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Effects of a High School-Based Peer-Delivered Corrective Mathematics *Program*

Abstract: The purpose of this study was to investigate the effects of a peer-delivered *Corrective Mathematics* program (*CM*; Engelmann & Carnine, 1982) in a secondary general education classroom with students with low mathematics performance. Ten learners and 9 peer tutors participated in the study. Peer tutors instructed individuals or pairs of learners in the *CM* program for 10 weeks. Pre- and posttest data were collected on the learners and peer tutors using the Woodcock–Johnson—Revised Tests of Achievement (WJ—R ACH) Calculation and Applied Problems subtests. Results showed that students who were instructed by their peers with the *CM* program exhibited improved performance on both subtests of the WJ—R ACH. Specifically, the learners' average improvement on the Calculation and Applied Problems subtests of the WJ—R ACH were statistically significant. The performance of the peer tutors also improved on both subtests of the WJ—R ACH. The peer tutors' average improvement on the WJ—R ACH Applied Problems subtest was also statistically significant. Results are discussed in terms of the implications for effective mathematics instruction and the need for future research.

Historically, students in the United States struggle with mathematics. In the 1995 Third International Mathematics and Science Study (TIMSS), American 12th-grade students were ranked 39th of 41 countries tested in the area of mathematics (International Study Center, 2001). Also, the National Center for Education Statistics (2001) noted that only 26% of 4th graders, 27% of 8th graders, and 17% of 12th graders performed at the proficient level in math. Proficient math performance is the goal for all students. These findings suggest that students exiting high school have limited basic mathematics skills needed for everyday life. They may lack the skills necessary to balance checkbooks, keep score at games, finance a car, and estimate shopping expenses.

Recently, the National Council for Teachers of Mathematics (NCTM; 2000) asserted that those who understand mathematics will have enhanced opportunities and options in shaping their own futures. In the *Principles and Standards for School Mathematics* (NCTM, 2000), the NCTM calls for a common mathematics foundation for all students while recognizing that not all students are alike. The NCTM emphasizes that mathematics curricula should not be watered down for diverse learners but rather curricular and instructional techniques should be devised so that diverse learners can think, problem solve, and reason. A comprehensive set of goals has been written for students through Grade 12. These goals

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serve as a resource for educators in improving mathematics instruction and developing curricular frameworks. The NCTM also listed several elements needed for effective instruction. These elements include providing students sufficient opportunities to learn important skills and using curricula that effectively build complex applications from basic mathematical concepts.

Effective instruction in basic skills implies that students *master* the key concepts in addition, subtraction, multiplication, division, fractions, decimals, and percentages. Unfortunately, however, instead of focused instruction that leads to mastery, many students are simply *exposed* to numerous concepts and provided little opportunity to use and retain the mathematical concepts (Stein, Silbert, & Carnine, 1997). When students are merely exposed to skills each year without mastery they only acquire a superficial understanding of mathematical concepts (Crawford & Snider, 2000; Snider & Crawford, 1996).

Another type of curricular design is scope and sequence (Miller & Mercer, 1997). In this design skills are ordered according to importance, and prerequisite skills are arranged in strands. New concepts build upon previously taught skills; these skills do not disappear at the end of a chapter but are continually reviewed for maintenance. Scope and sequence programs are designed to be both effective and efficient; skills are taught to mastery and reviewed for maintenance (Snider & Crawford, 1996). High school students who lack basic mathematics skills need to be taught from a scope and sequence derived curriculum that is both effective and efficient. Effective mathematics instruction includes modeling, guided practice with immediate feedback, independent practice, and review (Stein et al., 1997).

Direct Instruction (DI) mathematics programs (i.e., *DISTAR Arithmetic*, Engelmann & Carnine, 1975; *Connecting Math Concepts;* and *Corrective Mathematics*) are designed as mastery based scope and sequence curricula. That is, basic skills are sequenced from easiest to complex in a logical format. Each skill is separated into subskills that are taught to mastery with new skills building upon previous skills. In each lesson, new concepts are interspersed and connected to concepts previously taught. Through scripted lessons teachers are encouraged to use the essential elements of effective instruction including a rapid instructional pace and consistent presentation and correction techniques.

One DI mathematics program, *Connecting Math Concepts* (*CMC;* Engelmann, Carnine, Kelly, & Engelmann, 1996), is organized into strands such that each skill or concept is reviewed for a few minutes each day for several days (Crawford & Snider, 2000). Studies have reported increased student academic performance when the *CMC* program was used (Snider & Crawford, 1996; Vreeland et al., 1994). For example, Snider and Crawford found that students in the *CMC* program outscored control-group students who received mathematics instruction from the Scott Foresman series. The participants were randomly assigned to one of two fourth-grade classrooms. Twenty-three students were in each class and participants ranged from learning disabled to gifted. Snider and Crawford found that the *CMC* group scored significantly higher on rapid recall of mathematics facts and on the multiplication facts posttest.

Another DI mathematics program is *Corrective Mathematics* (*CM*; Engelmann & Carnine, 1982). *CM* is a remedial program for students in Grades 4–12 who are experiencing difficulties in mathematics. The focus of the program is to teach specific strategies for learning and retaining facts, solving computational problems, and discriminating between and solving various types of story problems. The curricular design is similar to *CMC*. That is, targeted skills are organized into strands composed of structured lessons. Placement tests are used to assign students into specific skill books within the program so that time is not wasted on skills that students already know. Unfortunately, no empirical investigations were found on the effectiveness of the *CM* program.

While curriculum individualization is a simple process, providing targeted instruction to a large number of students can often be difficult. One approach used successfully to deliver individualized mathematics instruction to a larger number of students is peer tutoring (Fantuzzo, King, & Heller, 1992; Maheady, Sacca, & Harper, 1987; Schloss, Kobza, & Alper, 1997). For example, Schloss et al. investigated the use of peer tutors for teaching money skills to high school students with moderate retardation. Schloss et al. found that students benefited from skilled peer models and exhibited high rates of correct responses. Additionally, students' appropriate interactions and on task behaviors increased. In another study, Maheady et al. reported that students who were part of a peer tutoring program improved on weekly mathematics assessments by 20%. Finally, Fantuzzo et al. implemented reciprocal peer tutoring with fourth- and fifth-grade students at risk for mathematics failure. Four out of five participating teachers reported improvements in student mathematics performance, social conduct, and social interactions.

Previous research has demonstrated the effectiveness of one DI mathematics program, *CMC*. Further, many investigations support the use of peer tutors for teaching mathematics. However, no research could be found on *CM*. Therefore, the purpose of this investigation was to assess the efficacy of a peer-delivered *CM* program in a general education classroom.

Method

Participants

Learners and peer tutors were selected to participate in this investigation. The selection and placement methods are described below.

Learners. School counselors identified a pool of learners based on their previous failure in Integrated Algebra, the lowest available mathematics class at the high school. From this pool of students, 10 learners volunteered to participate in the program. Each learner received one trimester mathematics credit applicable toward graduation. Six of the learners were sophomores, 2 were juniors, and 2 were seniors. Two of the learners were female and 8 were male; 1 was African American and 9 were Caucasian. None of the learners received special education services for mathematics. This class was the only mathematics class that the learners were enrolled in at the time of the study.

Peer tutors. High school mathematics teachers and school counselors recruited high school students to serve as peer tutors. Prerequisites for becoming a peer tutor included completion of the first trimester in Algebra II with at least a grade of B and an unstructured interview with the mathematics teacher coordinating the *CM* peer tutoring program (first author). Six 11th-grade students and three 12th-grade students were selected as peer tutors. Two of the peer tutors were male and seven were female. All of the peer tutors were Caucasian. Peer tutors received two college credits from a local university for participating as peer tutors.

The study took place in a suburban high school located in the Pacific Northwest. The high school enrolled 1,380 students. Approximately 16% of the students in the high school received free and reduced lunches. Instruction took place in a general education classroom at the high school. Learners and peer tutors sat one pair to a table (75 cm × 182 cm) facing each other or side-by-side. Instructional sessions were conducted 5 days per week during an 80-min instructional period. A general education teacher, certified to teach mathematics in Grades 4–12 as well as special education in Grades K–12, was present during each instructional session.

Curriculum and Materials

The *CM* program was selected for use in this study. The following levels and modules of *CM* were used: (a) Addition; (b) Subtraction; (c) Multiplication; (d) Division; (e) Basic Fractions; (f) Fractions, Decimals, Percents; and (g) Ratios and Equations.

Dependent Variables and Measurement

Dependent variables included basic mathematical calculation skills and the application of mathematical calculation skills to solve word problems. Dependent measures included standard scores based on age on the Woodcock–Johnson Psychoeducational Battery—Third Edition: Tests of Achievement (WJ—R ACH; Woodcock & Johnson, 1989) Calculation and Applied Problems subtests (Form A for pretest and Form B for posttest).

WJ—R ACH Calculation subtest. The WJ—R ACH Calculation subtest is 1 of 14 achievement subtests on the WJ—R ACH. The WJ—R ACH is an individually administered norm-referenced measure of academic achievement designed to provide information about four areas of academic performance including reading, mathematics, written language, and knowledge. On the Calculation subtest, the student is provided with worksheets containing computation problems and is required to write the answer to each problem. Items are presented in order of difficulty with simple number facts and basic operations presented first. More difficult problems require the manipulation of fractions and more advanced calculations using algebra, geometry, trigonometry, and calculus.

WJ—R ACH Applied Problems subtest. The WJ—R ACH Applied Problems subtest is another subtest of the WJ—R ACH. The items on this subtest are also presented in order of difficulty beginning with problems in which the assessor reads a question while the student looks at a drawing. Later, more difficult items involve the assessor reading word problems aloud. The student is required to give answers orally. However, the student is allowed access to pencil and paper for computation.

Design and Procedures

A preexperimental design (one-group pretest–posttest) was used (Martella, Nelson, & Marchand-Martella, 1999) to assess the effects of a 10-week implementation of a peer-delivered *CM* program on basic mathematical calculation skills and the application of mathematical calculation skills to solve word problems.

Peer tutor training. An assistant professor (third author) from the local university where the peer tutors received college credit served as the peer tutor trainer. She had 2 years of experience with DI programs and was a certified DI consultant for two other DI programs. She also served as a peer tutor trainer for another peer-delivered DI reading program. She trained the peer tutors to run the *CM* program in two 80-min sessions. Peer tutors were given a syllabus and course guide that introduced the DI model and explained why it was important in teaching mathematics to students in need of remediation. Peer tutors were also introduced to the various levels included in the *CM* program and other materials and information needed for implementation. The trainer modeled how to implement various exercises from the division and multiplication program levels that were included in the *Corrective Mathematics Series Guide* (Engelmann & Carnine, 1982). The peer tutors served as the students while the trainer modeled teaching from the example *CM* exercises. The peer tutors then acted as teachers while the trainer played the role of the student. Both positive and corrective feedback were provided. Finally, the peer tutors worked in pairs and role-played positions as both teachers and students. Instruction on error corrections and giving specific praise and feedback was provided by the trainer throughout the training session. Finally, the importance of confidentiality when working with the learners was emphasized as an integral part of the program.

Pretests/posttests. The *CM* placement test (all learners only for purposes of curricular placement) and the WJ—R ACH Calculation and Applied Problems subtests (Form A) (all learners and peer tutors) were administered by the first author and a special education graduate student during the 1st week of the 12-week trimester. The first author and special education graduate student administered the WJ—R ACH Calculation and Applied Problems subtests (Form B) (all learners and peer tutors) again during the last week of the trimester following the intervention.

Peer-delivered Corrective Mathematics *instruction*. The nine peer tutors instructed the 10 learners with the *CM* program for 10 weeks of a 12-week trimester. Instructional sessions were conducted 5 days per week during an 80-min instructional period. Based on each learner's score on the *CM* placement test, the learners were placed into a specific level of the *CM* program. One learner was placed in the addition level, 3 learners were placed in the subtraction level, 2 learners were placed in the multiplication level, and 4 learners were placed in the division level. Peer tutors were instructed to implement the *CM* program according to guidelines in the *CM* teacher's guide with the exception of instruction in peer tutoring pairs as opposed to small instructional groups. Most lessons included a series of exercises that the learners completed independently in a workbook. These exercises included previously taught skills. At the end of each exercise peer tutors corrected the learners' work.

Corrective Mathematics *mastery tests.* Mastery tests that accompanied the *CM* curriculum were administered according to the curriculum's specified administration schedule (every 10 to 15 lessons). Mastery tests were used as an evaluation tool for the peer tutors to determine if each learner mastered the material presented in the curriculum. These tests provided data concerning each learner's mastery of mathematics skills. If a learner did not perform at mastery level (at least 80% correct) on a mastery test, the peer tutor retaught suggested lessons as indicated in the mastery test booklet. After reteaching specified lessons, the learner was tested again with the same mastery test according to the curriculum's specified instructions. This process was repeated until the learner scored at or above mastery level on the mastery test. Once the learner scored at mastery level, instruction continued with the next new lesson.

Data Analysis

The performance of learners and peer tutors was evaluated separately. To investigate the change in basic mathematical calculation skills and the application of mathematical calculation skills to solve word problems of the learners, the WJ—R ACH Calculation and Applied Problems subtests were provided before and after the *CM* program. The performance of learners across pretest and posttest administrations of the WJ—R ACH Calculation and Applied Problems subtests was then compared with a t test for correlated means. The effect size measure, standardized mean difference (*SMD*), was also used to indicate the magnitude of any differences observed between the pretest and posttest performance of the learners on the WJ—R ACH Calculation and Applied Problems subtests. An effect size is independent of sample size and scale of measurement. The *SMD* was calculated by subtracting the pretest mean from the posttest mean and dividing the result by the pooled standard deviation of the two administrations of the test. *SMD* describes the extent to which distributions of scores overlap. The value of *SMD* can theoretically range from negative infinity to positive infinity.

The change of performance from pretest to posttest of the peer tutors on the WJ—R ACH Calculation and Applied Problems subtests was evaluated in the same manner as was done for the learners using *t* tests for correlated means. The effect size measure, *SMD*, was calculated to determine the magnitude of any observed differences between pretest and posttest.

Results

Learners

The means and standard deviations from pretest and posttest administrations of the WJ—R ACH Calculations and Applied Problems subtests for learners are shown in Table 1. The average learner made a standard score gain of 11.60 on the Calculation subtest and a gain of 5.80 on the Applied Problems subtest. To evaluate whether the differences between the means of the pretest and posttest administrations of the two WJ—R ACH subtests were statistically significant, paired-samples *t* tests were conducted. The *t* test for the Calculation subtest was statistically significant, $t(9) = -4.61, p < .01$. Posttest standard scores of the WJ—R ACH Calculation subtest differed statistically significantly from pretest standard scores of the WJ—R ACH Calculation subtest. The *SMD* effect size between pretest and posttest administrations of the WJ—R ACH Calculations subtest was 2.11, indicating that the posttest mean was over 2 standard deviations above the pretest mean. The *t* test for the Applied Problems subtest was also statistically significant, $t(9) = -2.52, p < .05$. Posttest standard scores of the WJ—R ACH Applied Problems subtest differed statistically significantly from pretest standard scores of the WJ—R ACH Applied Problems subtest. The *SMD* effect size between pretest and posttest administrations of the WJ—R ACH Applied Problems subtest was .89, indicating that the posttest mean was almost 1 standard deviation above the pretest mean.

Peer Tutors

The means and standard deviations from pretest and posttest administrations of the WJ—R ACH Calculations and Applied Problems subtests for peer tutors are shown in Table 1. The average peer tutor made gains of 7.40 on the Calculation subtest and 13.00 on the Applied Problems subtest. To evaluate whether the differences between the means of the pretest and posttest administrations of the two WJ—R ACH subtests were statistically significant, paired-samples *t* tests were conducted. The *t* test for the Calculation subtest was not statistically significant, $t(8) = -1.75, p > .05$. Posttest standard scores of the WJ—R ACH Calculation subtest did not differ statistically significantly from pretest standard scores of the WJ—R ACH Calculation subtest. The *SMD* effect size between pretest and posttest administrations of the WJ—R ACH Calculations subtest was .59, indicating that the posttest mean was over .50 standard deviations above the pretest mean. The *t* test for the Applied Problems subtest was statistically significant, $t(8) = -13.38, p < .01$. Posttest standard scores of the WJ—R ACH Applied Problems subtest differed statistically significantly from pretest standard scores of the WJ—R ACH Applied Problems subtest. The *SMD* effect size between pretest and posttest administrations of the WJ—R ACH Applied Problems subtest was 1.30, indicating that the posttest mean was almost 1 1/3 standard deviations above the pretest mean.

Discussion

This study examined the change in mathematics performance after a peer-delivered *CM* program was implemented in a secondary general education classroom. The results of the WJ—R ACH Calculation and Applied Problems subtests indicate that learners and peer tutors made important gains in mathematics. Specifically, statistically significant differences were observed from pretest to posttest for learners on the Calculation and Applied Problems subtests. Similarly, statistically significant differences were observed from pretest to posttest for peer tutors on the Applied Problems subtests.

Statistically nonsignificant differences were observed from pretest to posttest for peer tutors on the Calculations subtest. Nonsignificant differences may have been found due to small sample sizes. Only 10 learners and nine peer tutors participated in this study. As sample size increases, so does the probability of traditional statistically significant findings.

Of even greater importance is the educational significance of the findings. As opposed to statistical significance that identifies the probability of chance causing the results, educational significance refers to the extent to which the results of the investigation are meaningful in the real world. According to Adams and Engelmann (1996), an intervention that changes the performance of students by .25 of a standard deviation is considered educationally significant. This form of significance is considered much more important than traditional statistically significant differences. Hence, an *SMD* effect size of .25 or greater indicates educational significance. An examination of the *SMD* effect sizes for the Calculation and Applied Problems subtests for the learners and the Applied Problems subtest for the peer tutors (see Table 1) reveals that these statistically significant differences between the pretest and posttest administrations are considered to be educationally significant as well. The *SMD* effect sizes for the Calculations subtest for the learners (2.11) and the Applied Problems subtest for the learners (.89) and the peer tutors (1.30) were well above .25. Additionally, the statistically nonsignificant differences for peer tutors on the Calculations subtests had an *SMD* effect size of .59. Despite traditional statistical nonsignificance, this difference is considered educationally significant.

The results of this study extend the research on the use of the *CM* program to overcome mathematics skill deficits. Programs such as *CM* that apply the principles of effective instruction and are organized in a scope and sequence, such as DI formats, have been shown to be effective. For example, Din (1998) found that the use of DI techniques with focused mathematics curricula for students aged 7–16 produced average grade equivalent gains of 2.0 after 12 hr of instruction.

Although many DI programs have been researched extensively, there is little research specifically on DI mathematics programs. The results of this study are consistent with the

Table 1

Means, Standard Deviations, and Effect Sizes for Pretest and Posttest Administrations of the WJ—R ACH Calculation and Applied Problems Subtests for Learners and Peer Tutors

	Group	
Subtest	Learners	Peer tutors
Calculation		
Pretest	85.50	112.60
(*SD*)	(5.87)	(17.96)
Posttest	97.10	120.00
(*SD*)	(5.11)	(7.12)
SMD	2.11	.59
Applied Problems		
Pretest	92.90	104.78
(*SD*)	(4.91)	(10.60)
Posttest	98.70	117.78
(*SD*)	(8.19)	(9.38)
SMD	.89	1.30

research that does exist on DI mathematics programs. As was found in the study by Vreeland et al. (1994) on *CMC*, the learners and peer tutors made significant gains on applied mathematical problems. Likewise, the results of this study are consistent with the findings of an investigation of the *CMC* program by Snider and Crawford (1996). The learners and peer tutors were found to make gains in basic mathematical calculation skills after instruction with the *CM* program. The findings of this study align with previous research on DI mathematics programs and support the efficacy of the *CM* program.

The use of peer tutors has also been shown to be an effective way to present DI programs similar to *CM* in a one-on-one format (Butler, 1999). Students who work with peer tutors increase opportunities to respond to questions, reduce error rates, and increase correct responses per minute (Greenwood, Carta, & Hall, 1988). Previous studies that explored the use of peer tutors did not use peer tutors in conjunction with DI mathematics programs (Fantuzzo et al., 1992; Maheady et al., 1987; Schloss et al., 1997). In addition, few studies have examined the effects of peer-delivered instruction on peer tutors. This study adds to the research on the use of peer tutors for remediation of mathematics skills. The peer tutors in this study showed improvements in their problem solving skills as evidenced by the statistically significant gains on the Applied Problems subtest of the WJ—R ACH. No studies have assessed the academic gains of peer tutors in conjunction with the *CM* program.

Despite the benefits, some limitations were present in this study. First, data on the fidelity of the implementation of the *CM* program were not collected. Therefore, it is unknown if the *CM* program was implemented as intended by the program's authors. Second, the study did not incorporate a true experimental design; thus, its experimental control is compromised (Martella et al., 1999). It is unknown if other factors can account for the observed changes of performance. Future studies should include experimental and control groups and random assignment to these groups. Unfortunately, it was not possible to assign students randomly to another mathematics remediation class. Third, this study also was conducted in one school with one population (students who had failed the lowest mathematics course available in the high school); thus, results may not be generalizable to other high schools or student populations. Future studies should use the *CM* program in other settings and with students with varying backgrounds. Fourth, this study involved a small number of participants. As previously mentioned, this makes it more difficult to find traditional statistically significant differences. Future research should involve larger numbers of participants. Fifth, participants were not instructed with the entire *CM* program. Thus, this study has not investigated the effects of the complete *CM* program. Sixth, the primary dependent measurements were subtests from the WJ—R ACH. Future investigations should use other measures of mathematical skills. Finally, some of the peer tutors were also simultaneously enrolled in upper level mathematics courses at the high school. The observed differences in performance from pretest to posttest for the peer tutors may be due to instruction in these upper level mathematics courses. Future studies should use peer tutors who are not enrolled in other mathematics classes or compare results with others who are similarly enrolled.

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