DOCUMENT RESUME

ED 433 236 SE 062 764

AUTHOR	Hanlon, Ellie H.; Schneider, Yasemin
TITLE	Improving Math Proficiency through Self Efficacy Training.
PUB DATE	1999-04-00
NOTE	12p.; Paper presented at the Annual Meeting of the American Educational Research Association (Montreal, Quebec, Canada, April 19-23, 1999).
PUB TYPE	Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	Higher Education; *Mathematics Achievement; Mathematics Instruction; Metacognition; Pilot Projects; *Self Efficacy; Teaching Methods

ABSTRACT

This paper reports the results of a pilot intervention designed to improve students' mathematics proficiency through self-efficacy training. Seventeen pre-first year college students participated in a five-week summer program that included whole class instruction, small group tutoring, and individual meetings with instructional coordinators. As part of the intervention, the students made self-efficacy judgments on each of ten daily quizzes and compared these judgments to their math quiz scores. In the individual meetings, the students identified short term goals, created and maintained self monitoring forms, and were introduced to a math heuristic: the math card. The data from the self-efficacy training intervention were then analyzed using a hierarchical linear model approach. Over time, students' achievement scores on a math proficiency exam improved significantly, as did their confidence levels about passing this exam. Students who participated in the self-efficacy intervention group outperformed students who were involved in the regular remedial classes. (Author)

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Improving math proficiency through self efficacy training

Ellie H. Hanlon, Yasemin Schneider
Graduate School and University Center
City University of New York (CUNY)
33 West 42nd Street
New York, NY 10036

Abstract

This paper reports the results of a pilot intervention designed to improve students'mathematics proficiency through self-efficacy training. Seventeen pre first year college students participated in a five-week summer program that included whole class instruction, small group tutoring, and individual meetings with instructional coordinators. As part of the intervention, the students made self-efficacy judgments on each of ten daily quizzes and compared these judgments to their math quiz scores. In the individual meetings, the students identified short term goals, created and maintained self monitoring forms, and were introduced to a math heuristic: the math card. The data from the self-efficacy training intervention were then analyzed using a hierarchical linear model approach. Over time, students' achievement scores on a math proficiency exam improved significantly, as did their confidence levels about passing this exam. Students who participated in the self-efficacy intervention group outperformed students who were involved in the regular remedial classes.

We would like to thank Prof. Barry Zimmerman and Prof. John Hudesman for their support, guidance, and invaluable suggestions on this project.
Presented at poster session 29.14, AERA, Montreal 22 April 1999. .*The self and self related beliefs: Effects on motivation, learning, and achievement.* Division C.

IMPROVING MATHEMATICS PROFICIENCY THROUGH SELF EFFICACY TRAINING

Introduction

This paper reports the results of an intervention designed to improve students' proficiency in doing mathematics through self-efficacy training.

In 1977, Bandura proposed a theory of origins, mediating mechanisms, and diverse effects of personal efficacy beliefs for different domains of human functioning. Self-efficacy refers to personal judgments of one's capabilities to organize and execute courses of action to attain designated types of educational performances, such as math proficiency (see Bandura, 1977; 1997).

Self efficacy is distinctive as a construct in that it:

a. Involves self-judgments of capabilities to perform activities rather than personal qualities, such as one's physical characteristics or psychological traits.

b. Is context dependent because many non-ability influences can enhance or impede the execution of skills.

c. Depends on a mastery criterion of success rather than normative or other criteria, and

d. Is assessed before students are asked to perform and thus can play a causal role in academic functioning.

There is extensive evidence of consistent and sizable correlations between students' perceived efficacy and achievement. To date, self-efficacy assessment has been used as a psychological measure. In the present research, however, self-efficacy assessment will be used as an intervention procedure as well.

There is evidence that self-efficacy judgments of poor achievers rare often inaccurately high. Because of their metacognitive limitations, poor achievers often fail to perceive the difficulty of task or to self evaluate their progress accurately, and therefore, they do not study sufficiently.

Zimmerman, Bonner, and Kovach (1996) have suggested a compensatory intervention procedure in which students' self-efficacy assessment is linked directly to homework assignments or in class quizzes. Students are asked to make a self-efficacy judgment regarding a forthcoming assignment or quiz, and then graph it next to the grades they actually obtained. This " reality check" procedure compels students to adapt their self-efficacy judgments during subsequent study efforts and this typically produces an initial drop in self-efficacy.

The heightened awareness of academic limitations prompts overconfident students to reconsider their methods and amount of studying. If the students receive compensatory self-regulatory training as well, they will be motivated to implement new methods of studying. For example, task learning strategies can assist students to correct mistaken metacognitions, especially if they are demonstrated by expert models and if students are given social guidance and feedback during their efforts to emulate strategies.

This study was planned and conducted based on a social cognitive model of academic self-regulation. Such a model was used to benefit a summer remediation program in skill training by increasing awareness of students' efficacy judgments in mathematics.

The goal of remediation programs has been to help under prepared students coming into college. Remediation programs, traditionally, have focused on assessing incoming students, providing them with compensatory curriculum services and reevaluating them at the end of remediation. All incoming students take a mandatory assessment in the area of deficiency. If their performance on the assessment does not fulfill the minimum the university has set, they are placed in skill training programs to improve their understanding of the content areas as it relates to the assessment. Traditionally, these under prepared students receive tutoring in the subject area as well as a study skills class which addresses topics such as time management, note taking, and memory techniques. These study skills classes often removed from the specific content area the student needs assistance in and are global in nature.

Even though remediation programs have had a long history in college programs, they have not included training students to become more accurate in their self-efficacy judgments as a means of improving their performance in the content areas. This study proposes that the inclusion of assessing self-efficacy in a consistent manner will improve students understanding of the material and their performance on the posttest and on assessments that take place during the training program. As the research indicates, as students become more accurate in assessing their self-efficacy, they will be more willing to adjust their methods of studying. It is this self-awareness which will help to create change. Clearly, the inclusion of self-efficacy training can have positive results for the student as well as the remedial programs they are involved in.

Methodology

Subjects

The present study was conducted with students attending a five-week summer training program in mathematics at a technical college serving urban minority students. All of the participants had initially failed an entrance test in mathematics, which precluded their enrollment in regular college courses for the following fall semester. The entrance exam in mathematics that these students had failed evaluated general arithmetic computational knowledge through beginning proficiency in algebra.

Seventeen students who enrolled in the summer course volunteered to participate in a part of the program that emphasized a self-efficacy intervention. This group is referred to as the self efficacy intervention group in the data analysis and results section.

The students were part of a compensatory program aimed at helping educationally and economically disadvantaged students. As a group, the students had a high school average of 72% and an average in their high school math classes of 53%. Eight of them were females and nine of them were males. Their average age was 19.7 years. They had all had been accepted at the technical college for the upcoming year with the understanding that they would have to pass an entrance test in mathematics prior to being able take other math courses. The average incoming math proficiency exam score was 22.5out of 40(56%). The passing score on the proficiency math exam was 25 out of 40 (63%). On the average, each student had taken and passed 1.1 units of math courses in high school.

Intervention

The summer program was composed of several parts. Students attended whole class instruction math classes for three hours a day four times a week. The instruction followed a general problem solving procedure approach. This six-step approach was comprised of the following heuristic as students attempted each math problem:

1. Identify facts
2. Estimate answer, draw a picture
3. Decide how to solve
4. Compute answer
5. Check answer
6. Is it reasonable?

This six step process was printed and laminated on a small card and was referred to as the "math card. Students were encouraged to use this approach for all math problems they encountered.

The first part of the class consisted of a short quiz based on the previous homework assignment. Before taking the quiz, students predicted their score according to how well they believed they had understood the homework. For the next portion of class, they worked on reviewing homework problems, learning new material, and solving practice problems individually and in small groups. The math card steps were used during this process as well.

The next part of the program consisted of small group tutoring twice a week for an hour each time. These tutoring sessions were led by experienced math tutors and were meant to reinforce the whole group instruction with an emphasis on the individual student. These sessions allowed students the opportunity to practice further the procedures for solving problems. The tutors were also trained to encourage students to utilize the tool called the "math card".

The final part of the summer program included half hour individual meetings with an instructional coordinator twice a week for each student. In these meetings, instructional coordinator encouraged and modeled the use of metacognitive strategies such as identifying the math problem, linking to possible past experience with similar types of problems, and making an estimate of the answer to use as a benchmark for eliminating impossible choices. Such strategies were used as the coordinator and student worked on math problems from daily assignment. The instructional coordinators reinforced the use of the mathcard steps for each problem. The use of a math card was introduced as a guide for the student to use in identifying the problem, linking current problem demands to prior knowledge, and estimating a possible solution.

Study skills were directly linked to math content. The students with a homework log, for example, individually monitored time management. The students kept a record of how long they spent on the homework, where they worked, noting distractions in the process, and answered questions on how well they understood the particular topic. These logs were kept daily for the entire five-week summer program.

The role of the instructional coordinator was to help students identify short term goals during the summer program, set up self monitoring forms to encourage students to note the conditions of their study time as well as the quality of their study time. Helping students to plan provided students with opportunities for feedback and the use of the math card helped to structure how to think about math problems. The role of the instructional coordinator, therefore, was to encourage self-awareness in developing strategy use, goal setting, and self-monitoring techniques.

Data sources and design

There are four primary sources of data for assessing possible changes within and between the self-efficacy intervention group.

1. **Daily quizzes**- On each of ten daily quizzes, students predicted their score for that quiz. This estimate is referred to as the self -efficacy score for quizzes from time 1 which is quiz 1 to time 10 which was the last quiz or quiz 10. The students' actual score on each quiz is referred to as the math quiz score. This is referred to as the math quiz score. Using the absolute difference between the math quiz score and the predicted (self- efficacy) score on each of the ten quizzes created a discrepancy variable.

2. **Math proficiency exam** - Initial entrance/placement exam that students had failed prior to the intervention making them eligible for participation in the summer program. At the end of the intervention, students were evaluated on a different version of this proficiency exam. These two exams are referred to as the pre and post test measures of math proficiency.

3. **Self -efficacy judgments on the math proficiency exam** - Prior to the intervention students were asked to make a judgment on a 0 to 100 scale on how confident they were about passing the math proficiency exam if they were to take the exam that day. After the 5 week intervention,

students were again asked to estimate their confidence level concerning passing the proficiency math exam which they took the following day.

4.The overall passing rate of the self-efficacy intervention group is compared to the overall-passing rate for the school on the same proficiency exam.

Data Analysis

1.Using a repeated measures hierarchical data analysis approach, math quiz scores and self efficacy scores for the ten quizzes were nested within each student. Each student, therefore, had a math quiz score and a self-efficacy score for each of the ten quizzes. A discrepancy score was also calculated for each student. This score was the absolute difference between actual and predicted quiz scores. The discrepancy variable was created to evaluate whether students improved in their accuracy in predicting their performance on a math quiz based on how well they believed they understood the homework from the previous night. This method of analysis is similar to a regression in which each student has an equation. Each individual equation is then collapsed into an overall regression equation. This method was chosen over traditional repeated measures approaches for two reasons. It is a more sensitive analysis in the face of missing data and an equal number of observations are not required for each student. Achievement, self-efficacy, and discrepancy scores were separately modeled over the 10 quiz times.

2. A paired sample t test between pre and post performances on the proficiency exam was conducted. The results will be discussed below. This test was conducted to evaluate whether there were possible significant differences between the average pre intervention math proficiency score and the average post intervention math proficiency score.

3. A paired sample t test between pre and post intervention on the self -efficacy prediction measure was conducted. The results will be discussed below. This test was conducted to evaluate whether there were possible significant differences in students' confidence level regarding passing the proficiency exam.

4. A paired sample test was conducted to compare possible differences in the passing rate for the self efficacy intervention group as compared to the overall passing rate for the institution's passing rate.

Results

Using a hierarchical modeling analysis approach, three separate dependent variables were evaluated. These were math quiz score, self-efficacy score, and discrepancy score across the ten quizzes. The predictor variable in each case was performance across the ten quizzes. In the complete case, there were 10 actual scores for each student and ten self-efficacy scores and ten discrepancy scores. Using the ten quizzes as a set of data points nested within the seventeen students yielded a total of 170 data points for the analysis. Due to missing data, however, the analyses were performed on 157 data points.

The time variable was recoded so that quiz 10 would reflect the intercept or the average score. So quiz 10 had a value of zero and Quiz 9 had a value of -1

Discrepancy

Predictor used	Intercept (Average)	Slope(as a function of time)	Between student variance	Within student variance
None	18.28		35.61	239.7
Time = average discrepancy at quiz 10	18.59	.06709	35.48	241.3

The average discrepancy between actual and predicted score on quizzes over time was 18.28 with a great deal of difference within students and not as much between. The average discrepancy score at the end of the intervention with time used as a predictor is 18.59 with a non-significant effect of .07 for time. Over time, therefore, the discrepancy between math quiz and self-efficacy judgments on quiz scores did not change significantly. Because of the high level of variance not accounted for, it would be worthwhile to assess student level predictors such as past achievement, SES, etc. Our predictor variable of time does not account for the variance in the discrepancy of scores.

Math Quiz Scores

Predictor used	Intercept (average)	Slope (function of time)	Between student variance	Within student variance
None	73.81		138.8	448
Intercept	70.92	-.06096	349	436.1

73.81 is the average score on actual quizzes over time. The average math quiz score at the end of the intervention, using time as a predictor, is 70.92, with a non-significant effect for time of -. 61. This result indicates that the students' scores at the beginning of the intervention are not significantly different from their scores at the end of the intervention. Adding time as a predictor variable gives a slope of -. 6096 which means that achievement /actual scores on quizzes were higher in the beginning than at the end. This is due primarily to the reality that as instruction progressed, the complexity of the mathematic material increased. Initially, students did well and scored higher on the first few weeks of quizzes, which covered basic computational knowledge (rounding numbers, decimals, fractions, and percents). As the course progressed students worked on more complex mathematical problems including factoring, quadratic equations, Pythagorean theorem, and difficult evaluations of algebraic expressions. .

Self -efficacy

Predictor used	Intercept (Average)	Slope (function of time)	Between student variance	Within student variance
None	79.41		129.4	66.73
Time	77.12	-0.4772	194.2	60.01

The average self-efficacy score when time is not used as a predictor is 79.41. Using time as a predictor, the within students variance reduces. The average self-efficacy score at the end of the intervention, using time as a predictor is 77.12 with a non-significant effect of –0.48 for time. The self-efficacy scores on quizzes did not change significantly as the course progressed. However, like the math quiz scores, this can be explained by the content of the material covered in the course. As the material became more difficult, the students became more aware of their deficiencies and lowered their self-efficacy judgments.

Math proficiency exam (Pre and post intervention scores comparison)

Time of exam	Mean	N	Standard deviation	
Pre-intervention	22.58	17	1.46	
Post-intervention	33.71	17	3.95	

There is a significant improvement in the math proficiency exam scores from pre to post intervention. 95%of the students who participated in the intervention passed the math proficiency exam. Furthermore, a passing score for the exam is 25 or above and the mean post score for the intervention students is 33.71.

Self -efficacy judgments on math proficiency exam

Time of test	**Mean**	**N**	**Standard deviation**	
Pre-intervention	**59.23**	**13**	**25.32**	
Post-intervention	**80.00**	**16**	**10.47**	

There was a significant improvement in confidence level in passing the math proficiency exam. This increase in confidence is hypothesized to be a result of participating in the intervention and its various components including its attempt to increase self-efficacy through the use of goal setting and self-monitoring techniques. At the start of the intervention, the average judgment was a 59.23, with a standard deviation of 25.32, meaning that the students were approximately 60% sure that they could pass the math proficiency exam if they were to take it that day. All of the students had previously failed this exam, making them eligible for the intervention. At the end of the intervention, on average, the students were 80% sure they would pass the math proficiency exam that they took immediately after making the judgments.

Discussion

As the course progressed, the material became more difficult. The non-significant changes are a function of this increase in difficulty as well as function of the quizzes. Each quiz differed in topic and difficulty level. Therefore, making comparisons across quizzes involves more than self-efficacy judgments. Factors such as skill level for particular topic as well as quiz design variations obscure some of the expected growth in achievement and self-efficacy predictions.

While this was a pilot intervention, the results are promising for future interventions. With the proper measures, more differences can be accounted for in terms of students' actual and predicted performance and the discrepancy between such measures. With better measures, self-efficacy may be evaluated as an intervention tool to increase the flow of feedback to the student in encouraging him/her to develop opportunities to regulate academic behaviors. The high passing rate of the intervention group and the significant increase in confidence levels, while promising, despite our poor measure for self efficacy could also be the result of interactions that students had in the classroom, with tutors, and with instructional coordinators as well as a general increased awareness and use of strategies and monitoring techniques. Given the complexity of the intervention, it is difficult to single out only one causal explanation for our successful results in that an astounding majority of students improved in their mathematical knowledge and passed a crucial proficiency exam enabling them to enroll in credit earning college math courses as they began their journey as college students.

For future interventions, we are working on being able to calibrate the difficulty of the quizzes across topic areas in order to better understand the effects of self-efficacy training on students' mathematics proficiency. With such improvements on our dependent measures, we believe that the effects of self-efficacy training will be evident.

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Organization/Address: CUNY Graduate Center/Ed. Psych
365 Fifth Avenue
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