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SELF-EVALUATION: A LEARNED SELF-REGULATORY PROCESS

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SELF-EVALUATION: A LEARNED SELF-REGULATORY PROCESS

by

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Abstract

SELF-EVALUATION: A LEARNED SELF-REGULATORY PROCESS

by

Jeffrey Ringle

Advisor: Professor Barry Zimmerman

A major aim of education is the development of intellectually competent and socially responsible self-motivated individuals. Individuals such as these have been called self-regulated learners. A self-regulated learner is one who is capable of setting his or her own goals, planning and carrying out procedures for attaining these goals and evaluating whether or not the goals have been reached. While high ability students seem able to learn and utilize these strategies, low ability students lack these skills. Previous research (e.g., Bandura and Schunk, 1981) has shown that specific instruction in setting goals and planning procedures for attaining goals can enhance student achievement and motivation.

To date, no research has been conducted to study the self-regulatory process of evaluating whether or not one has attained the goal. Teaching children a specific technique for self-evaluating their own performance was compared to two other types of evaluation: cued self-

evaluation and external evaluation. With the former, the student was asked (without additional instruction) to recheck his or her own work in order to determine which problems are correct or not. With the latter method, it was the experimenter who evaluated the results of the student's work.

In this study, children who exhibited deficits and disinterest in subtraction tasks pursued a program of instruction under conditions involving either self-evaluation, cued self-evaluation, external evaluation or without any reference to evaluation. The hypotheses were given support: that the teaching of a specific self-evaluation strategy would serve as an effective mechanism for enhancing children's competencies, self-efficacy beliefs, and interest in dealing with subtraction tasks.

The educational implication of the argument presented here was that the teaching of self-evaluation strategies can play an important role in the development of self-regulation. Schools can and should facilitate this type of learning. If students become more competent in these processes, they may assume greater direction in setting and evaluating their own accomplishments and proceed toward longer-range goals.

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To my parents, Irving and Helen, and my sister, Michaelyn, who gave me love, support and early inspiration, I dedicate this dissertation.

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Chapter 1
Review of Literature

A general objective of education is the development of intellectually competent and socially responsible self-motivated individuals, who can carry out and solve a variety of complex tasks and problems as situations demand. Students who fit this description have been called by Corno and Mandinach (1983) self-regulated learners. More specifically, the term self-regulated learner has been employed to describe an individual who is capable of selecting and defining his or her own goals for learning, is able to plan and carry out procedures for attaining these goals and has the capability to evaluate whether or not these goals have been reached. American education, particularly in the early grades, has been dominated by one instructional strategy termed "classroom recitation" (Bellack Kliebard, Hyman and Smith, 1966). With this instructional method, it is the teacher who primarily establishes the goals, plans the activities and eventually evaluates whether the students have achieved the goals. While higher ability students through vicarious learning seem able to incorporate these skills and employ them, lower ability students lack these skills (Corno and Mandinach, 1983), and therefore fail more than they succeed which in turn seems to reduce their motivation to achieve. Thus, teaching strategies such as these keep many students in a prolonged state of dependency by depriving them of knowledge of certain skills and practices which would foster self-regulated learning. The basic premise of the present paper is that education can and should specifically teach students the necessary skills to guide their own learning effectively. Thus, the purpose of the present proposal is to investigate the effects that self-regulated learning practices especially that of evaluation of one's own work has on low ability students' achievement outcomes and motivation.

One aspect of the above general aim of education, as well as being linked to the process of self-regulated learning, is the issue of motivation.

Earlier research on children's achievement motivation had been dominated by the need (N) achievement model of McClelland, Atkinson, Clark and Lowell (1955). With this model, the children's achievement levels were inferred by testing with the Thematic Aperception Test (TAT). At first differences in childrens' levels of achievement motivation (high or low) were seen as the result of prolonged differences in parenting styles. A lack of predictive validity and poor reliability of scoring of the TAT contributed to the diminished employment of this model as a research tool.

In contrast to the above theory which envisioned a person's motivation to achieve as a generalized personal disposition, more current models of academic motivation share the assumption that motivated behavior is strongly influenced by learned cognitions or beliefs about one's capacity to control one's environment. Although several models of academic motivation have been proposed, such as Weiner's (1974, 1976) and DeCharm's (1976) Attribution Theory and Lesser and Campbell's (1982) Self-Evaluation Maintenance Model, the present research will be based on a social learning approach (Bandura 1977a, 1977b, 1982; Bandura and Schunk, 1981).

Bandura (1977) has recently expanded his social learning theory to consider people's cognitive beliefs of self-efficacy. Social learning theory views human functioning as based on a model of triadic reciprocality. In this model a person element (cognitive and affective processes) a behavior element and an environmental one are assumed to interact and affect each other bidirectionally. For instance,one aspect of this bidirectional conception deals with the interaction between person factors and behavior. What people think, believe and feel affects how they behave and the effects of their actions, in turn, partly determines their thought patterns and self-percepts. Thus, cognition is an important factor in the acquisition and regulation of behavior. Motivation which is primarily concerned with activation and persistence of behavior is also partly rooted in cognitive activities. Through cognitive representations of future outcomes individuals can generate current motivators of behavior. Bandura assumes that people's behavioral functioning is determined by their feelings of efficacy in coping with a particular situation. Self-efficacy is an important interpretative process which influences motivated behavior. The present theory is based on the principal assumption that psychological procedures, whatever their form, serve as means of creating and strengthening expectations of personal efficacy. Within this analysis efficacy expectations are distinguished from response-outcome expectancies.

An outcome expectancy is defined as a person's estimate that a given behavior will lead to certain outcomes. An efficacy expectation is the conviction that one can successfully execute the behavior required to produce the outcomes. Outcome and efficacy expectations are differentiated because individuals can believe that a particular course of action will produce a certain outcome, yet they may entertain serious doubts about whether they can perform the necessary activities. It is the latter information which Bandura (1977) contends truly influences one's behavior. In this conceptual system, expectations of personal mastery affect both initiation and persistence of coping behavior. The strength of people's convictions about their own effectiveness is likely to affect whether they will even try to cope with given activities or situations. At this initial level, perceived self-efficacy influences choice of activities as well as certain behavioral settings. People fear and tend to avoid threatening situations they believe exceed their coping skills, whereas they get involved in activities and behave assuredly when they judge themselves capable of handling situations that would otherwise be intimidating. Bandura (1982) writes, "There are many competent people plagued by a sense of inefficacy and many less competent ones who remain unperturbed by impending threats, because they are self-assured of their coping abilities", (p. 136). Not only can percieved self-efficacy have a direct influence on choice of activities and settings, but through expectations of eventual success, it can affect coping efforts once they are initiated. Bandura's basic hypothesis is that the stronger the perceived self-efficacy, the more active the efforts. The preceding analysis of how perceived self-efficacy influences performance is not meant to imply that expectation is the sole determinant of behavior. Expectation alone will not produce desired performance if the component capabilities are lacking. Moreover, there are many things that people can do with certainty of success that they do not perform because they have no incentives to do so. However, with appropriate skills and adequate incentives Bandura contends that self-efficacy judgments are a major determinate of people's choice of activities, how much effort they will expend, and of how long they will sustain effort in dealing with certain situations.

As stated previously Bandura's (1977) model of self-efficacy is not concerned with people's hopes for favorable outcomes but rather with their sense of personal mastery. With this conception, self-efficacy judgments are not assesed globally at a single point in a change process as though they represent a static, unidimensional factor. Both efficacy expectations as well as performance should be assesed at signifacant junctures in the change process to clarify their reciprocal effects on each other. Mastery expectations influence performance and are, in turn, altered by the cumulative effects of one's efforts.

Efficacy expectations vary on several dimensions that have important performance implications. They differ in magnitude. Thus when tasks are ordered in level of difficulty, the efficacy expectations of different individuals may be limited to the simpler tasks, extend to moderately difficult ones, or include even the most taxing performances. Efficacy expectations also differ in generality. Some experiences create circumscribed mastery expectations. Others instill a more generalized sense of efficacy that extends well beyond the specific treatment situation. In addition, expectancies vary in strength. Weak expectations are easily extinguishable by disconfirming experiences, whereas individuals who possess strong expectations of mastery will persevere in their coping efforts despite disconfirming experiences.

An adequate expectancy analysis, therefore, requires detailed assesment of the magnitude, generality and strength of self-efficacy expectations commensurate with the precision with which behavioral processes are measured.

If self-efficacy is viewed as an important interpretive process influencing motivated behavior, what processes influence self-efficacy? Within a social learning analysis self-efficacy expectations are assumed to derive from observation of one's environment. Individuals are seen as employing various sources of information to construct efficacy expectations. Expectations of personal efficacy are based on four major sources of information: knowledge, of prior performance accomplishments in similar situations, vicarious experience, verbal persuasion and existing physiological states such as anxiety.

Thus, according to Bandura (1977), self-efficacy expectations should be stronger when past successes are viewed as resulting from personal mastery, when others (seen as similar to the self) perform well or attest to their own successes and when performance anxiety is experienced at an optimal level. Furthermore, it is expected that performance accomplishments as a source of self-efficacy imformation will be especially influential because it is based on personal mastery experiences. Successes raise efficacy expectancies, while failures lower them.

At first, self-efficacy theory had only been used to guide research on clinical interventions designed to rid people of severe phobias (Bandura, Adams &Beyer, 1977; Bandura, Adams, Hardy & Howells, 1980). The results of the above studies revealed that self-efficacy has a strong positive influence on an individuals performance. i.e., the greater the increments in perceived self-efficacy, the greater the changes in behavior. Thus, the concept of self-efficacy was shown to be an accurate predictor of performance successes. Furthermore, consistent with the social learning analysis of the sources of self-efficacy, experiences based on performance accomplishments produced higher, more generalized and stronger efficacy expectations than did those based on vicarious experiences.

More recently efforts have been made to employ the theory to direct research on students' motivations to achieve on intellectual tasks. In perhaps the first such study, Brown and Inouye (1978) hypothesized that learned helplessness could be induced through modeling, but only under the condition that an observer felt himself or herself to be comparable in competence with a model. This study was conducted with college students and utilized an insolvable anagram task. Before witnessing the model perform on the task the observers were led to believe that their competence was equal to or greater than the model's. The model then performed and experienced failure on an anagram task. Subsequently, the observers were tested for persistence on another unsolvable anagram task. The results supported Brown and Inouye's hypothesis: Students who believed themselves to be of similar competence to the model persisted for a shorter time on the task and gave more negative ratings of self-efficacy than students who believed themselves to be of superior competence to the model. This study supported Bandura's contention that vicarious experiences are one source of information which can influence self-efficacy expectations and that self-efficacy measures are highly predictive of performance which in this case was task persistence.

Zimmerman and Ringle's (1981) study was designed as one of the first efforts to investigate the role of self-efficacy judgments during observational learning with young elementary school children. The study sought to examine the effects of a model's duration of persistence (high or low) and their expressed statements of optimism or pessimism regarding the solvability of the problem on the children's self-efficacy ratings and their subsequent task persistence. As with Brown and Inouye (1978), this study employed an insolvable task: a wire puzzle which consisted of two interlocked elements that each resembled the numeral nine. The object of the task was to separate the two interlocked elements. The wire puzzle was purposely bent closed enough to prevent it from being solved. The bending, however, was not visually obvious, and during the study, no child complained that the puzzle was insolvable.

In the high persistence conditions, the model pretended to solve the problem for five minutes, whereas in the low persistence conditions, this activity was curtailed to thirty seconds. Within each persistence condition, the subjects were exposed to two types of model comments. In the confident modeling condition, at the outset and several times during problem solving, the model said, "I am sure I can separate these wires; I just have to keep trying different ways, and then I will find the right one." At the end of the session, the model said," I'm going to stop now, but I know I will be able to separate these wires next time I try." In the pessimistic modeling condition, the model said, "I don't think I can separate these wires." In all of the above conditions, the model did not succeed in solving the problem.

According to Bandura's (1977) suggestions, self-efficacy judgments were collected at several times during the study: before and after the treatment conditions and after the subjects' performance. In order to assess the children's self-efficacy estimates about solving the puzzle, a series of faces were created. The faces varied in expression, with the face on the left depicted as smiling, the middle face as expressionless and the face on the right as frowning. Each time self-efficacy measures were collected, the model presented to the subject the card with the faces drawn on it and stated, "The first (left) picture is of a person who is very happy because he is absolutely sure that he can solve the puzzle. The person in the middle is not sure if he can solve the puzzle. The last (right) picture is of a person who is unhappy because he is sure that he cannot solve the puzzle. Point to the face which tells how you feel about solving the puzzle."

The results of this study clearly indicated that a child's motivation to persist with a problem solving task can be significantly enhanced by a model's persistence and his or her expressed confidence about achieving a solution to a problem. The additional hypothesis that self-efficacy judgments, collected just prior to the children's problem solving performances, would be significantly correlated with their actual task persistence, could not be tested because of the lack of variability in the children's self-efficacy judgments. The low number of children (only one out of 80) who made pessimistic judgments obviated a statistical test of the relationship between perceived self-efficacy and duration of persistence. However, one cannot simply dismiss the self-efficacy judgments as unreliable for children of this young age, since some explainable differences did emerge relative to modeling treatments. The authors suggested that one possible reason for the lack of positive results in regard to the self-efficacy measures was due to the fact that the children were acutely aware of the model's lack of success. Subjects who were exposed to the model who persisted for five minutes lowered their post-modeling self-efficacy judgments compared to their pretest estimates. Thus, the children seemed to have concluded that a five minute effort was substantial, and the model's failure to attain a solution indicated the difficulty they might have with the task. This conclusion seems consistent with an earlier study, Zimmerman and Blotner (1979), which found that a model's degree of success further increased the subject's motivation to achieve. Thus, it is quite possible, as the authors suggested that the children in this study were overtly influenced by the model's behavior (the subjects who were exposed to the five minute modeling episodes as well as the confident model persisted significantly longer than the children who observed the shorter modeling episodes and the pessimistic model).despite their self-efficacy beliefs that they really wouldn't be able to solve the problem.

Bandura (1977) has contended that one source of people's level of self-efficacy can be derived from vicarious experience. Seeing others perform difficult tasks with successful consequences can generate expectations in observers that they too will succeed if they intensify and persist in their efforts. They persuade themselves that if others can do it, they should be able to achieve at least some improvement in performance. However, vicarious experience, relying as it does on inferences from social comparisons, is a less dependable source of information about one's capabilities than is direct evidence of personal accomplishments. Consequently, the efficacy expectations induced by modeling alone are likely to be weaker and less consistent with one's behavior.

If prior performance accomplishments is an especially influential source of information which determines and affects self-efficacy judgments because it is based on personal competency, then the next logical step would be to discuss the recent research which has focused on the specific cognitive or metacognitive processes or strategies which can cultivate and enhance competency in school achievement and thus, raise one's self-efficacy expectations.

Recently, social learning theorists have conducted training studies to improve certain self-regulatory strategies which were termed by Thoresen and Mahoney (1974) as cognitive control practices. Two of these self-regulatory practices include the setting of goals and the planning and carrying out of the procedures for attaining the goals.

Bandura and Schunk (1981) studied the effects of goal setting with children who manifested gross mathematical deficits as well as a lack of interest in this subject. It was hypothesized that the setting of proximal subgoals would be significantly more effective than distal goals or no goals in enhancing mathematical competencies, self-percepts of efficacy and intrinsic interest in mathematical activities. The performance pretest consisted of 25 subtraction problems. Children who solved more than four problems were excluded from the rest of the study. Children's perceived self-efficacy for solving subtraction problems was measured three times during the study: after the pretest, after the treatment and after the posttest. The efficacy scale ranged from 10 to 100 in 10-unit intervals with the following verbal descriptions:

10 = not sure, 40 = maybe, 70 = pretty sure and 100 = real sure. On seven consecutive school days, the children worked on instructional material that was designed to teach various subtraction operations. The material was organized in such a way that the children could work independently at their own pace.

Children were assigned randomly to one of three treatment conditions or to a nontreated control group. For children in the proximal-goal treatment, the experimenter suggested that they might consider setting themselves a goal of completing at least six pages of instructional items each session. This suggestion was made at the beginning of the second session as well. For children assigned to the distal-goal treatment the experimenter suggested at the start of the first two sessions that they might consider setting themselves the goal of completing the entire 42 pages of instructional items by the end of the seventh session. The no goal treatment group pursued the self-directed learning without any reference to goals. A fourth group of children, the nontreated control group, was administered the full set of assessment procedures without any intervening exposure to the instructional material. At the end of the self-directed learning sessions the subjects were administered a posttest assessment of subtraction competence. Children's intrinsic interest in subtraction problems was measured the day after the posttreatment assessment. The subjects were given a choice of doing subtraction problems or rows of digit symbol problems or some of both. The children worked alone for 25 minutes. The number of subtraction problems the children solved constituted the measure of intrinsic interest.

The result of the study supported each hypothesis. Children who had employed proximal subgoals did significantly better in the performance posttest than the members of the other three groups. Likewise, the proximal subgoal group significantly exceeded all others in strength of perceived self-efficacy as measured both before and after the behavioral posttest. In addition, the children in the proximal subgoal condition solved significantly more subtraction problems under the free-choice (intrinsic interest) condition than the subjects in the other three groups. The involvement in arithmetic problems displayed by the proximal children was not at the detriment of the other activity. Children in all groups performed a comparable number of digit-symbol items. This study is extremely important for two reasons: (1) it showed that young low ability students could be trained to employ the strategy of proximal subgoals; and (2) that the use of this strategy could enhance both student achievement and perceived self-efficacy.

In another investigation, Schunk (1981) attempted through modeling to teach subjects to carry out specific procedures in order to attain competency in division as well as enhancing perceived self-efficacy. Fourth grade children showing low arithmetic achievement received either modeling of division operations or didactic instruction. Schunk found that modeling of specific, step by step strategies used to arrive at the correct solutions was significantly superior to didactic instruction in teaching children to divide. In addition, the children's perceived self-efficacy was shown to be an accurate predictor of division performance. Children with higher percepts of self-efficacy subsequently persisted longer and achieved more success on arithmetic tasks than their less efficacious counterparts.

The above training studies, as well as several others (Gaa, 1973, 1979; Schunk and Gaa, 1981; Schunk 1983), have revealed that specific instruction in self-regulatory practices such as proximal goal setting and planning procedures to attain the goal can enhance student achievement and percepts of self-efficacy. To date, no research has been conducted to study the self-regulatory process of evaluating whether or not one has attained the desired goal.

In the process of striving toward a goal, persons attempt to compare their present performance to the goal. As a result of this self-evaluation, people form accurate self-perceptions of their capabilities. Individuals tend to perform better and are more accurate about what they can and cannot do when they have a specific standard in mind than when they have a less explicit standard against which to compare their performance. In most classrooms, students are rarely, if ever, given specific standards against which to compare their work. In the usual learning situation, evaluation of student performance is accomplished in one of two ways: cued self-evaluation or external evaluation. With the former, the student is asked to check his or her own work in order to determine which problems are correct or not. Although a common occurrence in classrooms, this procedure should be considered the weakest way of enhancing student achievement because these students are cued to self-observe, self-evaluate or recheck their own work without the benefit of either knowledge of previous results (feedback) or additional instruction to do so.

With the latter method, it is the teacher who checks the correctness of the student's work. This procedure is somewhat better because the student is partially helped to self-evaluate because of the availability of the knowledge of previous results. In this way, he or she can at least compare their performance on the correct solutions with their performance on the incorrect ones.

There is a third and far less employed method: one can teach students specific techniques for evaluating their own performance. For example, in order to check the correctness of a subtraction problem, one need only to ascertain whether the sum of the subtrahend and the difference is equal to the minuend. If taught and learned properly, techniques such as these should enhance student achievement because they teach students an additional and specific strategy of self-evaluating their work by means of supplying them with an explicit standard or goal against which to compare their performance. When students begin to perceive how short term accomplishments are integrated and contribute to a larger goal, and as they begin to develop accurate means for assessing their capabilities, self-evaluative techniques help to develop self-motivation, feelings of self-efficacy and personal mastery.

The educational implications of the argument presented here is that self-evaluation can play an important role in the development of self-regulation. As mentioned previously, self-regulation involves setting goals, deciding on component subgoals, planning activities to obtain the goals and evaluating whether the goals have been reached. It would seem that low ability students with little interest in academic achievements need to be specifically taught these skills in order to promote desired outcomes. Schools can and should facilitate this type of learning. As students become more competent in these processes, they will assume greater direction in setting and evaluating their accomplishments and proceed toward longer-range goals.

The purpose of this study was to investigate whether low ability children can learn a self-evaluation technique and the effects this strategy would have on student achievement, interest and self-efficacy. The subjects attempted to learn three subtraction operations under conditions involving either cued self-evaluation, external evaluation, self-evaluation or without any reference to evaluation.

It was hypothesized that:

1. The subjects who were trained to employ the self-evaluative technique would get significantly more problems correct on the posttest than subjects in the other three groups;
2. The subjects in the external evaluation group would do significantly better on the posttest than the subjects in the cued self-evaluation and the control groups, which would not differ significantly from each other;
3. The subjects in the self-evaluative group would have significantly higher posttreatment self-efficacy judgments than the members of the other three groups;

4. The subjects in the external evaluation group would have significantly higher posttreatment self-efficacy judgments than the subjects in the cued self-evaluation and the control groups, which would not differ significantly from each other;
5. The self-evaluative group would display significantly more interest in subtraction problems by choosing to do additional problems as opposed to digit symbol ones than the subjects in the other three groups.
6. The subjects in the self-evaluative group would be significantly more accurate about the correctness and incorrectness of their solutions on the achievement posttest than the subjects in the other three groups.

CHAPTER 2

METHOD

Subjects

As an initial screening procedure, teachers from the New York City public school system identified 138 children in their classes who displayed deficits in subtraction skills. After the administration of the pretreatment procedures which will be discussed in detail below, 96 second graders drawn from this pool were selected as subjects. The subjects were randomly divided into four groups of 24 each. The subjects were distributed equally by age and sex across conditions. The subects were Black and Hispanic and from a low socioeconomic neighborhood in Harlem.

Pretreatment Measures

Mathematic Performance Pretest

The performance pretest consisted of five addition and 20 subtraction problems varying in level of difficulty. The subtraction problems, which ranged from one to three columns, were similar in form and difficulty to those which would be included in the treatment and posttreatment phases of the study. Appendix A contains a copy of the mathematical performance pretest.

Self-Efficacy Judgment

In measuring the strength of mathematical self-efficacy, the children were shown five pairs of subtraction problems of varying difficulty similar to those presented to them on the pretest. Each pair of subtraction problem represented one level of difficulty. The five levels of difficulty varied only in terms of the units (ones, tens, hundreds) of the minuend and the subtrahend. The five levels of difficulty were: (1) subtracting ones from ones, (2) ones from tens, (3) tens from tens, (4) tens from hundreds, and (5) hundreds from hundreds. The numbers in the minuend were always larger than those in the subtrahend, thus no borrowing or exchanging was necessary. This gradual strategy of varying the units which were to be subtracted was chosen because it was believed that instructing low ability children in the limited time of this experiment to understand the concepts of ones, tens and hundreds and to subtract one from the other was considered complex enough. See Appendix B for a copy of the subtraction examples employed to ascertain the subjects' mathematical self-efficacy judgments.

Treatment Conditions

The subjects were randomly assigned to one of three treatment conditions or to a nontreated control group.

Self-Evaluation. The subjects in this group were given a sheet of instructions. These instructions explained, with the aid of one example, how to check subtraction problems in order to determine whether a solution is right or wrong. In order to control for reading ability, the experimenter with the use of the chalkboard, explained the instructions to these subjects. No further help was given. The three self-evaluation technique instructions and the sample problems are presented in Appendices F, G, and H.

Cued Self-Evaluation. The subjects in this group were asked whether they thought they got each of the subtraction problems (that they attempted to solve) right or wrong. The experimenter simply pointed to each problem attempted and asked the subject if he or she thought that the solution was correct or not. Neither feedback nor any further assistance was given to this group.

External Evaluation. The subjects in this group were told whether the items attempted had the correct solution. The tester pointed to each problem and marked the correct ones with a check and the incorrect ones with an "x". No further assistance was given to these subjects.

No Treatment. A fourth group of subjects received the instructional material and were administered the full set of assessment procedures (mathematical performance tests and self-efficacy judgments) without any reference to evaluation. This group would provide a control for any possible effects of the instruction alone.

Instructional Material

It has been well documented that competence in subtraction requires the knowledge of many subskills (e.g. Bandura and Schunk, 1981). These include, among others, subtracting a number from a larger one; subtracting ones, tens, hundreds, etc.; subtracting zero; subtracting a number from itself; borrowing once, twice, etc.; and borrowing from zero. Pilot work in the development of the instructional materials revealed that because of the limited time of the experiment and the abilities of the subjects involved it was necessary: (1) to limit the number of subtraction skills involved in the instructional part of the study to three operations; and (2) to ensure that the increments in knowledge between the operations was as gradual as possible.

Sets of instructional material were designed incorporating the three subtraction operations.

The material was organized in such a way that the children were able to work independently at their own pace for a set time limit. The format of each instructional set was identical. The first page of each set contained a full explanation of the relevant subtraction operation along with an example illustrating how the solution strategy could be applied. The next page contained several problems to be solved using the designated strategy. Thus, for each subtraction operation, the instructional packet contained one page of instructions followed by many examples for the subjects to attempt to solve which were similar in type and form to the subtraction operation being taught. Appendices C, D, and E illustrate these instructional materials.

Procedure

The children were administered the mathematical performance pretest in groups of ten to fifteen. They were presented the set of 25 problems and were instructed to solve as many of the problems as they could. They were given 20 minutes to complete the pretest.

Since this study focused on children who have mathematical deficiencies in subtraction, those who correctly solved more than five subtraction problems were excluded from the rest of the experiment. However, the children had also to solve correctly at least four of the five addition problems. This restriction was included in the study in order to ensure that these subjects would have the prerequisite skills necessary to learn the various subtraction operations as well as to exclude from this study those children with gross learning disabilities.

On the following day, the subject's mathematical efficacy judgments were taken. The subjects first individually performed a practice task to familiarize them with the efficacy assessment format. Following Bandura and Schunk (1981), the tester stood at varying distances (from a few inches to several yards) from the children and asked them to judge whether they could jump these distances and then, to rate on a 10-point scale the degree of certainty to their perceived capability. In this concrete way, the children were shown how to use numerical scale values to convey the strength of their self-judged efficacy.

For the mathematical self-efficacy judgments, the subjects were shown, for four seconds each, the five pairs of subtraction problems described above. This brief exposure was sufficient to portray the nature of the tasks but much too short for them to attempt any solutions. After each sample exposure, the children judged their capability to solve the type of problem depicted and rated the strength of their efficacy judgment on a 10-point scale, ranging in one unit intervals from high uncertainty (one point) through intermediate values of certainty (4-6), to complete certitude (10 points). Thus, the higher the scale value, the stronger the perceived self-efficacy.

While individual scores were taken for each of the problems which illustrated varying degrees of difficulty, the overall measure of each subject's strength of self-efficacy was obtained by dividing the summed magnitude of the scores by the total number (5) of the problems shown.

The treatment phase consisted of three subphases: an instructional subphase, a treatment subphase, and a practice subphase. Each subphase was repeated three times.

On the third day, small groups of subjects (5-10) were taken by the experimenter to a quiet classroom. After having seated the subjects at comfortable distances from one another which would make it impossible for them to view another's work, they were presented with the instructional material. With the use of a chalkboard, the experimenter explained the first subtraction operation. The subjects were asked to listen closely but were told that no questions were allowed at this point. The experimenter then told the subjects to turn the page and to attempt to solve as many of the problems as possible.

This initial part of the first practice subphase was only five minutes. This allowed the subjects time to attempt some of the first examples but not enough time to finish all of them. When the five minutes had elapsed, this signaled the beginning of the first treatment subphase. The administration of the treatments lasted ten minutes.

After the first treatment subphase, the subjects were asked to continue to work on the examples that they had initially started for another ten minutes. Following this, the second instructional operation was illustrated. In terms of procedures, time and format, the second and third subphases of instruction, treatment, and practice were exact duplications of the first. The only differences between them were in terms of the subtraction operations and the corresponding examples employed. In all, the duration of the three subphases was approximately 75 minutes. Chart I outlines the three phases of the study.

Chart I

Phases of the Experiment.

Pretreatment Phase

Addition/subtraction pretest

Self-efficacy judgment pretest

Treatment Phase

Instruction on subtraction operation #1, then 5 minutes practice.

Administer treatment #1, then 10 minutes practice.

Instruction on subtraction operation #2, then 5 minutes practice.

Administer treatment #2, then 10 minutes practice.

Instruction on subtraction operation #3, then 5 minutes practice.

Administer treatment #3, then 10 minutes practice.

Posttreatment Phase

Self-efficacy judgment posttest.

Subtraction posttest.

Self-evaluation judgments (correct, incorrect).

Interest post-assessment (subtraction and digit symbol problems).

Posttreatment Assessment

Mathematical Performance Posttest

The procedures that were employed in the posttreatment phase of the study were administered on the day following the completion of the treatment subphases. A parallel form of the performance pretest was designed and given to each of the subjects. The posttest consisted of 20 subtraction problems similar in form and difficulty to those on the pretest. The subjects were allowed 30 minutes to complete the posttest. See Appendix I for a copy of the posttest.

Self-Efficacy Judgments

The children's self-efficacy judgments were assessed for a second time prior to the administration of the mathematical posttest. The reasons for this were two-fold: (1) to measure the effects of the various treatments on the pretreatment self-efficacy judgments, and (2) to measure the value of the self-efficacy judgments in predicting subsequent mathematical performance.

Posttest Self-evaluation

Following the posttest, an additional measure was taken. All of the subjects were asked to evaluate the correctness of their solutions on the achievement posttest. The experimenter pointed to each problem attempted and asked the subject how sure he or she was that it was correct. For this question, the same self-efficacy measures were employed. This procedure was administered in order to ascertain whether the self-evaluation group would be able to be more accurate than the other group members about the correctness of their subtraction solutions.

Interest

On the day after the posttreatment assessment, the subjects' interest in subtraction problems were assessed. In accordance with Bandura and Schunk (1981), the experimenter explained to the subjects individually that he had another task for them to do. The children were shown two stacks of two pages each. In one stack there were 20 subtraction problems similar to those on the posttest while the other stack contained rows of digit-symbol problems adapted from the Wechsler Intelligence Scale for Children. The digit-symbol problem involves filling in rows of empty squares with symbols corresponding to the digits appearing above each square. The children were informed that they could work on one or the other, or both tasks. This decision and the time spent on each activity would be up to them alone. The subjects were allowed 15 minutes for this activity. The children's measure of interest was determined by their initial choice of activity. The digit symbol and the post assessment subtraction problems are presented in Appendices J and K. Furthermore, the number of subtraction problems attempted by the subjects in all the four groups was also noted and was employed as an additional indication of the children's interest in working on subtraction problems.

Chapter 3

Results

Mathematical Performance

Analyses of variance were computed on the different sets of mathematical data with two genders (male, female), two phases (pretest, posttest), and four treatment conditions (self-evaluation technique, external evaluation, cued self-evaluation, and control) representing the main factors. No significant gender differences were found on any of the measures at either the pretest or posttest assessment phases. This was expected since the sample was confined to children with mathematical deficits.

At the pretest phase, the groups' scores did not differ on either of the two mathematical measures (addition or subtraction). This result was also expected because the subjects were selected based on limited parameters of these two measures.

Analyses of the posttest subtraction data showed a highly significant main effect for treatment, $F(3,92) = 64.39$ $p < .001$. Further comparisons among the individual groups were carried out employing the Sheffe procedure. These analyses revealed, as hypothesized, that the subjects who were trained to use the self-evaluation technique got significantly more subtraction problems correct than the subjects inthe external evaluation group ($p < .05$), the cued self-evaluation group ($p < .05$), and the control group ($p < .05$). No other comparisons attained statistical significance. The means of the number of problems correct for the treatment and control groups at the two phases of the study are shown in Table 1. The subjects' subtraction scores at the pretest and posttest phases of the experiment are presented graphically in Figure 1.

The posttest subtraction data was further analyzed in terms of the level of difficulty (easy and difficult) of the subtraction problems. The "easy" problems were defined as those that corresponded to the self-efficacy judgment level number one difficulty (subtracting ones from ones) and the "difficult" problems were defined as those that corresponded to the self-efficacy judgment levels of two to five respectively (subtracting ones from tens, tens from tens, tens from hundreds, and hundreds from hundreds). No further delineation of the levels was necessary because a look at the data revealed that only a few of the subjects were able to correctly solve any of the latter three levels of subtraction difficulty.

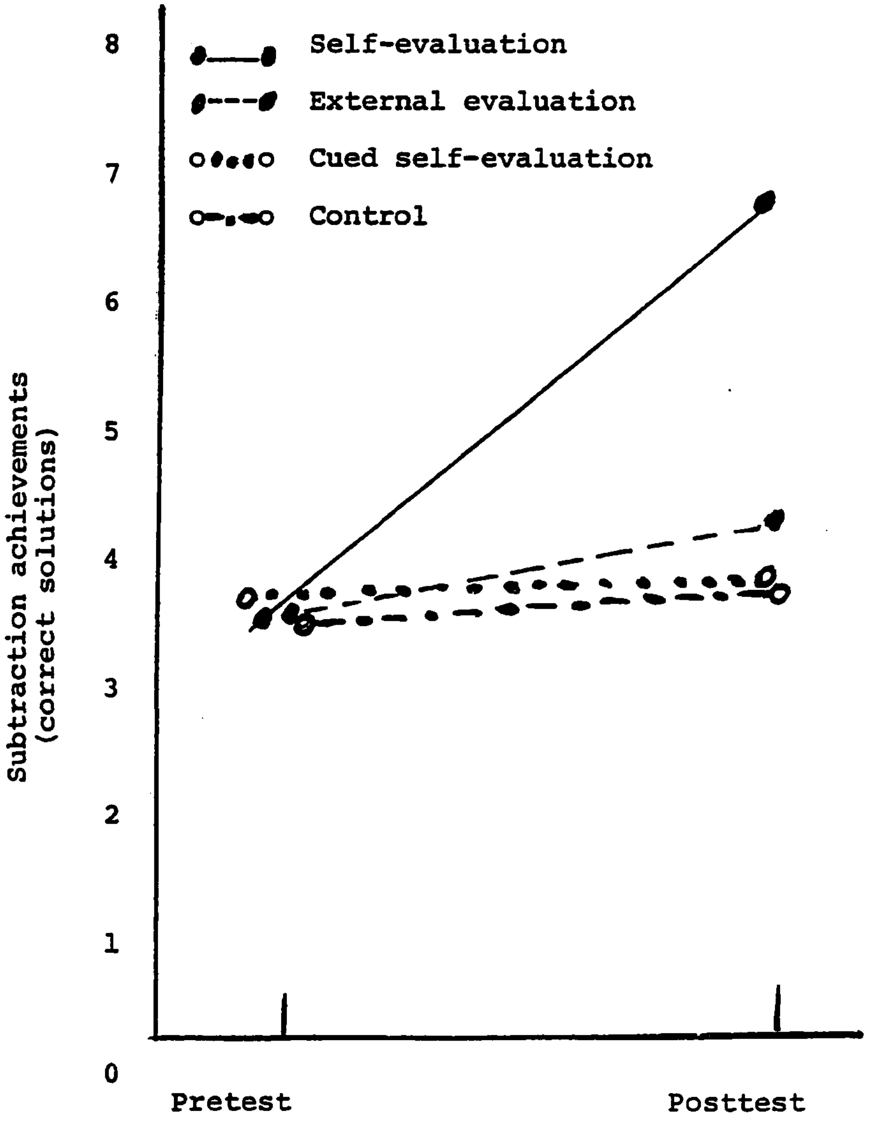
Analyses of variance were computed on this set of data with two genders, two levels of complexity (easy and difficult) and four treatment conditions as the main factors.

Table 1

Means in terms of the number of correct solutions at the different phases of the experiment for the four groups.

Group	Correct Solutions			
	Pretest		Posttest	
	M	SD	M	SD
Self-evaluation technique	3.29	.46	6.75	1.39
External evaluation	3.38	.57	4.13	.85
Cued self-evaluation	3.42	.50	3.67	.56
Control	3.36	.49	3.63	.58

Figure 1. Mean number of correct solutions for the various groups on the subtraction pre- and posttests.



These analyses revealed a significant difference between groups in terms of the number of correct solutions on the difficult subtraction problems, $F(3,92) = 69.50$ $p < .01$. No such difference existed between the groups for the easier problems. Scheffe post hoc comparisons showed that the self-evaluation group got significantly more difficult problems correct on the subtraction posttest than the members of the other three groups ($p < .05$). No other comparisons attained significance. This result indicated not only that the subjects in the self-evaluation group did significantly better overall on the subtraction posttest in terms of the number correct but also that they were able to obtain the correct solution of the more difficult problems significantly more often than the membersof the other three groups.

The mean scores of each group on the dependent measures are presented in Table 2.

Table 2.

Mean Scores on the Various Measures for Each Experimental Group.

	Group			
Measure	Self-evaluation	External	Cued	Control
Pretest self-efficacy	2.58	2.54	2.62	2.73
Posttest self-efficacy	3.45	3.42	3.49	3.58
Posttest self-evaluation (correct solution)	8.3	5.4	5.0	5.1
Posttest self-evaluation (incorrect solution)	1.7	4.4	4.6	4.7
Interest (subtraction number attempted)	8.2	5.1	4.9	4.0

Analyses also revealed a highly significant main effect for phase (pretest to posttest) of the experiment in terms of subtraction competency, $F(3,92) = 94.29$ $p < .001$. Post hoc comparisons showed that only the self-evaluation technique group attained statistical significance in terms of the number of problems solved correctly from pretest to posttest ($p < .05$).

Self-Efficacy Judgments

Analyses of variance were computed using a two (gender) by two (phases: pretreatment and posttreatment) by four (groups: self-evaluation technique, external evaluation, cued self-evaluation, and control) by five (self-efficacy judgments: levels of subtraction difficulty) design.

Contrary to what was predicted, the analyses revealed no significant main effects of group. There was, however, a significant main effect for phase, $F(3,92) = 39.68$ $p < .001$. While all of the groups increased their self-efficacy judgments from pretest (2.62) to posttest (3.49), the only significant difference found was between the phases of level number two difficulty. Post hoc comparisons revealed that pretreatment self-efficacy judgments of level two difficulty were significantly different from the posttreatment of the same level, $p < .01$.

Table 3 contains the pretest and posttest mean scores of the self-efficacy judgments.

Analyses of the other four levels of difficulty in terms of phase were not statistically significant. The means of the self-efficacy judgments of level two increased from 2.73 (pretreatment) to 6.38 (posttreatment). This indicates that regardless of group membership, the subjects felt nearly 2.5 times more confident about solving this type of subtraction problem after the treatment than they did before. Two questions are posed by this result which will be discussed in detail below: (1) Why did this difference occur at only this level of difficulty? and (2) were the self-efficacy judgments real or imaginary?, in other words, were all of the subjects able to correctly solve this level of subtraction problem or were their self-efficacy judgments inaccurate?

In an attempt to answer the second question, additional data was collected.

Table 3.

Pre- and Posttest Mean Scores of Self-efficacy Judgments by Levels of Difficulty for Each Group.

Group	Pretest				
	Levels of Difficulty				
	1	2	3	4	5
Self-evaluation	6.42	2.75	1.50	1.21	1.25
External evaluation	6.33	2.68	1.29	1.28	1.27
Cued self-evaluation	6.50	2.67	1.37	1.25	1.28
Control	6.63	2.80	1.42	1.38	1.42
Totals	6.47	2.73	1.40	1.28	1.31

Group	Posttest				
	Levels of Difficulty				
	1	2	3	4	5
Self-evaluation	7.0	5.89	1.71	1.29	1.25
External evaluation	6.58	6.50	1.38	1.33	1.29
Cued self-evaluation	6.38	6.75	1.58	1.34	1.42
Control	6.50	6.38	1.67	1.64	1.44
Totals	6.64	6.38	1.58	1.40	1.34

<u>Accuracy Between Self-efficacy Judgments and Performance</u>

Analyses of variance were computed using a two (gender) by four (groups: self-evaluation, cued self-evaluation, external evaluation and control) by two (accuracy: correct and incorrect solutions) design. These analyses revealed a main effect for group when the problem solution was correct, $F(3,92)=34.25$ $p < .001$, and a main effect for group when the problem solution was incorrect, $F(3,92)=30.54$ $p < .001$.

Scheffe's post hoc multiple comparisons showed that the self-evaluation judgments of the subjects in the self-evaluation technique group were significantly higher than those of the members of the other three groups (which did not differ significantly from each other) when the posttest subtraction problem attempted was correct ($p < .05$). By the same token, the self-evaluation judgments of the subjects in the self-evaluation technique group were significantly lower than those of the members of the other three groups (again, which did not significantly differ from each other) when the posttest subtraction problem attempted was incorrect ($p < .05$). What these analyses revealed, as was predicted, was that the self-evaluation judgments of the subjects in the self-evaluation group were significantly more accurate than those of the other subjects.

Post Assessment Interest

Another source of data in the present study involved the subject's choice of either attempting to solve some additional subtraction examples or working on some digit symbol problems. Frequencies of choice activity are presented in Table 4. Since this data involved two discrete entitites, it was analyzed nonparametrically. Chi-square procedures (two categories by four groups) were employed to analyze differences in choice of activity as it related to group membership.

The analysis revealed that choice of activity is significatnly related to group membership, $X^2(3) = 10.46$, $p < .015$. A further analysis, a partition of Chi-square, supported the hypothesis that significantly more subjects in the three treatment groups chose to attempt to solve additional subtraction problems than the subjects in the control group. In contrast, significantly more subjects in the control group chose to do the digit symbol problems than the subjects in the other three groups.

Table 4

Frequency count of subject's choice of activity as it was represented by group membership.

Group	Activity: Subtraction	Activity: Digit Symbol
Self-evaluation technique	17	7
External evaluation	13	11
Cued self-evaluation	11	13
Control	6	18

The final source of data was the number of subtraction problems attempted by the subjects in the post assessment interest phase. This data was analyzed by employing analysis of variance procedures with two genders and four treatment conditions representing the main factors.

While no significant gender differences were found, the analysis showed a significant main effect for treatment, $F(3,92) = 10.16$ $p < .01$. Post hoc comparisons revealed, as predicted, that the self-evaluation group attempted significantly more subtraction problems than the members of the other three groups ($p < .05$). No other comparisons were significant.

A final point to be made of the result was that during the practice phases, one hundred percent of the subjects in the self-evaluation group attempted to employ the self-evaluation technique.

Chapter 4
Discussion

The results of this study would seem to confirm that low ability second grade children can learn a self-evaluation technique which would in turn affect their competence, self-percepts of efficacy and interest in mathematical problems.

The present study provided evidence that teaching children to employ the self-regulatory process of self-evaluating their own work can increase their subtraction skills. Subjects who were taught to employ a self-evaluation technique did significantly better in terms of the number of correct solutions on the subtraction posttest than their counterparts who were taught in one of the two usual instructional styles: cued self-evaluation and external evaluation. While teachers have for years voiced the opinion that teaching children specific methods to evaluate their own work is a far superior way of enhancing student achievement, this study, as hypothesized, provided the first evidence that: (1) young, low ability students could learn a self-evaluation technique; and (2) that this technique could increase student performance.

As with previous research (Bandura and Schunk, 1981; Zimmerman and Ringle, 1981; Bandura and Cervone, 1983), the results of the children's self-efficacy judgments were more complex than initially hypothesized. While the subjects' self-efficacy judgments increased significantly from pretreatment to posttreatment because of the difference between the scores of level number two difficulty, it was not as originally hypothesized, related to treatment conditions. In fact, the pattern of the self-efficacy judgments from pretreatment to posttreatment were quite similar for all the groups. In order to understand this result more clearly, one must look more closely at the self-efficacy scores of the five different levels of difficulty.

The scores of the third, fourth and fifth levels of difficulty of the self-efficacy judgments remained quite low from pretreatment to posttreatment assessments for all groups (approximately a 1.5 self-efficacy rating). Apparently, neither the instructional materials nor the treatments had any effect on the subjects' confidence about being able to solve these types of problems. These types of problems were deemed too difficult to solve before the treatment conditions and remained so after the treatment conditions.

Bandura and Cervone (1983) attempted to explain this result. They suggested that when people commit themselves to explicit standards or goals, perceived negative discrepancies between what they can do and

and what they seek to achieve creates self-dissatisfactions that serve as motivational inducements for enhanced effort. However, they didn't suggest that perceived self-efficacy and performance motivation were a monotonically increasing function of the degree of perceived discrepancy. Rather, the authors posited that performances that fall markedly short of standards are apt to give rise to discouragement and thus, as with this study, not have a positive effect on the subjects' self-efficacy judgments.

By contrast, the scores of the first level of difficulty remained quite high from pretreatment to posttreatment (approximately a 6.5 self-efficacy rating). It would seem that the subjects had, on the average, the same high level of confidence about solving this easy type of subtraction problem both before and after the treatments. This result seems also to be in accordance with the theorizing of Bandura and Cervone (1983) who stated that attainments that match or surpass personal standards create self-satisfactions that serve to maintain a high level of perceived self-efficacy.

On the other hand, the self-efficacy ratings of the second level of difficulty of subtraction problem type increased significantly from pretreatment (2.7) to posttreatment (6.4) and, as stated previously, irrespective of group membership. At first glance, this result would seem to support the fact that the instructional material and/or the treatments had a positive effect on the subjects' beliefs about being able to solve this level of difficulty of subtraction problems. It is possible that the subjects felt that this second type of problem didn't look too much more difficult than the first type and thus, they would be able to solve it correctly. Bandura and Cervone (1983) and Bandura (1986) seem to agree with the above supposition when they stated that moderately discrepant performances which allow the person to view the new standard or goal as just slightly exceeding their previous performance and thus attainable are likely to increase the level of one's perceived self-efficacy judgments.

The results of the subtraction posttest showed that the children's self-efficacy judgments were quite accurate in regard to the first, third, fourth and fifth levels of difficulty of subtraction types. While the subjects did quite well in terms of correct solutions with the first level of subtraction problems, they did quite poorly with regard to the latter three levels of difficulty. What remained to be seen was whether the subjects' self-efficacy judgments on the Type #2 difficulty level were accurate and if this accuracy was related to treatment conditions.

Additional data obtained from the subjects after the posttest was administered revealed the answers to the above-posed questions. The results showed that the self-evaluation judgments of the subjects in the self-evaluation technique group were significantly higher than those of the members of the other three groups when the posttest subtraction problem attempted was correct. In contrast, the self-evaluation judgments of the subjects in the self-evaluation technique group were significantly lower than those of the members of the other three groups when the posttest subtraction problem attempted was incorrect. While it is quite clear that group membership did not have an effect on the increase of self-efficacy judgments, as was originally hypothesized, it is equally clear tha: group membership did have an effect on the accuracy of the subjects' self-efficacy judgments, i.e., the self-evaluation technique group were significantly more accurate in regard to their posttest self-efficacy judgments than the members of the cued self-evaluation, external evaluation and control groups. This result supports the previous research of Bandura and Schunk (1981) and Zimmerman and Ringle (1981) which found complex and, at times, perplexing but accurate and consistent patterns in terms of children's self-efficacy judgments. In addition, the above result of this study supports the previous research of Bandura and Schunk (1981) and Schunk (1981, 1983) which found that children's self-efficacy judgments can be employed, although not easily, as a way of predicting future achievement.

Another area of interest of this study was concerned with enhancing the motivation of low ability students. Would teaching them a self-evaluation technique increase their interest in attempting to solve subtraction problems? The results of the data concerned with this issue confirmed the initial hypothesis in two ways. First, the results revealed that significantly more subjects in the three treatment groups initially chose to do additional subtraction problems than the subjects in the control group and second, the subjects in the self-evaluation group attempted significantly more subtraction problems in that free-choice situation than the subjects in the other three groups.

Bandura (1986), in his recent book which reevaluates this whole area, has suggested that a person's perceived self-efficacy not only determines his or her choice of activity but also determines the amount of sustained effort the person will be motivated to expend on that activity. The results of the present study supported both of these assumptions. Bandura (1986) discussed the importance and need to teach self-evaluation techniques such as the one in this study if we are to develop self-regulated learners. He stated that two necessary components of an effective self-evaluation technique are knowledge of one's performance (feedback) and a standard or goal to which one can compare their performance. To regulate learning effectively, performers must have at least some information about what they are doing and some idea of the performances they are seeking to attain. Clear goals and discernible levels of performance will influence performance attainment. However, when goals are unclear and monitoring one's performance is not possible, the learner is left in foggy ambiguity. Bandura and Cervone (1983) conducted a study which confirmed the above assumptions. The results revealed that the subjects who were given both feedback and goals increased their performance level significantly greater than subjects who were given either feedback or goals alone.

The self-evaluation technique employed in this study taught the subjects a method of attaining immediate feedback of their performance and a standard to which they could compare their performance.

If, as this study suggests, self-evaluation techniques can enhance student achievement, judgments and accuracy of self-efficacy and interest in learning, then the educational implications of this study are quite significant. A competent, self-efficacious and motivated student is one who is self-directed. A self-regulated learner is, overall, the primary goal of education. However, at this point, our schools are full of what appears to most people as incompetent, non-efficacious and unmotivated students who are consistently failing, causing discipline problems and, thus, eventually leave school or are thrown out. Possibly, it is the educational system which is failing the students and not the other way around.

This study, as well as the previous research described above, have taught young, non-achieving and unmotivated students self-regulatory skills such as setting goals, planning activities to attain the goals, and establishing techniques to evaluate the goals. These skills can and should be taught at an early age.

At first, teachers will need to formulate reasonable goals and narrow self-evaluative skills such as the one in this study. At a later date, more time and eventually whole courses could be designed to teach self-regulatory skills.

Many of these skills are already known (such as the one in this study and others in the area of mathematics) but are underemployed. In other content areas teachers could have students practice setting reasonable goals for themselves and then teach them to evaluate whether those goals were attained or whether smaller subgoals would have been more appropriate.

When educators are further convinced of the significance of these metacognitive skills, they will devise more creative and broader methods of employing the concept of self-regulation and self-evaluation. With development, students should become increasingly responsible for promoting their own learning with less teacher direction. They may then be able to assume greater direction in setting and evaluating their accomplishments and proceed toward longer-range goals.

Conclusion

Self-evaluation techniques can play an important and necessary role in the development of a self-regulated learner. Self regulation involves setting goals, deciding on component subgoals, planning activities to obtain the goals and then evaluating whether the goals have been reached. If a major aim of education is the development of self-regulated learners who are defined as intellectually competent and socially responsible self-motivated individuals, then schools can and should teach students the skills necessary to promote this.

The results of this study indicated that students can be taught a self-evaluation technique which did affect their achievement, self-efficacy judgments and interest in subtraction problems. Thus, it is hoped that this study will, in a small way, encourage the teaching of the development of self-regulation. This self-evaluation technique involves only one aspect of one area of knowledge and thus, obviously, additional research is needed in order to extend this concept into other areas of knowledge.

Appendices

APPENDIX A: Mathematical Performance Pretest.

2	1	6	5	7
+3	+4	+2	+2	+5
8		9		6
−3		−5		−3
7		35		48
−4		−3		−4
63		78		47
−2		−5		−21

Appendix A continued

63 -52	57 -23	89 -45
389 -63	456 -21	379 -54
678 -66	898 -567	746 -635
674 -353	879 -456	

Appendix B: the subtraction problems varying in levels of difficulty employed to obtain the subjects' self-efficacy judgments.

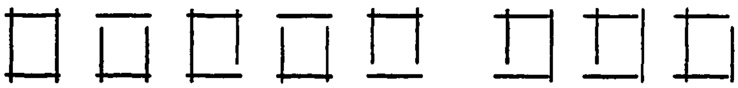
1.	8 -3	9 -5
2.	35 -3	48 -4
3.	47 -21	63 -52
4.	389 -63	456 -21
5.	674 -353	879 -456

Appendix C: instructional material; first subtraction operation and examples.

1. First we have 8 boxes

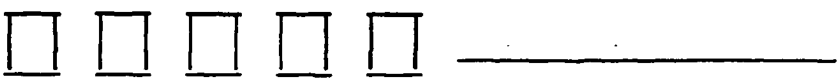
8

2. Now we want to take away 3 boxes from the 8



$$\begin{array}{r}8\\-3\\\hline\end{array}$$

3. Now we have 5 boxes left.



$$\begin{array}{r}8\\-3\\\hline 5\end{array}$$

4. Turn the page and do the other examples.

Appendix C continued

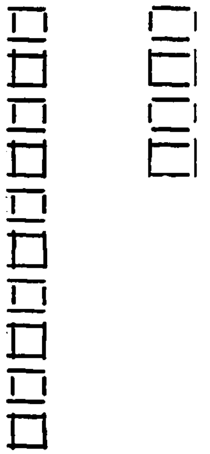
Examples

9	7	8	5	4
-5	-6	-4	-3	-2
3	6	9	5	8
-1	-3	-7	-4	-6
8	6	7	4	9
-5	-4	-3	-1	-6
9	8	6	2	7
-1	-3	-5	-1	-5

Appendix D: instructional material; second subtraction operation and examples.

1. First we have 14 boxes

tens	ones

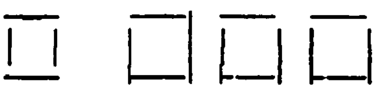


tens	ones
1	4

2. Now we want to take away 3 boxes

tens	ones
1	4
-	3

3. First we go to the ones column and take 3 ones from the 4 ones



and now we have 1 one left.

tens	ones
1	4
-	3
	1

4. Next we go to the tens column and there is nothing to take away, so we just bring down the one ten. and now we still have 1 ten left.

1	4
-	3
1	1

5. Our answer is 11.

$$\begin{array}{r} 14 \\ -3 \\ \hline 11 \end{array}$$

6. Turn the page and do the other examples.

Appendix D continued

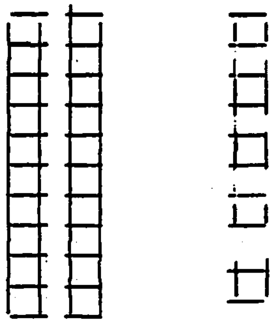
Examples

15	18	27	33	47
-3	-6	-5	-2	-4
9	8	6	9	7
-4	-5	-4	-6	-2
36	47	56	68	57
-5	-1	-4	-3	-2

Appendix E: instructional material; third subtraction operation and examples.

1. First we have 25 boxes.

tens ones

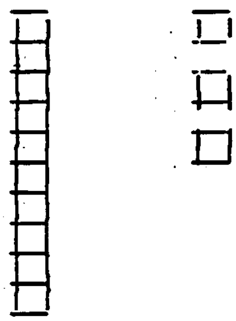


tens	ones
2	5

2. Now we want to take away 13 boxes - one ten and 3 ones.

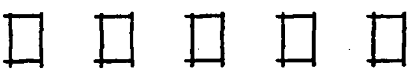
tens	ones
2	5
-1	3

tens ones



3. First we go to the ones column and take 3 ones from the 5 ones.

$$\begin{array}{r} 25 \\ -13 \\ \hline 2 \end{array}$$



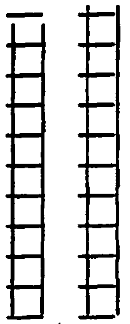
and now we have 2 ones left.

(CONTINUED ON NEXT PAGE)

Appendix E continued

4. Next we go to the tens column and take away 1 ten from the 2 tens.

$$\begin{array}{r} 2\ 5 \\ -1\ 3 \\ \hline 1\ 2 \end{array}$$



and now we have 1 ten left

5. Our answer is 12

$$\begin{array}{r} 2\ 5 \\ -1\ 3 \\ \hline 1\ 2 \end{array}$$

6. Turn the page and do the other examples.

Appendix E continued

<u>Examples</u>

24	25	38	46	65
-12	-14	-22	-33	-43
9	8	7	9	8
-8	-4	-5	-7	-6
37	47	56	68	57
-6	-2	-5	-4	-3

Appendix F: self-evaluation technique for the first subtraction operation.

Now, I'm going to show you a way to check your own work.

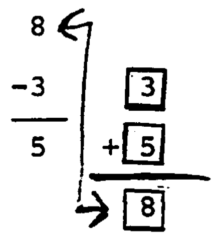
1. First, do the subtraction problem.

$$\begin{array}{r} 8 \\ -3 \\ \hline 5 \end{array}$$

2. Then, we add the bottom 2 numbers

$$\begin{array}{r} 8 \\ -3 \\ \hline 5 \end{array} \qquad \begin{array}{r} \boxed{3} \\ +\boxed{5} \\ \hline \boxed{8} \end{array}$$

3. If the answer is the same as the top number, the subtraction is right.



4. If the answer is not the same, do the subtraction again.

Appendix F continued

Examples

9 -5	7 -6	8 -4	5 -3
4 -2	3 -1	6 -3	9 -7
5 -4	8 -6	8 -5	6 -4
7 -3	4 -1	9 -6	9 -1
8 -3	6 -5	2 -1	7 -5

Appendix G: self-evaluation technique for the second subtraction operation

1. First do the subtraction problem.

$$\begin{array}{r} 14 \\ -3 \\ \hline 11 \end{array}$$

2. Then, we add the bottom 2 numbers.

$$\begin{array}{r} 14 \\ -3 \\ \hline 11 \end{array} \qquad \begin{array}{r} \boxed{3} \\ +\boxed{11} \\ \hline \boxed{14} \end{array}$$

3. If the answer is the same as the top number, the subtraction is right.

$$\begin{array}{r} 14 \leftarrow \\ -3 \\ \hline 11 \end{array} \qquad \begin{array}{r} \boxed{3} \\ +\boxed{11} \\ \hline \rightarrow \boxed{14} \end{array}$$

4. If the answer is not the same, do the subtraction again.

Appendix G continued

__Examples__

15 -3	18 -6	27 -5	33 -2
47 -4	9 -4	8 -5	6 -4
9 -6	7 -2	36 -5	47 -1
56 -4	68 -3	57 -2	

Appendix H: self-evaluation technique for the third subtraction operation.

1. First, do the subtraction problem.

$$\begin{array}{r} 25 \\ -13 \\ \hline 12 \end{array}$$

2. Then we add the bottom 2 numbers.

$$\begin{array}{r} 25 \\ -13 \\ \hline 12 \end{array} \qquad \begin{array}{r} \boxed{13} \\ +\boxed{12} \\ \hline \boxed{25} \end{array}$$

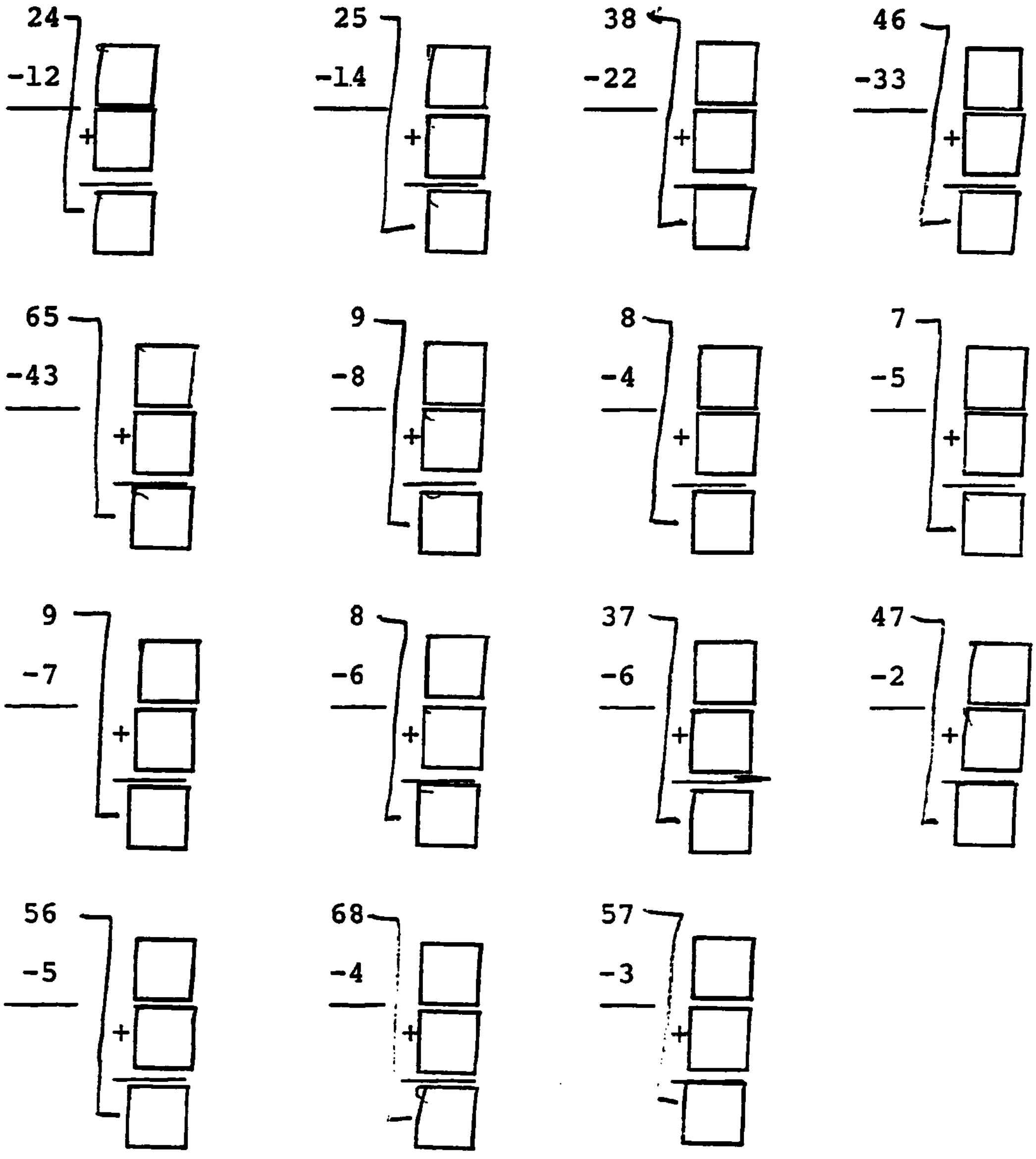
3. If the answer is the same as the top number, the subtraction is right.

$$\begin{array}{r} 25 \leftarrow \\ -13 \\ \hline 12 \end{array} \qquad \begin{array}{r} \boxed{13} \\ +\boxed{12} \\ \hline \rightarrow \boxed{25} \end{array}$$

4. If the answer is not the same, do the subtraction again.

Appendix H continued

<u>Examples</u>



Appendix I: Subtraction posttest.

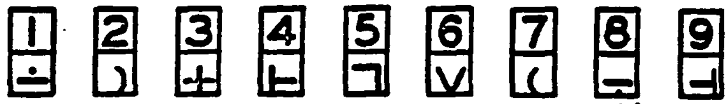
8	9	7	6
-6	-4	-3	-2
15	24	33	45
-3	-3	-2	-4
68	77	47	59
-46	-35	-25	-16

Appendix I continued

676	567	487	565
-34	-13	-64	-33
864	675	243	364
-342	-343	-132	-251

Appendix J: Digit Symbol problems.

B



SAMPLE

2	1	4	6	3	5	2	1	3	4	2	1	3	1	2	3	1	4	2	6	3	1	2	5	1

3	1	5	4	2	7	4	6	9	2	5	8	4	7	6	1	8	7	5	4	8	6	9	4	3

1	8	2	9	7	6	2	5	4	7	3	6	8	5	9	4	1	6	8	9	3	7	5	1	4

9	1	5	8	7	6	9	7	8	2	4	8	3	5	6	7	1	9	4	3	6	2	7	9	3

3	1	5	4	2	7	4	6	9	2	5	8	4	7	6	1	8	7	5	4	8	6	9	4	3

1	8	2	9	7	6	2	5	4	7	3	6	8	5	9	4	1	6	8	9	3	7	5	1	4

9	1	5	8	7	6	9	7	8	2	4	8	3	5	6	7	1	9	4	3	6	2	7	9	3

2	1	4	6	3	5	2	1	3	4	2	1	3	1	2	3	1	4	2	6	3	1	2	5	1

Appendix J continued

9	1	5	8	7	6	9	7	8	2	4	8	3	5	6	7	1	9	4	3	6	2	7	9	3

1	8	2	9	7	6	2	5	4	7	3	6	8	5	9	4	1	6	8	9	3	7	5	1	4

3	1	5	4	2	7	4	6	9	2	5	8	4	7	6	1	8	7	5	4	8	6	9	4	3

2	1	4	6	3	5	2	1	3	4	2	1	3	1	2	3	1	4	2	6	3	1	2	5	1

1	8	2	9	7	6	2	5	4	7	3	6	8	5	9	4	1	6	8	9	3	7	5	1	4

3	1	5	4	2	7	4	6	9	2	5	8	4	7	6	1	8	7	5	4	8	6	9	4	3

2	1	4	6	3	5	2	1	3	4	2	1	3	1	2	3	1	4	2	6	3	1	2	5	1

9	1	5	8	7	6	9	7	8	2	4	8	3	5	6	7	1	9	4	3	6	2	7	9	3

Appendix K: Post assessment subtraction_problems.

6 -3	8 -5	7 -4	9 -2
16 -4	23 -2	34 -3	45 -2
67 -36	76 -45	48 -34	58 -17

Appendix K continued.

675 -33	567 -24	486 -65
564 -31	865 -342	674 -423
244 -123	365 -241	

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