Article

Use of Explicit Instruction and Double-Dosing to Teach Ratios, Proportions, and Percentages to At-Risk Middle School Students

Lisa Piper, Nancy Marchand-Martella, and Ronald Martella

Abstract: *The purpose of this action research was to determine the level of improvement of middle school students who were low performers in a mathematics class (N = 8) and who received "explicit instruction" with "double dosing" compared to their peer group who received normal instruction (N = 49). Results showed that at-risk participants: (a) demonstrated large increases in noncalculator and calculator performance, (b) performed near their peer group on the posttest assessments, and (c) performed at or near their peer group across the four quizzes. Implications for future research are discussed.*

Introduction

Mathematics and other technical skills play an important role in our everyday lives. In 1970, only 9% of all U.S. jobs were considered technical; today, technical jobs make up nearly one-third of all employment opportunities (PBS Parents, 2003). Accordingly, the National Mathematics Advisory Panel (2008) recommended that, "national policy must ensure the healthy development of a domestic technical workforce with adequate scale and top-level skill" (p. 3). As the world's reliance on technology has grown, so too has the demand for people who have solid skills in mathematics and science. Kilpatrick, Swafford, and Findell (2001) noted that mathematics has had an important impact on science, technology, engineering, business, and government. Therefore, in order for individuals to participate more fully in society, they must know basic mathematics.

Unfortunately, mathematics achievement in the U.S. lags behind that of other countries. Over the past decade, a number of international measurements and analyses of student academic performance (e.g., Trends in International Mathematics Study or TIMSS) has shown the U.S. as having relatively unimpressive results compared to other countries (Gonzales et al., 2004). Lemke et al. (2004) noted that in mathematics literacy (i.e., judgments about space and shape, change and relationships, quantity, and mathematical uncertainties) and problem solving (i.e., applying basic mathematical skills to authentic situations), the U.S. ranked 24th out of 29 nations. Further, Baker, Gersten, and Lee (2002) reported that more than 90% of 17-year-olds struggle with multistep math problems and algebra; students who do not take algebra or geometry are far less likely to go to college than their peers who do take these courses (36% versus 83%).

Further, statistics highlight the difficulties students experience in math. The 2007 National Assessment of Educational Progress (Lee, Grigg, & Dion, 2007) showed dismal results with only 32% of math scores for eighth graders at or above the proficient level. The proficient level was defined as having "a thorough understanding of basic-level arithmetic operations and understanding sufficient for problem solving in practical situations" (p. 36). Even the top-ranked state of Massachusetts resulted in only 51% of students who tested at or above the proficient level, leaving nearly half of all students tested performing at or below basic levels of math competency. Additionally, Ginsburg, Cooke, Leinwand, Noell, and Pollock (2005) reexamined data from three international surveys assessing mathematics achievement. Countries that scored well on items requiring knowledge of facts and procedures (a lower-level skill) also scored well on items emphasizing mathematical reasoning (a higher-level skill); these results suggest that basic skills are essential prerequisites to more complex mathematical tasks. Compared to other countries, U.S. students do not do well on questions at either skill level.

In response to the low mathematics achievement evidenced by U.S. students, the Fordham Foundation released a report (Klein et al., 2005) that conducted an analysis of state standards to determine their efficacy. Several areas of concern were noted after examining standards across all 50 states: (a) overemphasis of calculators; (b) limited memorization of basic math facts; (c) lack of teaching standard algorithms; (d) insufficient instruction on fractions; (e) overemphasis of patterns, manipulatives, and estimation; and (f) lack of a gradual increase in problem solving. Interestingly, the National Council of Teachers of Mathematics (NCTM; 2006) published curriculum focal points that highlight important concepts, algorithms, and basic skills that should be emphasized at increasing levels of education. The NCTM curriculum focal points recommended mathematics instruction that is fast paced, includes teacher modeling with many teacher-directed, product-type of questions, and transitions from demonstration to error-free student responding. Given the concerns raised by Klein et al. and the recent NCTM curriculum focal points, it appears that a focus should be placed on instruction that is more explicit in nature.

Explicit instruction is defined as clear, accurate, and unambiguous instruction (Stein, Kinder, Silbert, & Carnine, 2006). Tasks are broken down into small steps. The teacher models a specific skill, practices the skill with the students, providing feedback when needed, and allows time for students to practice the skill independently. Error correction procedures are conducted immediately and correct responses are praised. Guessing is kept to a minimum because students are shown specific methods to solve particular types of problems (e.g., students shown how to convert a decimal to a fraction by saying the decimal correctly, writing it as a fraction, and then simplifying the fraction using factors common to the numerator and denominator). Consequently, explicit instruction works well for basic skill development (NCTM, 2007a). It requires skill mastery before advancing to more difficult skills.

In contrast, the constructivist approach is largely student centered and focuses on inquiry-based activities where students approach a problem and create their own way to solve it. They then share different ways to approach the problem. Many tasks are open-ended and may have several different answers or one answer with many different approaches. Unfortunately, for students at risk for school failure, this approach may prove problematic (Kroesbergen, Van Luit, & Maas, 2004). Kroesbergen et al. compared constructivist instruction (CI) to explicit instruction (EI) and found that low-achieving students (ages 8 to 11) benefited more from instruction that involved explicit teaching of strategies and how and when to apply them. It was originally hypothesized that students in EI condition would show more favorable results in automaticity of basic multiplication facts, and that students in the CI condition would have a more favorable showing of results in the area of problem solving. Their findings were surprising to them. There was no significant difference in automaticity of multiplication facts, and in problem solving, the students in the EI condition outperformed students in the CI condition. They attributed that constructivist instruction resulted in lower scores as compared to explicit instruction because low-achieving students experienced both correct and incorrect solutions leading to increased confusion.

The NCTM (2000) reported the importance of the *equity principle*—namely that all students should be enrolled in a rigorous mathematics curriculum. To achieve this end, Bottoms and Carpenter (2003) found that extra help for struggling students was more effective in advancing achievement when provided by the regular classroom teacher as compared to remedial math placement. With extra assistance and modifications to a challenging mathematics curriculum, students at risk for school failure may achieve mastery of the basic skills necessary to participate in everyday activities that involve higher-order thinking skills (Kilpatrick et al., 2001; Woodward & Brown, 2006). Kilpatrick et al. stressed the importance of procedural fluency or working problems with ease, noting that in its absence, students will have trouble solving more complex mathematical problems. Further, the NCTM (2007b) noted that development of skill efficiency was promoted in classrooms that included teacher-led, whole-class instruction, a task-focused environment, and faster-paced lessons with time devoted to seatwork.

Baker et al. (2002) conducted a meta-analysis to determine the efficacy of intervention strategies for students at risk for math failure. Fifteen studies were examined spanning the years 1971 to 1999. Results showed that four interventions led to significant improvements in the mathematical skills of at-risk students. First, curriculum-based measures were effective in monitoring student progress, providing teachers with the necessary data to pinpoint specific student needs (effect size = 0.57). Second, peer tutoring was found to improve math achievement, particularly in the area of computation (effect size = 0.62). Third, supplying parents with feedback of their children's progress was found to be effective (effect size = 0.42). Finally, explicit instruction proved beneficial for low-achieving students (effect size = 0.58). The NCTM (2007a) echoed the importance of explicit instruction in their research brief highlighting effective strategies for teaching students who experienced math difficulties. The Baker et al. study was cited in this brief noting the importance of explicit instruction. Unfortunately, no studies were found on the use of explicit instruction to teach ratios, proportions, and percentages to middle school students at risk for school failure.

In addition to using explicit instruction to improve the skills of students at risk for failure, double dosing has been found to be an effective intervention. Double dosing involves the provision of additional time to acquire mathematics skills that were not achieved during the regular class period; it gives students the opportunity to hear concepts again allowing for increased academic learning time (Maxwell, 2006). Increasing instructional time has been found to be one of the most important correlates to academic learning. Anderson and Walberg (1993) noted that, "time is a central and irreducible ingredient among the alterable factors in learning" (p. 6). Double dosing offers this additional time. Bottoms and Carpenter (2003) suggested that schools should require students earning less than a B to attend extra help sessions at least twice a week, preferably offered by their regular classroom teacher. Maxwell described the importance of a second period or "double-dose" of the same subject for students at risk for failure. Double dosing in the form of extra periods or Saturday classes may be just the ingredient to academic success for struggling students. Unfortunately, no studies were found on the use of double dosing to improve skills in solving problems involving ratios, proportions, and percentages on middle school students at risk for school failure.

The purpose of this action research was to assess the effects of explicit instruction coupled with double dosing in ratios, proportions, and percentages on the mathematics skills of middle school students at risk for school failure.

Method

Participants

Two sets of participants were involved in this action research. The first set involved an at-risk group and the second involved a peer group.

At-risk participants. This at-risk group included 8 participants. There were 6 females and 2 males. All participants were Caucasian with an average age at the onset of the action research of 13 years and 2 months (range = 12 years 9 months to 13 years and 6 months).

Participants were selected for participation in this action research because they did not meet the minimum mathematics standard on the sixth-grade Washington Assessment of Student Learning (WASL). Meeting standard on the WASL was defined as earning a minimum score of 400. The WASL is divided into four levels. Level one is well below standard with scores ranging from 275-374. Level two is defined as below standard with scores ranging from 375-399. Level three is defined as meeting standard with scores ranging from 400-424. Level four is noted as exceeding standard with scores ranging from 425-550. At the middle school in this action research, 63.5% of the seventh graders at the middle school met or exceeded the seventh grade math standard; the state average was 48.5%. The participants in this action research scored between 359-391 (levels one and two) with 3 students scoring well below standard (level one) and the remaining 5 participants scoring below standard (level two).

These participants also scored at or below 40% on the district mandated mathematics diagnostic test given to all middle school students at the beginning of the school year (average score for participants selected for this action research = 29.5%; range = 22%-38%). They also earned scores below 70% correct (D or F) on mathematics assessments administered during the fall quarter of their seventh-grade academic school year (average score = 62%; range = 55%-68%). Six of the eight students were enrolled in one or more support classes because they were reading one or more years below grade level. These support classes included reading strategies, remedial science, remedial social studies, and remedial English. Additional risk factors included one student formerly identified to receive special education services, one student who received multiple discipline referrals (35 demerits; students with more than 10 demerits are defined as behaviorally at risk and are placed on a behavior contract by the school). The students in the at-risk group did not meet qualifications to be placed in an honors mathematics class and were not recommended for placement in a remedial class. No students in this group were identified for special education.

Peer group. The peer group involved those 49 students who were performing at grade level in mathematics. These students were part of an academic team. This academic team shared students among the four core academic subjects—math, science, English, and social studies. The students in the peer group did not meet qualifications to be placed in an honors mathematics class and were not recommended for placement in a remedial class. No students in this group were identified for special education.

The teacher (first author) conducted this action research in her classroom. The purpose of action research is to "solve a practical problem in an authentic setting" (Nolen & Vander Putten, 2007, p. 406). Action research can involve a teacher helping a researcher design and conduct a study (Martella, Nelson, & Marchand-Martella, 1999) as was done in this investigation. The teacher was the only math instructor for all students in both the at-risk group and peer group. Students in both groups were mixed within two periods of seventh-grade math.

Setting

This action research took place in a middle school located in the suburbs of a midsized city in the Pacific Northwest. It was comprised of seventh- and eighth-grade students, with an enrollment of 817 students (434 seventh graders and 383 eighth graders). Approximately 18% of the students qualified for free or reduced price lunch. Diversity at the school included 8% of students from culturally diverse backgrounds (American Indian or Alaskan Native, 0.5%; Asian or Pacific Islander, 3%; Black, 1.6%; and Hispanic, 1.8%).

There were three core academic teams at the seventh- and eighth-grade levels. Teams were comprised of four core academic teachers for math, science, social studies, and English. Elective and health-and-fitness teachers were not assigned to a specific team. Each academic team was assigned approximately one-third of the students at each grade level. Each of those students had the same math, science, social studies and English teacher. The middle school offered math classes for students with Individualized Education Programs, remedial math classes (two classes of 18 students), classes for students performing at grade level, and honors math classes (single and double acceleration).

The teacher in this action research was an author. She conducted this action research as part of her requirements for a master's degree in interdisciplinary studies with focus on mathematics and special education. She earned a bachelor's degree in education with a major in mathematics and hold a K-8 endorsement. She has 10 years of experience teaching middle school mathematics with four years of experience providing remedial mathematics instruction. The district trained her in the use of the district-approved mathematics program. She has also participated in two 1-week summer institutes offered by her employing school district. The institutes sought to align curriculum with the Washington State Grade Level Expectations (GLE) across grades K-12 within the district.

Curriculum

Connected Math Project (CMP). CMP (Lapan, Fey, Fitzgerald, Friel, & Phillips, 2004) was the district-approved middle school mathematics program. The program is an inquiry-based mathematics program that is taught to sixth- and seventh-grade students. One seventh-grade unit of *CMP* was used in this action research project—Comparing and Scaling. The Comparing and Scaling unit contained very little basic skill instruction or review; thus, basic skills worksheets and lessons were developed to supplement the *CMP* unit. Once the basic skills lessons were taught, students then participated in the inquiry-based lessons found within the Comparing and Scaling unit. This unit included: (a) conversion of fractions, decimals, and percents; (b) proportions from word problems; (c) unit rates from word problems; (d) comparison of ratios using inequalities and equal symbols; (e) solving for missing numbers in proportions; (f) finding missing numbers in percent sentences; and (f) calculation of tax and discounts.

Conversion of fractions, decimals, and percents. Lessons on this topic included calculator use as well as a requirement to memorize conversions for frequently used fractions with denominators such as 2, 3, 4, 5, 8, and 10. Students were taught to convert between fractions and decimals followed by conversion between decimals and percents. To convert between fractions and percents, students would convert to a decimal as an intermediate step. An example problem might include the following: “Convert 5/8 to a decimal and a percent. Do not round. Describe the process that you used.”

Proportions from word problems. Students were taught to read problems twice and place the information into a proportion using a variable for the missing number. Cross products were then used to solve the problem. An example problem might include the following: “Gavin traveled 354 miles on 12 gallons of gas. How many miles did Gavin travel using 20 gallons of gas?”

Unit rates from word problems, The same format that was used to solve unit rates was used to solve non-unit-rate proportions, but attention was focused on converting unit rates into fraction form to complete a proportion. Students could solve a problem such as the following: “If 4 pounds of watermelon cost $2.16. What is the cost per pound?”

Comparison of ratios using inequalities and equal symbols. Three methods of comparison were taught. These included comparison of two ratios by conversion to a decimal, comparison of cross-products, and use of common denominators. Students used the method of their choice after showing mastery (80% correct) for each method. An example problem might read: “Place a symbol for less than (‹), greater than (›) or equal to (=) between the two given ratios using the method indicated.”

Solving for Missing Numbers in Proportions. Three out of four numbers were placed in a direct proportion with a variable in place of the missing number. Students were taught to use the product of the extremes set equal to the product of the means (cross products). A sample problem might include “3/4 = c/8. Use cross products to solve for c.”

Finding a missing number in percent sentences. A percent sentence was given in words and students were asked to place the numbers and one variable into a percent proportion. Students used cross products to solve for the missing number. An example problem could be written as follows: “What is 6% of 200?”

Calculation of tax and discounts. Students calculated tax and discounts using the percent proportion. These problems were multistep in nature and asked students to decide if they needed to add or subtract an amount or complete further calculations to arrive at the final solution. An example problem could ask students: “Calculate a 20% discount. Find the sale price. Add a 9% sales tax to arrive at the new total.”

Additional Materials

Besides paper and pencil practice, students used dry erase boards, markers, and erasers to practice basic skills. Additionally, a Jeopardy-style piece of technology (i.e., Eggspert—see www.callowayhouse.com for details) that allowed students to ring in electronically to give an answer was used to review for tests.

Four-function basic calculators were used to convert between fractions and decimals and to calculate percents, discounts, tax, and some cross products. Spiral notebooks were required and used to keep class notes organized. They were also used for basic skill review problems.

Basic skill worksheets were created and selected by teachers who attended two 1-week summer institutes sponsored by the school district in this action research. Worksheets were selected from reproducible basic skill workbooks from various publishers including Steck-Vaughn, Instructional Fair, and Frank Schaffer Publications.

Dependent Variables and Measures

The at-risk group was assessed before and both groups (i.e., at-risk and peer) were assessed and the intervention provided to the at-risk group. These pre- and posttest assessments were teacher-developed and in alignment with grade level expectations and the *CMP* curriculum. Students in both the peer and at-risk groups received the same assessments. Tests and quizzes were not modified for students in the at-risk group. Students were given up to two 50-minute class periods to complete each assessment, depending on individual needs. Four quizzes were also provided during the course of the action research to all students. Quizzes were completed during the 50-minute class period.

Pre- and Posttest Assessments

The teacher administered a pretest to the at-risk participants in the action research to evaluate their specific needs. This pretest was comprised of a calculator section and a noncalculator section. There were a total of 48 problems on the pretest. The calculator section included 22 problems. Ten problems asked students to convert a fraction, decimal, or percent to its two remaining forms. Two word problems (one unit rate proportion and one nonunit rate proportion) asked students to set up the proportion and solve it. The noncalculator section included 26 problems. Students had two problems that asked them to explain the process used to convert from a decimal to a fraction and from a fraction to a decimal. Three problems were set up as direct proportions with three of four numbers given, and a variable was used to represent the unknown quantity. Students were asked to find the value of x in the proportion. Students received six problems that asked them to compare two ratios using less than (<), greater than (>), or equal to (=) symbols. They were asked to use the cross-product method for three of the problems and the common-denominator method for the remaining three problems. Three word problems dealt with tax, discounts, and sale prices and were multistep in nature. The last six problems were percent sentences (e.g., “15 is what percent of 45?”). The pretest was scored but not entered as part of the student’s grade. Percentage correct served as the dependent measure.

The posttest was administered to all students (i.e., at-risk and peer groups) and was entered as part of each student’s grade. It included 44 problems. Items that were previously found in only the calculator or noncalculator sections of the pretest were now found in both sections of the posttest. On the noncalculator section (18 problems), two problems asked students to describe the process of converting a fraction to a decimal and a decimal to a fraction. Five problems asked students to convert a fraction, decimal, or percent to its two remaining forms (e.g., “Express .375 as a fraction and as a percent”). Eight problems asked students to find the percent of a number (e.g., “What is 10% of 62?”). Three problems had students calculate a sale price, a discount, and tax. The noncalculator section included 26 problems. Ten problems asked students to convert a fraction, decimal, or percent to its two remaining forms (e.g., “Express 114% as a decimal and as a fraction”). Four word problems had students set up a proportion and solve it. Two of the word problems were unit rate proportions, and the remaining two problems were nonunit rate proportions. Students were given six problems that had them compare two ratios using less than (<), greater than (>), or equal to (=) symbols. They were asked to use the cross-product method for two of the problems, the decimal-conversion method for two problems, and the common-denominator method for the remaining two problems. The final six problems were percent sentences (e.g., "15 is 60% of what number?"). Students had to find the value of x in a direct proportion on the pretest, but this type of problem was not directly tested on the posttest because this basic skill was embedded in several other test questions (e.g., word problems, percent sentences). Percentage correct served as the dependent measure.

Quizzes

Four quizzes were administered to all students during the action research; percentage correct served as the dependent measure. These quizzes were included in the students' grades. The first quiz covered conversions between fractions, decimals, and percents. Mixed numbers were introduced creating percents over 100%. Decimals were selected that were easily simplified into their fraction form. Percents less than 1% were also assessed. Fractions were selected that converted to terminating as well as repeating decimals. Students were asked to compare two ratios using less than (<), greater than (>), or equal to (=) symbols using the decimal-conversion, cross-products, and the common-denominator methods. There were 13 conversion problems and six ratio-comparison problems (total problems = 19).

The second quiz assessed conversion between fractions and decimals using more difficult numbers and solving percent sentences using the is-of-percent-100 proportion. There were 10 conversion problems and eight percent sentence problems (total problems = 18).

The third quiz assessed each student's skill in analyzing a word problem and placing it into a proportion to solve for an unknown. Two types of direct proportions were assessed in this quiz—a proportion that sought a unit rate (e.g., per pound, per hour) as a solution and a proportion that asked for a solution other than a unit rate (e.g., if 2 pounds cost $1.68, then how much do 5 pounds cost?). There were nine problems on this quiz.

The fourth quiz assessed each student's skill in calculating various percents of a number (26 problems). It also assessed how to calculate tax and discounts and to solve multistep problems (three problems). Total number of problems equaled 29.

Procedures

Twenty-four instructional days were allocated for the explicit instruction of basic skills and seven instructional days were allocated for inquiry-based lessons taken from the Comparing and Scaling unit of *CMP* for a total of 31 instructional days. All students (in both the at-risk and peer groups) were taught using the same method of instruction during the regular class period. Additionally, the skills taught on Monday, Tuesday, and Wednesday were reviewed during the Thursday double-dose session (described later).

Explicit instruction was used to teach the various skills. The teacher began the class with warm-ups (review problems from previous lessons) for approximately 5-7 min at the beginning of a class period. I then followed the "I do. We do. You do" model of delivery for the first 10-15 minutes of each lesson. Further, I modeled between five and 10 problems determined by the difficulty and length of a specific skill. The students watched this demonstration. Next, the students practiced one problem at a time with the teacher for a minimum of five problems, depending on the level of difficulty. Students then practiced one problem independently and then compared their calculations and answer with the teacher's calculations and answer.

After several problems were completed using this process, students used the think-pair-share strategy. This strategy provided quiet time for students to complete a task on their own, an opportunity for them to share their work with a neighbor, and time to share processes and answers. Students then worked independently to complete a series of problems while the teacher circulated to check student progress. When necessary, error correction procedures were provided. The teacher would say, "Watch me do the problem. Now let's do one together. Now let me watch you do one." Once students completed several practice problems independently with immediate feedback from the teacher using specific (e.g., "Yes the answer is 18") and general (e.g., "super") praise statements, they were given application problems. Lessons ended with a review of strategies taught during the lesson.

After all necessary basic skills had been taught, students from both groups participated in inquiry-based lessons taken from the Comparing and Scaling unit. Students worked in small groups to solve proportional reasoning tasks, participated in small and large group discussions, and presented solutions to these tasks to the class. Students were required to include an explanation of the process used to solve each task in their small group presentations.

The teacher offered a double-dose session each Thursday for 25 minutes during lunchtime. During this time, skills were reviewed and practiced from lessons taught during the week and followed the same procedures previously described for in-class instruction. The double-dose sessions included between six-to-eight of the at-risk participants. Thursdays were selected because they occurred the day before a quiz and could offer additional review after four consecutive class days. The at-risk group was the group targeted for this additional instruction; however, sessions were open to anyone who wanted to attend. Zero, one, or two students from the peer group attended sessions offered during the course of the action research. The exception was the final double-dose session before the posttest. At this session, all students from the at-risk group attended and 12 students from the peer group attended. No individual student from the peer group attended more than two double-dose sessions.

Instructional Fidelity

An observer (i.e., fellow teacher in the same building as the teacher in this action research) observed instruction during the double-dose sessions for instructional fidelity purposes. She had taught science for 16 years and had formerly taught mathematics at the middle school level. She holds a bachelor's degree in science education (4-12) and an endorsement in elementary education (K-8). She also earned a master's degree in education. She received training from the teacher in this action research. During the training, the teacher described the procedures to be observed. The explicit instruction procedure, "I do.

We do. You do" was explained as well as error correction procedures. These procedures were recorded on a form developed by the teacher in this action research. There were three observations made by the observer, and the form was signed to verify that the teacher in this action research followed these procedures. The form included the following points: (a) teacher demonstration of basic skill problems, (b) guided practice problems, (c) independent practice problems, (d) use of positive praise (specific and general), (e) error correction procedures, and (f) the session lasted 25 min. Two observations during the double-dose sessions were conducted. Instructional fidelity was maintained for both observations.

Results

Pre- and Posttest Assessments

Large increases were noted across all at-risk participants for noncalculator and calculator assessments. They performed near their peer group level on the posttest assessments.

Noncalculator assessments. As shown in Table 1, all at-risk participants demonstrated improved performance on the noncalculator and calculator assessments. The smallest increase from pretest to posttest was 38 percentage points for Participant 1. Participant 4 demonstrated the largest improvement of 75%. The average increase across all at-risk students was 52.25%. The average posttest performance for the at-risk group was slightly above the peer group's posttest performance.

Calculator assessments. Table 1 shows that all at-risk participants demonstrated large improvements in performance. Participant 4 demonstrated the smallest improvement of 38%, while the largest improvement was 60% by Participant 5. The average increase was 46% resulting in a posttest score near that of their peer group.

Quizzes

As shown in Table 2, the average quiz performance for the at-risk participants was at or above 73% (range 73.38 to 90.75) across the four quizzes. All at-risk participants performed at or above 60% (Participant 1, quiz 1) with the exception of Participant 6 who performed at 29% on quiz 4. The at-risk participant averages across all four quizzes were similar to those of their peer group. The similarity in average scores is shown in Figure 1.

Table 1

Calculator and Noncalculator Pretest and Posttest Scores Across At-Risk Participants and Peer Group

At-Risk Participants	Non-calculator Pretest	Non-calculator Posttest	Non-calculator Gain	Calculator Pretest	Calculator Posttest	Calculator Gain
1	39	77	38	25	83	58
2	35	83	48	33	77	44
3	31	87	56	21	71	50
4	15	90	75	29	61	32
5	35	70	35	17	77	60
6	31	83	52	29	67	38
7	27	83	56	29	72	43
8	39	97	58	38	81	43
At-Risk Average (sd)	31.50 (7.84)	83.75 (8.12)	52.25 (12.52)	27.63 (6.61)	73.63 (7.35)	46.00 (9.55)
Peer Group (n = 49) Average (sd)	n/a (n/a)	82.70 (18.92)	n/a (n/a)	n/a (n/a)	76.60 (16.61)	n/a (n/a)

Table 2

Quiz Scores Across At-Risk Participants and Peer Group

At-Risk Participants	Quiz #1	Quiz #2	Quiz #3	Quiz #4	Average
1	78	90	87	74	82.25
2	80	100	90	80	87.50
3	60	95	80	80	78.75
4	70	80	70	89	77.25
5	73	90	80	91	83.50
6	83	83	93	29	72.00
7	70	90	93	80	83.25
8	73	98	93	71	83.75
At-Risk Average (sd)	73.38 (7.17)	90.75 (6.90)	85.75 (8.38)	74.25 (19.48)	81.03 (4.82)
Peer Group (n = 49) Average (sd)	73.70 (18.57)	85.40 (17.59)	84.40 (14.09)	78.90 (21.99)	80.60

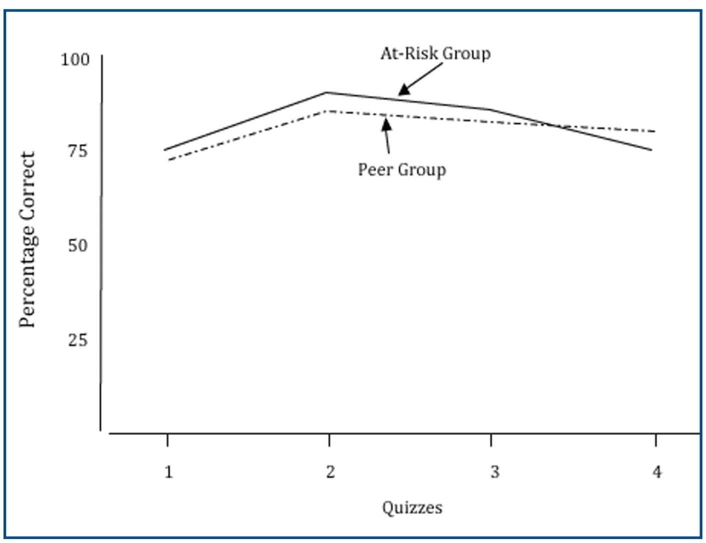

Figure 1. Percentage correct for the quiz performance of at-risk participants and their peer group..

Discussion

The purpose of this action research was to examine the effects of explicit instruction and double dosing for academically at-risk students in the area of mathematics, specifically ratios, proportions, and percents. Overall, the findings were positive. Results showed that the at-risk participants demonstrated large improvements in mathematics performance. In addition, at-risk participants performed at or near their peer group. These findings show the importance of an explicit method of instruction that emphasizes acquisition of basic skills to better prepare academically at-risk students to participate in their math course. All students from both groups received explicit instruction for the acquisition of basic skills during the regular class period. The same method of instruction was also used during the double-dose sessions each Thursday during lunchtime. Interestingly, higher performance was demonstrated in noncalculator use as compared to calculator use. These findings may be attributed to the increased attention I placed on getting the right answer using paper and pencil and using the calculator only as a means of checking work.

Another positive outcome of this action research was the relative impact that explicit instruction and double dosing had on student attitudes toward math, specifically, and school, in general. As students from the at-risk group progressed through the basic skills lesson delivered in an explicit instructional format and double-dose sessions on Thursdays at lunch time, they began to participate more frequently in class discussions. They also began to ask questions for clarification and volunteer answers or ideas during class discussions. Before the action research began, some of the students in the at-risk group had never contributed to a large group discussion.

These results are consistent with results reported by Baker et al. (2002) that showed how beneficial explicit instruction was for low-achieving students. These results also show that with extra assistance and modifications, students at risk for school failure may achieve mastery of the basic skills necessary to participate in everyday activities that involve higher-order thinking skills (Kilpatrick et al., 2001; Woodward & Brown, 2006).

The results of this action research add support to the suggestions of Klein et al. (2005) and the NCTM (2007b) where mathematics instruction that is fast paced includes teacher modeling with many teacher-directed, product-type of questions, and transitions from demonstration to error-free student responding are recommended. Klein et al. note that skills should be mastered before students enter high school. To that end, this action research showed that students who were at risk for academic failure in mathematics were able to perform at levels similar to their peers, thus increasing the likelihood of their success in higher level mathematics.

Action research, by its very nature, may be limited in its ability to control for other possible causal factors (i.e., threats to internal validity; Martella et al., 1999; Stringer & Genat, 2004). Additionally, action research is usually limited in the ability to generalize the results to other settings and/or other students (i.e., external validity; Martella et al., 1999; Stringer & Genat, 2004). As such, the following limitations are present due to the action research focus of the investigation. First, I specifically invited students from the at-risk group to attend the double-dosing sessions. However, access to the double-dose sessions remained open to all students. It is unlikely that only one double-dose session per week that was 25 minutes in length would have a significant impact on student achievement. Student gains were likely attributed to the presentation of well-designed lessons that used the explicit instructional format. In future investigations, more double-dosing sessions should be offered per week and should be offered exclusively to students in the at-risk group to assess the impact of double-dosing.

Second, this action research included a small number of participants. It is unclear to what extent these results would generalize to other students in other settings. Similarly, given that only one teacher (author) implemented the program, it is unclear to what extent these results would generalize to other teachers. Future research should include multiple participants in multiple settings to increase the generalizability of findings.

Third, the instructor was familiar with the participants and enjoyed a close relationship with them; thus, this relationship might have affected the outcomes of the action research. It is likely that the personal relationship that was fostered between the teacher and students had some influence on the students' motivation. Therefore, future research should consider the motivational aspects of teacher-to-student relationships that will affect student performance.

Fourth, the teacher developed the assessments used in this action research; thus, these assessments lacked information on their psychometric properties. Therefore, future investigations should include standardized assessments. On the other hand, teachers many times use assessments they have constructed; thus, the assessments used in this action research may be more representative of what other students are exposed to and, thus, may have greater external validity.

Fifth, given the lack of a true control group, cause-and-effect claims cannot be made. The peer group aids in showing that the at-risk participants performed at or near the level of their peers; however, it is unknown if extraneous variables may have contributed to the improved performance of the at-risk participants. Additionally, because the pretest was only recorded for the at-risk group, the amount of mathematics gain cannot be determined for the peer group. Thus, a comparison cannot be made with regard to gain scores. Future research should use an adequate experimental design to allow for cause-and-effect statements to be made.

Sixth, there was a lack of instructional fidelity. Only two full observations were made by an outside teacher of the double-dose sessions. There were no observations made by an outside teacher during the regular class period. Future investigations should include several observations during both the double-dose sessions and the regular class period. Finally, given that the experimenter collected the data, there was a lack of independent verification of the math performance. Therefore, future investigations should either have an independent evaluator (i.e., another person who administers and scores the assessments) or should include a measure of inter-scorer agreement on the assessments.

In conclusion, explicit instruction and double-dosing have shown great potential in improving math performance of those students who experience difficulties in mathematics (Baker et al., 2002). The results of this action research are especially important given that there is a lack of studies on the use of explicit instruction to teach ratios, proportions, and percentages to middle school students at risk for school failure and on the use of double-dosing to improve these skills.

References

Anderson, L. W., & Walberg, H. J. (1993). *Timepiece, extending and enhancing learning time.* Reston, VA: National Association of Secondary School Principals.

Baker, S., Gersten, R., & Lee, D. (2002). A synthesis of empirical research on teaching mathematics to low-achieving students. *The Elementary School Journal, 103*, 45-74.

Bottoms, G., & Carpenter, K. (2003). *Factors affecting mathematics achievement for students in rural schools*. Atlanta, GA: Southern Regional Education Board.

Ginsburg, A., Cooke, G., Leinwand, S., Noell, J., & Pollock, E. (2005). *Reassessing U.S. international mathematics performance: New findings from the 2003 TIMSS and PISA.* Washington, DC: American Institutes for Research.

Gonzales, P., Guzmán, J., Partelow, L., Pahlke, E., Jocelyn, L., Kastberg, D., & Williams, T. (2004). Highlights from the trends in international mathematics and science study (TIMSS) 2003 (NCES 2005-005). U.S. Department of Education, National Center for Education Statistics. Washington, DC: U.S. Government Printing Office.

Kilpatrick, J., Swafford, J., & Findell, B. (2001). *Adding it up: Helping children learn mathematics.* Washington, DC: National Academy Press.

Klein, D., Braams, B., Parker, T., Quirk, W., Schmid, W., & Wilson, W. (2005). *The state of state math standards.* Washington, DC: Thomas B. Fordham Foundation.

Kroesbergen, E., VanLuit, J., & Maas, C. (2004). Effectiveness of explicit and constructivist mathematics instruction for low-achieving students in the Netherlands. *The Elementary School Journal, 104*, 233-252.

Lapan, G., Fey, J., Fitzgerald, W., Friel, S., & Phillips, E. (2004*). The Connected Mathematics Project: Comparing and scaling.* Needham, MA: Prentice Hall.

Lee, J., Grigg, W., & Dion, G. (2007). *The nation's report card: Mathematics 2007* (NCES 2007-494). Washington, DC: National Center for Education Statistics, Institute for Education Sciences, U.S. Department of Education.

Lemke, M., Sen, A., Pahlke, E., Partelow, L., Miller, D., Williams, T. . . . Joycelyn, L (2004*). International outcomes of learning in mathematics literacy and problem solving: PISA 2003 results from the U.S. perspective*. (NCES 2005-003). Washington, DC: U.S. Department of Education, National Center for Education Statistics.

Martella, R. C., Nelson, R., & Marchand-Martella, N. E. (1999). *Research methods: Learning to become a critical research consumer.* Needham Heights, MA: Allyn and Bacon.

Maxwell, L. (2006). Massachusetts schools experiment with extra time. *Education Week, 26*(2), 30-33.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics: The equity principle.* Reston, VA: Author.

National Council of Teachers of Mathematics. (2006). *Curriculum focal points for pre-kindergarten through grade 8 mathematics: A quest for coherence.* Reston, VA: Author.

National Council of Teachers of Mathematics. (2007a). *Effective strategies for teaching students with difficulties in mathematics.* Reston, VA: Author.

National Council of Teachers of Mathematics. (2007b). *Effective teaching for the development of skill and conceptual understanding of number: What is most effective?* Reston, VA: Author.

National Mathematics Advisory Panel. (2008). *Foundations for success: The final report of the National Mathematics Advisory Panel.* Jessup, MD: U.S. Department of Education.

Nolen, A. L., & Vander Putten, J. (2007). Action research in education: Addressing gaps in ethical principles and practices. *Educational Researcher, 36,* 401-407.

PBS Parents. (2003). *Math disabilities.* Retrieved June 19, 2009, from http://www.pbs.org/parents/strugglingtolearn/understanding_math.html

Stein, M., Kinder, D., Silbert, J., & Carnine, D. (2006). *Designing effective mathematics instruction: A direct instruction approach* (4th ed.). Upper Saddle River, NJ: Prentice-Hall.

Stringer, E., & Genat, W. (2004). *Action research in health*. Upper Saddle River, NJ: Pearson Merrill Prentice Hall.

Woodward, J., & Brown, C. (2006). Meeting the needs of academically low-achieving students in middle grade mathematics. *The Journal of Special Education, 40*, 151-159.

Authors

Lisa Piper, M.S., is a teacher at Northwood Middle School in Spokane, Washington. Her research interests are at-risk students, gifted and talented students, explicit instruction techniques, and problem solving.

Nancy E. Marchand-Martella, Ph.D., is in the Department of Counseling, Educational, and Developmental Psychology at Eastern Washington University in Cheney, Washington. Her research interests are explicit instruction, adolescent literacy, and academic remediation.

Ronald C. Martella, Ph.D., is in the Department of Counseling, Educational, and Developmental Psychology at Eastern Washington University in Cheney, Washington. His research interests are behavior management, positive behavior support, and explicit instruction.