between one's judgment and subsequent performance can be problematic (Klassen, 2002, 2006). Research indicates that accuracy correlates positively with performance (Bol & Hacker, 2001). In a number of studies, Hacker and Bol found that even after prolonged training, many students remain inaccurate in their judgments, indicating that these judgments are hard to learn or resistant to change. Low-achieving students are less accurate and more overconfident than their high-achieving counterparts who tend to be underconfident, but perform better (Bol & Hacker, 2001; Hacker & Bol, 2004).

Chen (2003) conducted a study of the accuracy and predictability of self-efficacy beliefs with 107 seventh-grade students. The goal of the study was to examine the role of calibration in students' self-efficacy judgments and possible causes of inaccurate self-efficacy beliefs. Another important issue was how differences in students' accuracy of self-efficacy judgments influence postperformance judgments, such as self-evaluation and perceived effort. Chen hypothesized that calibration accuracy would predict postperformance measures of effort attributions and self-evaluative judgments. Her second hypothesis was that linear trends would occur between difficulty and self-efficacy and between difficulty and calibration. Students completed this study in two sessions. They made a self-efficacy judgment before solving each math problem. After completing each problem, they made effort and self-evaluative self-judgments.

The results showed that the calibration measures of bias and accuracy did not correlate significantly with the strength of students' self-efficacy beliefs, implying that calibration and strength dimensions were distinct and statistically independent. Second, self-efficacy calibration improved the predictive power of self-efficacy strength measures. Third, path analysis results indicated that calibration accuracy had a significant effect on students' self-efficacy judgments. Fourth, gender was not a significant cause of calibration and self-efficacy beliefs, but it correlated with self-evaluation. Boys evaluated their math performance more favorably than girls. Finally, regarding the task difficulty, Chen (2003) found significant linear trends between math item difficulty and calibration accuracy, bias, self-efficacy, effort judgment, and self-evaluation. Students had more accurate calibration, higher self-efficacy beliefs, and more favorable self-evaluations on easier math items compared to more difficult ones.

Garavalia and Gredler (2002) conducted a study with 69 college seniors who were involved in a health science case study. This study examined the effects of goal-setting instruction on students' perceptions regarding the use of self-regulated learning strategies. Additionally, the study examined how accurate or inaccurate calibrators differed in their perceptions of self-regulated learning strategies. Students were randomly assigned to an experimental (i.e., goal instruction) and a comparison group. At the end of the study, both groups were divided into accurate and inaccurate calibrators in order to evaluate the interaction between the goal-setting instruction and students' degree of calibration. The measures included a self-efficacy for self-regulated learning scale, which was comprised of 24 items; a goal-analysis test with 10 goal statements; expected grade; prior achievement; and final course grade.

All students reported similar beliefs regarding their use of self-regulatory learning strategies, regardless of their calibration accuracy. Students in the goal-setting condition were more accurate grade predictors and earned higher grades for the course. Moreover, the grade differences between accurate and inaccurate students was statistically significant, indicating that accurate beliefs are key in gauging one's performance on a test or task (Garavalia & Gredler, 2002). In the total sample, 30% of the students were inaccurate in predicting their grades and had expectations that were inconsistent with prior achievement. The researchers noted that these advanced undergraduate students should have been able to predict accurately and that inaccurate predictions may be maladaptive in academic settings.

There is some evidence that properties of the academic task may influence accuracy judgments. Klassen (2002) found that, in the area of mathematics, students were generally accurate in their self-efficacy judgments. He conducted a review of self-efficacy studies involving students with learning disabilities and found that these students consistently overestimated their capability in writing assignments, but the results were different for mathematics task. In mathematics, students with learning disabilities were generally accurate in their self-efficacy judgments and performance. In one study, Alvarez and Adelman (1986) showed students with learning disabilities pairs of math problems that increased in difficulty. Next, students rated their efficacy judgments to complete each pair of problem and afterward, completed as many problems as they could. The results showed that 30% of the students' judgments were overestimates, 2% were underestimates, but the remaining 68% of the judgments were reasonably accurate. Klassen (2002) suggested that in mathematics, it is possible to show students the actual task, allow them to rate their efficacy, and then complete the problem. Thus, the task analysis aspect is much clearer for a mathematics problem compared to a writing task.

Overall, the research indicates that high-performing students are better calibrated than low-performing students. One possible reason is that high-performing students use more effective self-regulatory processes, such as learning strategies or metacognitive monitoring, compared to low-performing students. Zimmerman (1990) theorized that self-regulated learners are aware of knowing or not knowing something (i.e., they are well-calibrated). However, this relation appears untested. Pajares (1996) suggested that students' calibration can be improved by helping them to understand what they know and what they do not know.

Research on the relation between self-efficacy judgments, performance, and calibration among elementary and middle school students is limited (Hacker & Bol, 2004; Schunk & Pajares, 2004). Schunk and colleagues (Schunk & Ertmer, 2000) have conducted many intervention studies on elementary students using various self-regulatory processes such as modeling, goal-setting, self-monitoring, strategy training, attributional feedback, and self-evaluation; however, in these studies, calibration was not a dependent outcome. These studies found that elementary students were able to improve their self-efficacy for learning and their use of self-regulatory skills (Schunk & Ertmer, 2000).

Purpose of the Study

The present study addressed the following research questions: Will training students to use a self-correction strategy to check their answers improve their self-efficacy, self-evaluation, and math performance? Will students who are trained to use a self-correction strategy evidence higher self-efficacy and self-evaluative calibration?

This study differed from previous studies because it sought to test whether key processes from a three-phase cyclical model of self-regulation (Zimmerman, 2002) would improve students' calibration and math performance. As we discussed, calibration is an important dimension of academic motivation and success (Chen & Zimmerman, 2007). It is a measure of metacognitive monitoring, which occurs during the performance phase but is linked conceptually to forethought processes, such as self-efficacy beliefs as well as the self-reflection phase of self-evaluative judgments within a cyclical phase of self-regulation. In the present study, during the forethought phase, students assessed their capability on a self-efficacy scale, an important self-motivational belief (Bandura, 1986, 1997). During this phase, the researcher taught students in the experimental group a self-correction strategy to check the answers during the performance phase. This strategy is important because it enables learners to distinguish between effective and ineffective performance and to locate the source of errors (Zimmerman & Cleary, 2006). Finally, during the self-reflection phase, students made a self-evaluative judgment of their performance. According to Schunk (2003), the process of self-evaluating one's abilities or performance is important for fostering strong self-efficacy beliefs. Students who are dissatisfied with their performance on a task would remain motivated if they are self-efficacious about improving by using more effective strategies on future performance (Zimmerman & Cleary, 2006). Thus, self-efficacy serves a precursory or forethought role in self-regulatory learning (Zimmerman & Schunk, 2008).

To answer the above research questions, we tested the following hypotheses. First, students in the self-correction strategy (experimental) condition will have higher self-efficacy and self-evaluative judgments, and will perform significantly better on the posttest. Second, students in a self-correction strategy (experimental) condition will be better calibrated (more accuracy and less bias) compared to students in a control group.

Method

Participants

Participants were 21 fifth- and 21 sixth-grade students from a parochial school and a private afterschool program located in an urban northeastern city. The researcher distributed 100 parental consent forms and students' assent forms to parents for their children's participation. Forty-two parents granted permission, with 20 students from the parochial school and 22 students from the afterschool program. There were 20 male and 22 female students. Both schools did not classify students regarding their ethnicity and religion; as a result, data on these variables were not collected. The researcher assigned each student a random number and used the random assignment feature of SPSS to allocate students to control and experimental groups respectively. To determine whether the sample size provided sufficient statistical power, Cohen's (1988) power analysis indicated a sample of 64 students is necessary to detect a medium effect size at $\alpha = .05$ level with 80% power and a sample of 21 is necessary to detect a large effect size. The sample of 42 in this study would yield a medium effect size at $\alpha = .05$ level with 63% power and a large effect size with 96% power (Cohen, 1988).

Task

The task involved solving four math long division problems (decimal) of varying difficulty. The researcher created these problems according to the math text (Maletsky, Andrews, Buton, Johnson, & Luckie, 2002) used in the school and in consultation with the school's principal. Both pretest and posttest phases had four identical problems. However, the order of the problems in the posttest phase was different. An example of one problem is $73.664 \div 1.2 = ?$

Design and Procedure

This experimental study utilized a pretest-posttest control group design. Students in each grade level were randomly assigned to either a training group or a control group. There were four phases in the study that lasted a total of 45 to 50 minutes. Students completed the study in groups of two or four depending on their schedule and the math teacher's approval. During the first phase, students completed a pretest. The researcher told them to do their best and finish as many problems as they could. This phase lasted for approximately 10 minutes. During the second phase, training occurred. Students in both groups learned a step-by-step solution strategy to solve the division problems. However, the experimental group learned an additional strategy for self-correcting their answers. After solving the problem, the experimental group learned how to self-check their answers. They learned to multiply the quotient by the divisor, and if the resulting number is similar to the dividend, then the answer would be verified as correct. If it is not, then the answer would be deemed incorrect. This phase lasted approximately 10 minutes.

During the third phase, all students solved three problems. The experimental group had a checklist to guide them to self-correct their work. This session lasted approximately 10 minutes. Finally, during the fourth phase, posttesting, each student rated his or her capability to solve the problem on the self-efficacy scale. Students saw each problem briefly for a few seconds, and rated their capability to solve each mathematics item. Next, they solved the problems and afterward, completed a self-evaluative scale for each item. After the study was completed, the control group participants learned the self-strategy to check their answers for ethical reasons. This fourth phase lasted approximately 15 to 20 minutes.

Measures

Math pretest scores. The scoring for the math problems were 1 for an incorrect answer, 5 for a partially correct answer, and 10 for a correct answer. The rationale for this scoring was based on Pajares and Miller's (1997) method of calculating accuracy and bias scores. It is easier to calculate accuracy and bias scores when the scoring for the mathematics problems are similar to the scores on the Likert-scale for self-efficacy, which also is from 1 to 10 in this study.

Math performance. These problems were scored similar to the pretest method mentioned above. The Cronbach alpha measure of internal reliability was .83 for both pretest and posttest math items.

Self-efficacy. The researcher developed the self-efficacy measure using Bandura's (2006) guidelines. Students rated their capability prior to solving the item on the posttest. The self-efficacy item was: How sure do you feel in your capability to complete this decimal division problem? The ratings ranged from 10 to 100. In analyzing the data, the ratings were divided by 10 and the new range was from 1 to 10. The final self-efficacy scores could total between 4 and 40; the mean of the four problems ranged from 1 to 10. The Cronbach alpha measure of internal reliability was .70.

Self-evaluation. Students completed this measure after solving the math problems on the posttest. This measure was adapted from Chen's (2003) self-evaluative scale. Chen's scale ranged from 1 to 8; however, this was changed to 10 to 100 and then 1 to 10 for statistical analysis in this study. This self-evaluation measure was presented as follows: After solving the problem, how sure are you that you have solved it correctly? The final self-evaluation scores could total between 4 and 40; the mean of the four problems ranged from 1 to 10. The Cronbach alpha measure of internal reliability was .70.

Self-efficacy calibration bias. There were two measures of calibration, a bias score and an accuracy score. According to the description of Schraw (1995) and Keren (1991), the researcher computed a mean bias score. Bias is the direction of the errors in judgment, and it is calculated by subtracting the actual posttest math score from the self-efficacy score (Pajares & Miller, 1997). In this study, the score for a correct answer was 10, partially correct answer 5, and an incorrect answer 1. The Likert scale for self-efficacy was the same range from 1 to 10 (after recalculation). If a student expressed no confidence (1) and answered incorrectly (1), the bias score will be (1 – 1) zero. On the other hand, if a student had no confidence, but the answer was correct, the bias score would be (1 – 10) -9, suggesting underconfidence. Likewise, a confidence score of 10 and an incorrect answer of 1 will result in a bias of (10 – 1) 9, signifying overconfidence. Therefore, scores greater than zero indicate overconfidence and scores below zero imply underconfidence. SPSS calculated a mean bias score from the four bias scores.

Self-efficacy calibration accuracy. To calculate this measure, the absolute value of each bias score was subtracted from 9 (Pajares & Miller, 1997). This score conveys the magnitude of the judgment error and it ranged from 0 (*complete inaccuracy*) to 9 (*complete accuracy*). SPSS computed a mean accuracy score for each student from the four accuracy scores.

Self-evaluation calibration scores. Using the self-evaluation ratings and the math scores on the posttest, self-evaluative accuracy and self-evaluative bias score scores were calculated similar to the self-efficacy accuracy and bias measures above.

Results

Table 1 presents the means and standard deviations for the following dependent measures: mathematics performance, self-efficacy, self-evaluation, self-efficacy accuracy, self-efficacy bias, self-evaluation accuracy, and self-evaluation bias. To address the two research hypotheses, we performed a 2 × 2 × 2 multivariate analysis of covariance (MANCOVA) on the above dependent measures. The independent or demographic variables were two groups (strategy intervention vs. control), two grades (fifth vs. sixth), and two genders (male vs. female) with math pretest as the covariate. The results revealed a significant main effect for training group, Wilks' lambda = .49, $F(5, 42) = 6.07$, $p < .05$, $\eta^2 = .51$, and an interaction between gender and grade, Wilks' lambda = .65, $F(5, 42) = 3.15$, $p < .05$, $\eta^2 = .35$.

Regarding the main effect for training groups, univariate analysis of covariance (ANCOVA) follow-up tests were conducted on each dependent measure, with the pretest as a covariate. The results revealed that the experimental groups differed significantly on six dependent measures, mathematics performance, self-evaluation, self-efficacy bias, self-efficacy accuracy, self-evaluation bias, and self-evaluation accuracy (see Table 2). Students in the strategy training group surpassed those in the control group in self-efficacy accuracy, self-evaluation accuracy, and math performance, but were significantly lower in self-efficacy bias and self-evaluation bias and self-evaluation. The latter finding revealed that the self-evaluations of trained students (M = 6.38) were significantly lower than those of the control group (M = 7.15).

Regarding the significant multivariate interaction between gender and grade, univariate follow-up tests revealed a significant two-way interaction between gender and grade for self-efficacy accuracy (see Figure 1). The fifth-grade boys surpassed the fifth-grade girls in their self-efficacy accuracy, but sixth-grade girls surpassed the sixth-grade boys on this measure.

The results for correlation analyses are presented in Table 3. All variables were significantly correlated with math performance. Self-efficacy correlated positively with math performance (r = .49) as did self-evaluation (r = .60). Self-efficacy accuracy also correlated positively with math performance (r = .75) as did self-evaluation accuracy (r = .44). Self-efficacy bias was negatively (r = -.75) correlated with math performance as was self-evaluation bias (r = -.44). The negative direction of the bias measures reveals that students' math performance decreased as they became more overconfident (Chen, 2003).

Discussion

The first research hypothesis concerned whether training in the use of a self-correction strategy would improve students' self-efficacy, self-evaluation, and mathematics performance. The second hypothesis dealt with whether training in the use of a self-correction strategy would improve the students' calibration. The dependent measures underlying both hypotheses were analyzed initially using a MANCOVA, and a significant main effect for training group was found. The size for this main effect was .51, which is classified statistically as large (Cohen, 1988). This result indicates that the self-regulatory strategy training greatly enhanced students' self-regulatory judgments and math perfor-

Table 1

Students' Grade Level and Gender Means and Standard Deviations for All Dependent Measures

Fifth-Grade Boys Control (n = 4)			Fifth-Grade Girls Control (n = 7)		
Variable	*M*	*SD*	Variable	*M*	*SD*
Math perf.	3.94	1.90	Math performance	4.32	2.54
Self-eff.	7.75	1.94	Self-efficacy	7.36	1.93
Self-eval.	8.63	1.71	Self-evaluation	5.18	3.27
Self-eff. bias	3.81	1.21	Self-efficacy bias	3.04	3.59
Self-eff. accuracy	4.94	0.83	Self-eff. accuracy	4.11	1.56
Self-eval. bias	4.69	1.70	Self-eval. bias	0.86	2.87
Self-eval. accuracy	4.31	1.70	Self-eval. accuracy	6.36	1.93
Fifth-Grade Boys Experimental (n = 4)			**Fifth-Grade Girls Experimental (n = 6)**		
Variable	*M*	*SD*	Variable	*M*	*SD*
Math perf.	6.56	2.47	Math perf.	7.25	2.95
Self-eff.	6.88	2.25	Self-eff.	8.08	1.78
Self-eval.	5.94	2.77	Self-eval.	6.58	2.89
Self-eff. bias	0.31	0.75	Self-eff. bias	0.83	1.69
Self-eff. accuracy	7.94	1.09	Self-eff. accuracy	6.50	1.46
Self-eval. bias	-0.63	1.51	Self-eval. bias	-0.67	0.65
Self-eval. accuracy	7.88	1.45	Self-eval. accuracy	8.08	0.58

Sixth-Grade Boys Control (n = 6)			Sixth-Grade Girls Control (n = 4)		
Variable	*M*	*SD*	Variable	*M*	*SD*
Math perf.	6.54	2.07	Math perf.	7.38	1.49
Self-eff.	7.00	2.25	Self-eff.	7.75	1.32
Self-eval.	8.00	1.51	Self-eval.	7.88	1.48
Self-eff. bias	0.46	1.76	Self-eff. bias	0.38	1.75
Self-eff. accuracy	6.36	1.34	Self-eff. accuracy	6.86	0.25
Self-eval. bias	1.46	1.07	Self-eval. bias	0.50	1.21
Self-eval. accuracy	6.96	1.24	Self-eval. accuracy	7.25	0.74
Sixth-Grade Boys Experimental (n = 6)			**Sixth-Grade Girls Experimental (n = 5)**		
Variable	*M*	*SD*	Variable	*M*	*SD*
Math perf.	6.96	2.42	Math perf.	8.40	2.22
Self-eff.	7.36	1.35	Self-eff.	8.50	1.73
Self-eval.	5.29	1.97	Self-eval.	7.80	3.19
Self-eff. bias	0.42	2.03	Self-eff. bias	0.10	0.78
Self-eff. accuracy	5.67	0.97	Self-eff. accuracy	7.30	2.29
Self-eval. bias	-1.67	1.99	Self-eval. bias	-0.60	1.08
Self-eval. accuracy	6.58	1.49	Self-eval. accuracy	7.90	1.52

Note. Math perf. = math performance, Self-eff. = self-efficacy belief, and Self-eval. = self-evaluation belief. The range for these three variables is 1 to 10. Self-eff. bias is self-efficacy bias, and Self-eff. accuracy is self-efficacy accuracy. These are calculated using self-efficacy and math scores. Self-eval. bias is self-evaluation bias, and self-eval. accuracy is self-evaluation accuracy. They are calculated using self-evaluation and postmath scores. The range for both bias scores is -9 (*underconfident*) to 9 (*overconfident*). For both accuracy scores, it is 0 (*completely inaccurate*) to 9 (*completely accurate*).

Table 2

Univariate Main Effect *F*-Ratios and Effect Size η² for Strategy Training on the Dependent Measures

Measures	*F*	η^2
	Between Subjects	
Math perf.	4.82*	.13
Self-eff.	0.04	.00
Self-eval.	4.83*	.13
Self-eff. bias	4.44*	.12
Self-eff. accuracy	7.60*	.19
Self-eval. bias	24.25*	.42
Self-eval. accuracy	8.40*	.20

Note. See Table 1 for description of measures. * $p < .05$.

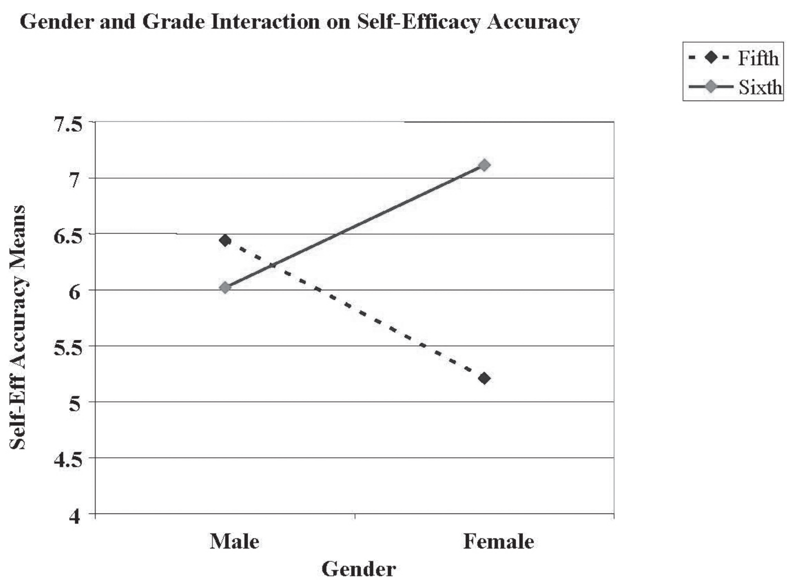

Figure 1. Interaction between grade level and gender for students' self-efficacy accuracy.

Table 3

Correlations Among Dependent Measures (Students n = 42)

Measures	1	2	3	4	5	6	7
Math perf.	–	.49**	.60**	-.75**	.75**	-.44**	.44**
Self-eff.		–	.58**	.21	.22	.10	.18
Self-eval.			–	-.22	.48**	.47**	.10
Self-eff. bias				–	-.67**	.57**	-.35*
Self-eff. accuracy					–	-.29	.58**
Self-eval. bias						–	-.39*
Self-eval. accuracy							–

Note. See Table 1 for description of measures. * correlation is significant at the .05 level (two-tailed); ** correlation is significant at the .01 level (two-tailed).

mance of the strategy training group compared to the control group. To explore this result in greater detail, we conducted separate univariate ANCOVA tests on each dependent measure. With regard to the second hypothesis, the results showed that students in the strategy training group displayed significantly higher accuracy and lower bias in their self-efficacy and self-evaluation calibration scores than their control group counterparts. This finding confirms hypothesis two and indicates that it is possible to train students to improve their accuracy and reduce the bias in their self-efficacy and self-evaluation judgments.

Regarding hypothesis one, students who received strategy training also displayed a higher level of math division performance than students in the control group, confirming that part of hypothesis one. However, the other parts of hypothesis one were not confirmed. Students in the control group unexpectedly displayed significantly higher self-evaluation scores than students in the strategy training group. This result, when considered along with the self-evaluation bias results, indicates that students in the control group overestimated their self-evaluative judgments of math performance. Furthermore, there were no significant differences in self-efficacy between self-correction strategy training students and control group students. When considered along with the self-efficacy bias results, this also indicates that students in the control group overestimated their self-efficacy judgments of math performance. However, the correlation data revealed that self-efficacy (r = .49) and self-evaluation (r = .60) measures both predicted the students' math performance significantly. Of course, the correlational measures combined data from both experimental and control group students.

The MANCOVA also revealed a significant interaction between the students' grade level and their gender. This effect was medium in size according to Cohen's statistical criteria. Follow-up univariate ANCOVA tests revealed that the interaction was created by differences in the accuracy of students' self-efficacy accuracy measure. This interaction (see Figure 1) revealed that girls were less accurate in their self-efficacy beliefs than boys at the fifth-grade level but were more accurate than boys at the sixth-grade level.

In terms of a three-phase cyclical perspective of self-regulation (Zimmerman, 2002), the present training study demonstrated that forethought phase strategy training enhanced not only metacognitive monitoring (as assessed using calibration measures) but also math performance. The calibration measures proved to be important metacognitive monitoring processes that enable students to distinguish between effective and ineffective performance, and to locate the source of errors. Finally, during the self-reflection phase, students made self-evaluative judgments of their performance. Although self-correction strategy training decreased the strength of students' self-evaluations, it made them more accurate, less biased, and more predictive of math learning outcomes.

Educational Implications

The results of this study have important implications for teachers. They suggest that teachers need to monitor students' self-efficacy judgments as well as their mathematics learning in order to provide optimal instruction. Inaccuracies in self-judgments appear to be a major liability for elementary and middle school children.

Classroom practice must not only cultivate the knowledge to succeed, but should nurture the belief that one can succeed.

Second, accuracy training can be incorporated in a curriculum such as asking students to judge how they will perform on a set of math problems in classroom work. After they solve the problems, teachers can show students how well they judged their capability to solve the problems. This training will enable students to assess their capabilities more realistically. Students who can assess what they know and what they do not know will become better self-regulated learners.

Third, strategy training in mathematics is very important. Students learn various strategies in school to solve various mathematics problems, but they may not apply the strategies if they do not see their value. Teachers need to show the connection between strategy training and self-efficacy judgments and how these psychological variables relate to better mathematics performance. Students who utilize strategies in problem solving will develop higher efficacy compared to those who do not utilize them.

Fourth, the present research confirms that accurate self-reflection is important to students' success in math, especially when learning on their own. Children do not automatically self-evaluate progress. Teachers can help students to hone this invaluable self-regulatory skill by giving them frequent opportunities to evaluate what they have learned or where they erred after completing a task. Students' self-efficacy is strengthened with tangible indicators of progress.

Finally, unrealistically low self-efficacy beliefs and not lack of ability or skill may be responsible for avoidance of challenging academic courses such as math. Teachers will have to identify these inaccurate judgments and design and implement appropriate interventions to change them.

Limitations

Regarding the size of the sample of students, a power analysis indicated large effects would be readily detected (Cohen, 1988), but medium size effects may not be detected. Thus, differences in variables that did not reach statistical significance may be detected in future studies with a larger sample.

Second, the fifth- and sixth-grade students were selected from parochial schools; therefore, the results should not be generalized beyond these two grade levels and parochial schools. Future studies should incorporate students from public schools to determine whether the same results would ensue.

A third limitation concerns the relatively brief duration of the strategy training intervention. Our decision regarding time limits was based on the schools' restrictive policy against removing the students from instructional activities. These rules allowed us access to students during only lunch or recess time, which leaves approximately 30 minutes to conduct a study lasting 45 to 50 minutes. Due to that period, it was not possible to include more items for the posttest. Four items may not be sufficient to get a range of problems from easy to difficult, making it difficult to do an analysis across item difficulty level.

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