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The effect on teaching problem-solving skills for students with learning disabilities using the connected mathematics project

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THE EFFECT ON TEACHING PROBLEM-SOLVING SKILLS FOR STUDENTS WITH LEARNING DISABILITIES USING THE CONNECTED MATHEMATICS PROJECT

by
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ABSTRACT

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THE EFFECT ON TEACHING PROBLEM-SOLVING SKILLS FOR STUDENTS WITH LEARNING DISABILITIES USING THE CONNECTED MATHEMATICS PROJECT
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The purpose of this study was to examine the effectiveness of the Connected Mathematics Project (CMP) for seventh-graders with learning disabilities in acquiring math problem-solving skills in the areas of comparisons, percents, ratios, and rates. A total of 10 middle school students in a small rural district participated in the study. The CMP unit, Comparing and Scaling, was taught to those students for six weeks. Four pre-tests and post-tests were given to evaluate their performance. A survey was provided to investigate their satisfaction with their learning experience in the CMP. All students gained scores, with an average increase of 55.72%. Most students had positive responses to the survey. The results show that the CMP is an effective approach for students with learning disabilities to learn problem-solving skills in mathematics.

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CHAPTER I

Introduction

Statement of Problems

Mathematics is an important subject area for all students in school. Although not always obvious, math pervades much of what students do at home, in school, and in their communities. Many daily activities involve mathematical concepts and skills with problem solving being perhaps the most important. Thus, student performance in learning math is critical. According to the National Assessment of Educational Progress, 2000 (NAEP), only a quarter of American fourth- and eighth-graders are performing at the proficient levels in math, and twelfth-graders' math scores have not improved since 1996. It is criticized that American schools are not producing the math excellence required for global economic leadership and homeland security in the 21st century (United States Department of Education, 2006).

No Child Left Behind (NCLB) Act (2001) mandates all states should "ensure schools to use scientifically based methods with long term records of success to teach math and measure student progress" (United States Department of Education, 2006). It also requires that states develop their curriculum standards to evaluate school programs and student achievement in mathematics. In New Jersey, the Core Curriculum Content Standards (CCCS) for Mathematics were developed with a vision of achieving one crucial goal to enable ALL children to acquire the mathematical skills, problem solving abilities, and higher level of thinking skills to succeed in their careers and daily lives

(New Jersey Department of Education [NJDOE], 2006). Middle school students are required to be proficient in number and numerical operations, geometry and measurement, patterns and algebra, data analysis, probability and discrete math, and mathematical processes (NJDOE). These skill areas are examined yearly by state wide standardized tests. Students with disabilities are mandated to be included in the state assessment system with accommodations according to their Individual Education Plans (IEP) or with alternatives (NJDOE).

According to Geary (2004), five to eight percent of school-aged children are estimated to have some form of memory or cognitive deficit that interferes with their ability to learn concepts or procedures in one or more mathematical domains. Of those students, some are classified as being mathematics learning disabled (LD), and appear to have nearly average levels of number processing skills, at least for the processing of simple numbers (e.g. 3, 6), but present deficits in some areas of arithmetic and counting knowledge. They frequently commit procedural errors and have an immature understanding of certain counting principles. For example, they use problem-solving procedures that are commonly used by younger children such as finger counting (Geary).

A characteristic of children with mathematics LD is that they have difficulties retrieving basic arithmetic facts from their long-term memory. As a result, they often do not have a shift from procedure-based problem solving to memory-based problem solving. If they do retrieve arithmetic facts from long-term memory, errors are presented and longer reaction times are needed compared to children without disabilities. These difficulties often persist despite intensive instruction in basic facts (Geary, 2004).

Various remedial programs have been provided to students with learning disabilities. These programs often included features such as introducing new concepts systematically, providing adequate practice and review, and teaching big ideas. Scripts for daily lessons are provided for teachers, with accompanying workbooks for students to practice (Hallahan, Kauffman, & Lloyd, 1999).

One approach that has been documented to be successful with these students is Direct Instruction (Engelmann, S., Canine, Engelmann, O. & Kelly, 1991). According to Jones and Southern (2003), Direct Instruction has three steps in its sequence. First, the lesson is opened and students' attention is gained, skills are reviewed and instructional objectives for the daily lessons are stated. Second, during instruction, skills are modeled, prompted, and tested. Finally, at the conclusion of instruction, learned skills are briefly reviewed, a preview of the next lesson's objectives is provided, and practice activities are assigned. Because of the explicit instruction with a step-by-step fashion, students with LD have consistently shown substantial benefits in academic learning (Hallahan et al., 1999).

Connecting Math Concepts (CMC) is a basal program based on the Direct Instruction model. Using CMC, highly structured lessons are provided with frequent teacher questions and student answers. As a result, students learn fundamental skills for solving mathematical problems. The focus of CMC is that explicit strategies in problem solving are taught, as well as basic facts; for example, number families or part-whole relationships (Engelmann et al., 1991).

The Connected Mathematics Project (CMP) is another recent mathematics teaching approach (Lappan, Fey, Fitzgerald, Friel, & Philips, 2004). The CMP is also a

standards-based, problem-centered curriculum designed for middle school students (Cain, 2002). According to Lappan et al. (2004), this problem-based strategy allows students to develop their understanding of mathematics through a series of connected problems with abstract powerful mathematical ideas, problem-solving strategies, and high levels of thinking about mathematics.

The CMP is organized to allow students to continually solve problems that have important mathematical concepts and skills. This program organization is different from teacher-directed instruction in which students learn first by observing a teacher's demonstration to solve a problem followed by the practice of solving similar problems (Lappan et al., 2004). Research has proved the effectiveness of the CMP (e.g. Ben-Chaim, Fey, Fitzgerald, Benedetto & Miller, 1998; Cain, 2002; Krebs, 2003); however, only regular education students were selected as samples in those studies. Is this program effective to students with LD? It is questionable. Research on the CMP for students with disabilities is needed.

Background

In 2003, the Trends in International Mathematics and Science Study (TIMSS) compared American students' mathematics achievement scores to those of students at the fourth- and/or eighth-grade levels in 46 countries (National Center for Education Statistics, 2003). The scores of fourth graders ranked twelfth, in the middle of the 46 countries, and the eighth graders' average scores ranked tenth. While the TIMSS scores are acceptable to some, the rank only puts the United States at the average level compared to other countries. However, the data has indicated the need to improve mathematics education in the United States.

The National Council of Teachers of Mathematics (NCTM) in 1989 provided *Curriculum and Evaluation Standards for School Mathematics* as a guideline for mathematics education in schools. The standards articulate extensive goals for mathematics education. *Principles and Standards for School Mathematics* (2000) provided specific requirements and goals to improve school mathematics curriculum, teaching and assessment. Since 2001, the NCLB legislation has embraced these standards, and calls for all states to measure student progress in learning mathematics annually. It mandates that all students should be included in the state assessment system. Thus, students with LD are included in the state standardized testing.

Currently, students with LD are placed in resource centers or inclusive classrooms together with their age appropriate peers without disabilities. According to the Individuals with Disabilities Act (IDEA 1990), students with disabilities should be educated in an environment that is the least restrictive. Placement decisions are based on an IEP that is developed for each special education student. The least restrictive environment for placement would be in an inclusive classroom where students with learning disabilities are studying together with their non-disabled peers in a regular education classroom. Both regular education and special education teachers follow the general education curriculum with accommodations to meet the needs of students with disabilities according to their IEPs. Another option for placing of students with LD is a resource center, where a small group of students are taught by a special education teacher (United States Department of Education, 2006).

Significance of the Study

Students with LD have difficulties in learning math skills, especially problem solving. Research has been conducted to remediate those students in basic mathematical skills and computation (e.g. Engelmann et al., 1991; Hallahan et al., 1999). Connected Mathematics Project has been provided in middle schools as a problem-centered curriculum (e.g. Ben-Chaim et al., 1998; Cain, 2002; Krebs, 2003). This particular program in mathematics instruction has been evaluated to be effective for middle to high achieving students in demonstrating strong algebraic reasoning (Krebs, 2003). After implementing the CMP program in Lafayette Parish, Louisiana it is also found that these schools significantly outperformed non-CMP schools on student scores of standardized tests (Cain, 2002).

Meanwhile, both students and teachers indicate that the CMP is helping students become better problem solvers. As a result, students that participated in the CMP performed better than those in a control group without participation in the CMP in regards to problem solving skills in the areas of ratio, proportion and percentage (Ben-Chaim et al., 1998). Unfortunately, only regular education students participated in the past studies; no students with disabilities were included in the samples. To verify the previous research, this present study was designed to examine the effects of the CMP with seventh-graders with learning disabilities placed in both resource centers and inclusive classrooms.

Statement of the Purpose

The purposes of this study were to (a) examine the effectiveness of the CMP for seventh-graders with learning disabilities in acquiring problem-solving skills in the areas

of comparisons, percents, ratios, and rates; and (b) investigate their perceptions on their math learning in the Connected Mathematics Project.

Research Questions

1. Do students with learning disabilities gain scores on their math tests when the Connected Mathematics Project is provided as mathematics instruction?
2. What are the perceptions of students with learning disabilities on their mathematics learning when the Connected Mathematics Project is provided?

CHAPTER II

Review of the Literature

According to Geary (2004), in theory, a learning disability can result from deficits in the ability to represent or process information in one or all of the many mathematical domains, for example, probability. Remedial math instruction using effective strategies seems important for these students to obtain skills and enhance learning. This chapter reviews research articles related to math instruction of students with LD and different programs used in practice, including video-based anchored instruction, schema-based word problem solving, and CMP.

Students with Learning Disabilities in Learning Mathematics

Students with LD often have poor performance in learning math (Geary, 2004). It is complicated to distinguish if their poor achievement is due to inadequate instruction or due to their actual cognitive disability (Geary, Brown, & Samaranayake, 1991). However, when the disability is apparent, and a classification of LD is warranted, these students have difficulties sequencing the multiple steps in complex problems, retrieving mathematical facts, and in spatially representing numerical and other forms of mathematical information and relationships (Geary, 2004).

There is another factor to consider regarding instructional goals and approaches which may influence whether a particular deficit would be considered a learning disability. There is one type of instruction presented by the NCTM (2000) that focuses on mathematics as an applied domain and tends to de-emphasize the learning of

procedures and mathematical facts, and to emphasize conceptual understanding. This differs from instruction where procedures and facts are more heavily emphasized and instruction that approaches mathematics as a scientific field to be mastered. According to Geary (2004), with the former approach the deficit in arithmetic fact retrieval may not be considered a serious learning disability because of the de-emphasis on this memory-based knowledge. With the latter approach, it would be considered a serious disability.

In Geary's study (2004), students with LD were analyzed into three subtypes: learners with procedural deficits, semantic memory deficits, and visuospatial deficits. With the procedural subtype, students commit frequent errors in the execution of procedures, they have a poor understanding of the concepts underlying procedural use, and have difficulties sequencing the multiple steps in complex procedures. Students with the semantic memory subtype not only have difficulties retrieving mathematical facts, for the facts that are retrieved there is a high error rate, and unsystematic reaction time for correct retrieval. Finally, with the visuospatial subtype, students have difficulties in spatially representing numerical and other forms of mathematical information and relationships, and have frequent misinterpretation or misunderstanding of spatially represented information (Geary).

In 2001, Bottge, Heinrichs, Chan and Serlin studied eighth graders' performance in a remedial math class compared to the students in the pre-algebra class. The instruction was video-based and applied problems aligned to current math standards. Seventy-five students in a rural district in the upper Midwest participated in the study. Of the fourteen students who attended a remedial math class, eight were classified as having learning disabilities. Sixty-one students were in one of three pre-algebra classes, eleven

of which were receiving special education services: eight with learning disabilities, two with emotional disabilities, and one health impaired. The students in the remedial math class, as well as one of the pre-algebra classes, received the video-based anchor instruction on problem solving involving distance, rate and time, graphing, and prediction (Bottge et al.). The video-disc format allows the students to quickly search locations in the video where relevant information for solving the problem is located. Students in the other two classes were taught in a more traditional way to solve a variety of standard word problems involving the same topic. Prior to instruction, students in the remedial class scored lower than students in the pre-algebra class on computation and problem-solving tasks. After the intervention, all students were tested. The results showed that students in the remedial class matched the problem-solving performance of students in the pre-algebra class that had the video-based instruction, as well as the two pre-algebra classes receiving the instruction in a more traditional manner. It appears that LD students benefit from this type of specific video intervention to improve their word problem solving skills.

Jitendra and Hoff (1996) indicate that mathematics instruction has failed to represent a balance of mathematical topics but in general, a major emphasis has been placed on arithmetic computation. However, the computation skill usually comes at the expense of attaining higher order skills, such as reasoning, connectedness, and problem solving. In their study, three students with LD were taught using schema-based instruction for solving word problems. This included an explicit framework of schemata to allow students with poor memory skills to organize information using the semantic relations. As a result, student performance on each set of math word problems improved

after the schema-based instructional strategy was implemented. The students were also successful in generalizing skills to solve novel math problems. In addition, it was found that the strategy was effective for students in learning math and they liked it.

The schema-based instruction was further examined in 2005 (e.g. Xin, Jitendra, Deatline-Buchamn). In their study, 22 middle school students, 18 with learning disabilities, one with severe emotional disorders, and three at risk for mathematics failure participated in the study. These students were randomly assigned to two groups provided with schema-based instruction and general strategy instruction respectively for learning word problem-solving skills. Both groups were taught to follow a four-step general problem-solving procedure including reading the problem to understand, representing the problem, planning the strategies, solving the problem, and checking for correct results.

Subsequently, the two different intervention strategies (schema-based vs. general strategy) were involved in the second and third steps. The schemata-based group was taught to identify the problem structure and use a schema diagram to represent and solve the problem. The general strategy group learned to draw semiconcrete pictures to represent information in the problem and facilitate problem solving. The results showed that students in the schema-based instruction group significantly outperformed the general strategy instruction group on immediate and delayed post-tests as well as the transfer test (Xin, et al., 2005). It indicates that effective instructional strategies are important for LD students in learning math problem-solving skills.

Connected Mathematics Program in Mathematics Instruction

There are various programs available today that are considered problem-based, student-centered approaches to teaching mathematics. One such program using a

problem-based, student-centered approach is the Connected Mathematics Project (CMP). The CMP was funded by the National Science Foundation (NSF) between 1991 and 1997 to develop a mathematics curriculum for grades 6-8 (Lappan et al., 2004). According to Lappan et al., this problem-based curriculum guides students to develop their understanding through a series of connected problems which allows them to abstract powerful mathematical ideas, problem-solving strategies, and multiple ways of thinking about mathematics. The CMP is organized to allow students to continually solve problems that have important mathematical concepts and skills. This organization is different from teacher-directed instruction in which students learn first by observing a teacher's demonstration of a problem solving strategy, and, then practice that method to solve similar problems (Lappan et al.).

The authors of the CMP combined multiple mathematical goals into a single standard as they developed materials. This standard states that:

> All students should be able to reason and communicate proficiently in mathematics. They should have knowledge of skill in the use of vocabulary, forms of representation, materials, tools, techniques, and intellectual methods of the discipline of mathematics. This knowledge should include the ability to define and solve problems with reason, insight, inventiveness, and technical proficiency. (Lappan et al., 2004, p. 1)

This shift in mathematics teaching from a teacher-centered approach to a problem-centered approach was a result of reform (e.g. NSF funded reform curriculum projects) (Reinhart, 2000). The problem-centered approach makes positive changes of student performance in learning math when students were involved in this problem-

centered approach and participating in problem solving activities (Reinhart). According to Lowe (2004), the CMP has been successful in schools, and teachers and administrators must master the program's key parts. These parts include teacher training, administrative support and additional math instruction for supplement. For example, the CMP is very different from what the students and teachers are used to in traditional teacher-centered instructional procedures. The CMP requires a lot of time, and gives less attention to math skills, therefore it may need to be supplemented with additional skills instruction (Lowe). However, if it is implemented with proper teacher training and support from parents and administrations, the program will be successful at teaching mathematics using a problem-centered approach.

A formative internal evaluation was conducted to examine the CMP's implementation in Lafayette Parish, Louisiana (Cain, 2002). Schools implemented the CMP to those without the CMP were compared. The average standardized test scores of the four schools using the CMP was 16% higher than the non-CMP schools at the sixth grade level and 9% higher at the seventh grade level. A student survey demonstrated that 65% of students prefer the CMP to previous methods of mathematics instruction they had received, while 25% had no opinion and only 10% did not like the CMP (Cain). Both the test data and responses to survey questionnaires indicate that the CMP is effective for students learning math and they are satisfied with the program in that school district.

A similar study was conducted to evaluate seventh grade students from several different states (Ben-Chaim et al., 1998). Student performance from eight classes using the CMP was compared to six classes without the CMP. The CMP sample included 187 students, and 128 students were in the non-CMP group. Students were tested on a variety

of proportional reasoning problems presented in three forms distributed randomly in each participating class. The students learning math with the CMP outperformed those without participation in the CMP on solving problems in the areas of rate or density, ratio, or scaling by 58% verse 28% (Ben-Caim et al.). It was also found that the CMP students were capable of providing a good quality of written and oral explanations to their work (Ben-Caim et al.). This is further supported by Zawojewski, Robinson and Hoover's study (1999) in which the CMP students have been found to use more vocabulary words and language expression to explain their answers.

The CMP has been used for teaching probability to explore multiple meanings of concepts and make connections between these different representations (Wilensky, 1995). Similar results were found through two case studies in learning probability skills (Wilensky, 1997). These case studies indicate that in a CMP learning environment, learners are supported in actively connecting areas of their previous knowledge while in a non-CMP instruction environment, new and previous skills remained separate (Wilensky, 1997).

A quasi-experimental study was conducted by Riordan and Noyce (2001) using matched comparison groups in Massachusetts. Twenty-one middle schools using the CMP were compared to 34 middle schools using a traditional type of curriculum. The scores of an eighth-grade statewide-standardized test were compared between those schools with and without the CMP. It was found that the students in the CMP significantly outperformed the matched peers without participation in the CMP. The positive impact found the CMP schools was remarkably consistent across students with different gender, race and economic status. Also, students at the top, middle, and bottom

of their classes all did better with the CMP instruction than they had performed before the CMP was introduced.

The mathematics achievement of eighth-graders in the first three Missouri school districts to adopt NSF standard-based middle grades mathematics curricular was compared to similar schools without such curricular. The main comparison was evaluated by the percentage of students receiving free and reduced lunches, location and size (Reys, R., Reys, B., Lapan, Holliday, & Wasman, 2003).

The three schools using the NSF-funded programs had been implementing the curriculums for two years prior. One school was using the CMP and the other two schools were using Math Thematics, a program that is very similar to the CMP in that it is a complete middle-grade program that encourages students to investigate mathematical concepts through exploratory, activity-based learning. Open-ended questions, projects, and presentations are utilized throughout the course to assess each student's skills in problem solving, reasoning, and communication (Billstein & Williamson, 1998).

Reys et al. (2003) found that students using the CMP or Math Thematics equaled or exceeded the achievement of students from matched comparison districts on the mathematics portion of the Missouri Assessment Program. All of the significant differences in achievement reflected higher performance for those students using NSF standard-based materials. Also, students in the CMP and Math Thematics schools scored higher in two areas, specifically in the content areas of data analysis and algebra (Reys et al.).

The coverage of algebra in the CMP is a much discussed and debated topic. Most schools offer a traditional Algebra I course in the eighth grade; however, there has been

some research about a reform to change the traditional mathematics curriculum to the CMP. One study discussed the topics in the traditional Algebra I class versus just getting the algebra content through the eighth grade CMP units (e.g. Star, Herbel-Eisenmann & Smith, 2000). In their study, the researchers could make no conclusions other than fundamental differences between the two approaches were found. They could not indicate which approach was better because there were no significant differences in scores from the two groups. In 2003, Krebs examined middle to high achieving students who had all three years of middle school with the CMP instruction and found that those students develop algebraic reasoning skills as students in traditional Algebra I courses do (Krebs). This does not give an answer as to whether Algebra I should be taught using a traditional method of instruction or using the CMP, but simply suggests that there is not a disadvantage to using the CMP to teach algebraic reasoning.

Instruction of Students with LD Using the CMP

According to the authors of CMP, the program:

> "...can be and has been successfully taught in classrooms in which special-needs students are included in heterogeneous groups. Teaching mathematics through problems allows all students an opportunity to achieve higher levels of understanding. Students develop their understanding through group as well as individual work and benefit from conversations about the mathematics embedded in the problem and the various strategies used to solve the problem." (Lappan, et al., 2004, p. 41)

This has thus far not been supported by research specific to LD students, but just stated that a student with LD could be successful. Also, some studies on the CMP have

included heterogeneous classrooms (e.g. Ben Chaim et al., 1998); however, LD students are not identified as a subgroup. Other studies have specifically stated that the reported data did not include any special education students (Riordan et al., 2001).

Summary

Word problem solving skills are important for students with LD in learning mathematics. Various studies have shown the effectiveness of using video-anchored instruction and schemata-based instruction for students to learn problem-solving skills. These two instructional strategies help students with LD to attain a higher level of thinking than remedial instruction on computational skills (e.g. Bottage et al., 2001; Jitendra et al., 1997; Xin et al., 2005). The CMP is effective in the regular classroom using a problem-centered approach to teach seventh grade math (e.g. Cain, 2002; Ben-Chaim et al., 1998; Wilensky, 1995; Wilensky, 1997; Riordan et al., 2001; Reys et al., 2003; Krebs et al., 2003). However, there is no existing research specific to students with LD using the CMP. The participants in the previous studies were mostly regular students in heterogeneous groups with only a few students with LD included. Thus, the results were general, including all student performance without specific reports on this particular student population.

The effectiveness of the CMP in regular education classrooms has been proven to be successful in various states and classroom settings (e.g. Cain, 2002; Ben-Chaim et al., 1998). This program appears effective in learning problem-solving skills so that students have an opportunity to experience with mathematics rather than computational practice only. The CMP seems to be an effective instructional approach for regular education students and it may also be effective for students with LD both in the regular education

classroom and resource center. It is hoped that students with LD would be involved in the problem-centered curriculum of the CMP, and, as a result, they may learn more about mathematics than just computational skills.

CHAPTER III

Method

This study examined the math performance of students with learning disabilities when they were enrolled in the CMP math program during the 2006-2007 school year, as well as their satisfaction.

Participants

School

The study was conducted in a middle school located in a small rural district of Southern New Jersey. A total of 210 students enrolled in fifth through eighth grades were attending the school. The students in the fifth grade used the Everyday Math curriculum and those in the sixth through eighth grade used the 2004's copyright of the CMP.

Students

Ten students in the seventh grade participated in the study. All of them were identified as being specific learning disabled with IEPs in mathematics based on the diagnosis of the Child Study Team according to the state's eligibility standards. The students' IEPs required their education to be either in the resource center or in the regular classroom with a special education teacher serving as in-class support. Parental permission for participation in the study was granted for all ten students (see Appendix A). Table 1 presents the general information of the participating students.

Table 1: General Information of Participating Students

Placement	Female	Male
Resource Center	1	4
Inclusive Classroom with In-Class Support	1	4

Each student was assigned a number to protect his or her identity. Table 2 presents their math performance through first and second marking period grades as well as their scores of the 2006 NJ Assessment of Skills and Knowledge (ASK) for Language Arts and Mathematics. The NJ ASK 6 was administered in the Spring of 2006. A score of 199 or below is considered partially proficient, 200-249 is proficient and 250 or higher is advanced proficient.

Table 2: Participating Students' Performance

Student Number	Age	2006 1st Marking Period Grade	2007 2nd Marking Period Grade	2006 NJ ASK Language Arts Scores	2006 NJ ASK Mathematics Scores
1	13	A- 92%	B 88%	210	213
2	14	F 65 %	F 53%	225	246
3	13	F 57%	D 71%	189	207
4	13	B- 83%	C 79%	192	194
5	12	D- 70%	C- 75%	200	207
6	13	C+ 82%	B 88%	221	193
7	13	B+ 90%	C 79%	193	216
8	12	B- 85%	C 79%	217	182
9	13	B+ 91%	B 86%	214	203
10	12	C- 75%	D- 70%	210	190
average	12.8	C 79%	C 77%	207	205

Research Design

A single subject design with AB phases was used. Each student had four pre-tests and four post-tests. At the completion of the unit, students were also given a survey (see Appendix B) to examine their satisfaction with the CMP in learning mathematics.

Measurement

Tests

The CMP curriculum provides quizzes and a final unit test. All ten participants took four pre- and post-tests. The researcher altered the questions in each of the tests to develop a pre-test. A sample of one of the tests can be found in Appendix C.

Survey

A Likert scale survey was designed to obtain the students' attitudes towards the CMP and satisfaction with the program. The survey was replicated from a similar survey in a previous study (see Cain, 2002). Each of the first four questions had five choices from which the students could select: 5=strongly agree, 4=agree, 3=no opinion, 2=disagree, and 1=strongly disagree. The first four questions asked the students their perceptions on the CMP, becoming a better math problem solver with the CMP, if the CMP makes them think more, and if the problems help them understand the mathematics concepts. The students were also asked two open-ended questions about what they liked the best and the least about the CMP.

In order to examine the content validity, this survey was field-tested by four eighth-graders in the school. These students had been enrolled in the CMP program for an entire year. They were asked to respond to each survey question, and then interviewed

individually about their experience with the survey they took. All of them reported that there were no errors with the survey; the questions were easy to understand and answer; and response time was flexible and reasonable. It was also determined, from this field test, that it should take the students about 15 minutes to complete the survey.

Instructional Materials

The Connected Mathematics Project is designed as middle school curriculum for grades 6-8. There are eight units for each grade level. The participating school was in its first year of implementing the program for the sixth grade and third year for both seventh and eighth grades.

The school's curriculum require that in the seventh grade, six units should be covered including Variables and Patterns, Stretching and Shrinking, Comparing and Scaling, Accentuate the Negative, Filling and Wrapping, and What Do You Expect. The research was conducted during the third unit of instruction, Comparing and Scaling. The main focus of the unit is on comparisons, percents, ratios, and rates and is taught through four investigations within the unit (see Table 3).

Procedure

Instruction

Each student received 50 minutes of mathematics instruction daily. A special education teacher with two years of experiences in teaching the CMP taught the students in the resource center. A regular education teacher and a special education teacher, both of whom also have two prior years of experiences in teaching the CMP, taught the students in the regular classroom with in-class support. All three teachers attended the

CMP implementation training as well as follow-up training. The researcher is the special education teacher instructing the in-class support class.

All three teachers followed the model called "launch-explore-summarize" provided by the program (Lappan et al., 2004). This model requires that in the first phase, the teacher launches the problem with the whole class. This involves helping students understand the problem setting, the mathematical context, and the challenge. In the explore phase, students will either work individually, in pairs, in small groups or occasionally as a whole class to solve the problems. The nature of the problem suggests which way the teacher should choose the students to work. Finally it is during the summary that the teacher guides the students to reach the mathematical goals of the problem and to connect their understanding to prior mathematical goals and problems in the unit (Lappan et al., 2004). In addition to the above procedures, the students with LD are provided the necessary accommodations according to their IEPs. These included extended time during testing, having tests read aloud, and providing students with study guides.

The Comparing and Scaling Unit has six investigations. The first four investigations were taught, following the school's curriculum. The unit was taught over the course of six weeks. Table 3 gives the title of investigations with the number of problems presented in each investigation.

Table 3: Comparing and Scaling Unit

Investigations	Number of Problems
1. Making Comparisons	3
2. Comparing By Finding Percents	2
3. Comparing By Using Ratios	3
4. Comparing By Finding Rates	3

Math Testing

Mathematics performance was measured by comparing each student's pre- and post-test scores individually. All of the tests were scored by all three of the teachers involved to ensure valid grades were obtained. A numerical number identified each student in order to be able to compare all of the pre- and post-tests for the data collection. Students were permitted to use a TI-73 graphing calculator on all of the tests and the test directions were read aloud to the students. They were given one class period of 50 minutes to complete each test.

Survey

The survey was administered to the students at the completion of the unit, and all of the tests. The directions and each survey question were read aloud to the students. They were given about 15 minutes to complete the survey.

Data Collection and Analysis

The results of the survey were organized for each question. The data from the first four questions were analyzed and the mean was calculated. The responses of the two open-ended questions were examined for commonalities among the answers. Typical answers were then rated based on the percentage of students who responded in the same manner.

The results of each student's pre-test and post-test for each of the four sections of the units were compared and presented in baseline and intervention phases. The percentage points gained from each students pre-test average to post-test average was also calculated.

CHAPTER IV

Results

This chapter presents the results of student pre- and post-tests as well as student responses to survey questions about the CMP.

Student Achievement

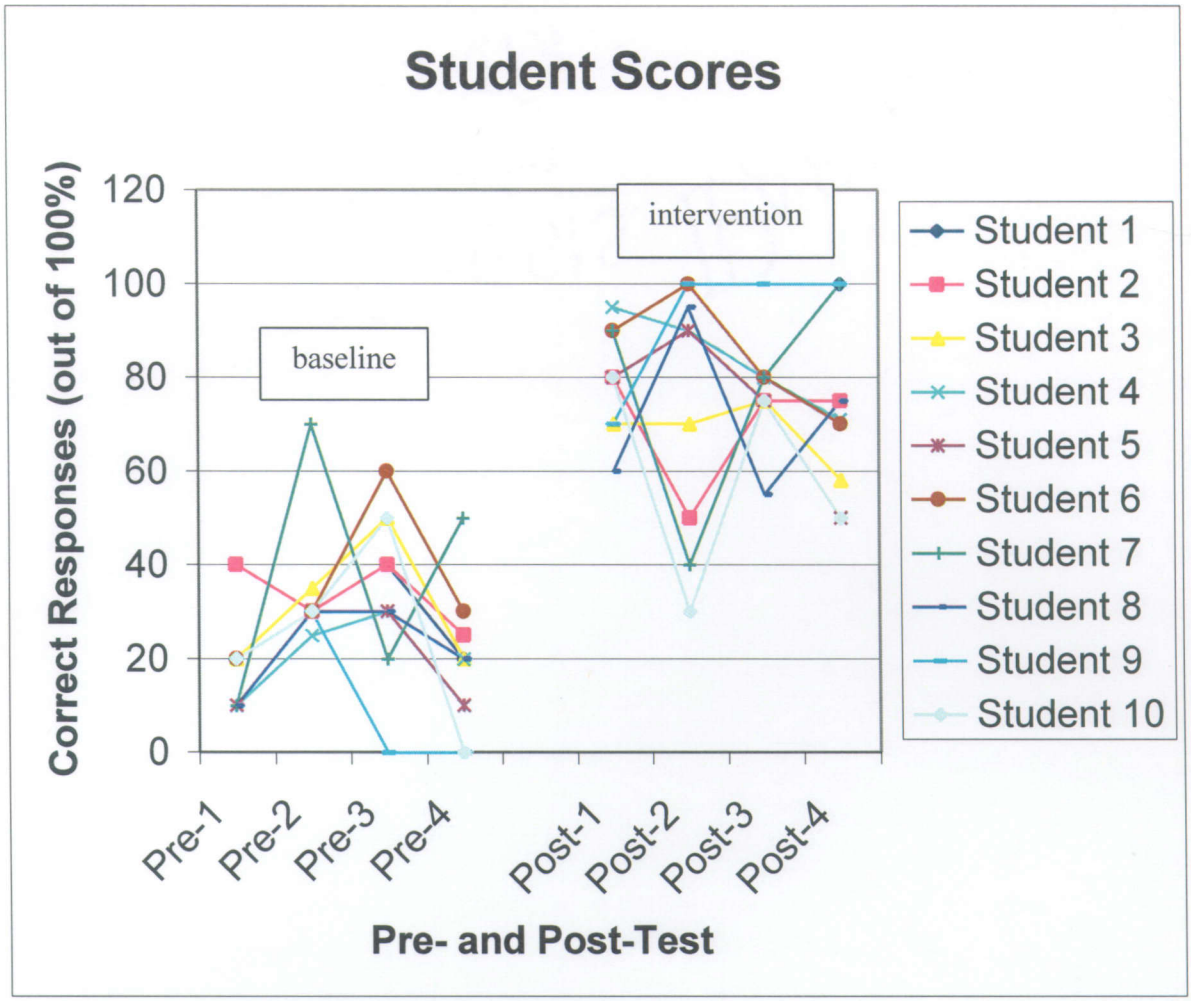
Table 4 presents student scores of each test and means and gains scores of each individual student. The bottom row of the table presents the mean scores of all ten students.

Table 4: Student Pre- and Post- Test Scores

student	Pre-1 (%)	Pre-2 (%)	Pre-3 (%)	Pre-4 (%)	Pre-Mean (%)	Post-1 (%)	Post-2 (%)	Post-3 (%)	Post-4 (%)	Post-Mean (%)	Gain Scores (%)
1	20	30	40	20	27.5	90	100	80	100	92.5	65
2	40	30	40	25	33.75	80	50	75	75	70	36.25
3	20	35	50	20	31.25	70	70	75	58	68.25	37
4	10	25	30	20	21.25	95	90	80	71	84	62.75
5	10	30	30	10	20	80	90	75	50	73.75	53.75
6	20	30	60	30	35	90	100	80	70	85	50
7	10	70	20	50	37.5	90	40	80	100	77.5	40
8	10	30	30	20	22.5	60	95	55	75	71.25	48.75
9	20	30	0	0	12.5	70	100	100	100	92.5	80
10	20	30	50	0	25	80	30	75	50	58.75	33.75
Mean	18	34	35	19.5	26.63	80.5	76.5	77.5	74.9	77.35	50.72

Figure 1 presents student progress in the baseline and intervention phases. The pre-test scores are presented in the first phase (baseline) and the post-test scores in the second phase (intervention).

Figure 1: Student Progress



Survey Responses

The student survey responses to questions 1-4 are calculated and analyzed with descriptive statistics including means, standard deviations, and percentages. The means are calculated based on a scale where 5 represents "strongly agree", 4 for "agree", 3 for "no opinion", 2 for "disagree", and 1 for "strongly disagree". Table 5 presents means, standard deviations, and percentages of their responses. Table 6 combines the positive

responses of "strongly agree" and "agree" as well as the mean of the positive responses for the four questions.

Table 5: Student Survey Responses

Question	Mean	SD	Strongly Agree (%)	Agree (%)	No Opinion (%)	Disagree (%)	Strongly Disagree (%)
1. Prefer CMP	3.7	0.95	20	40	30	10	0
2. Better problem solver	4.2	0.79	40	40	20	0	0
3. Think more	3.8	0.63	10	60	30	0	0
4. Understand concepts	3.9	0.57	10	70	20	0	0

Table 6: Positive Responses

Question	Combined % for "Strongly Agree" & "Agree"
1. Prefer CMP	60
2. Better problem solver	80
3. Think more	70
4. Understand concepts	80
Mean	72.5

Sixty percent of students either strongly agreed or agreed that they preferred the CMP, 80% supported that they became better problem solvers, 70% indicated that the program made them think more about math, and 80% reported they understood math concepts better. It is found that Question 2 "I am becoming a better math problem solver from working in Connected Mathematics" ranked the first with a mean of 4.2 indicating that the students on average agreed with the statement. For questions number 4, 3, and 1

the means of 3.9, 3.8, and 3.7 were calculated, with a range of 2-5 indicating an average of responses between "no opinion" and "agree".

Student responses to the two open-ended questions on the survey were summarized by percentages and descriptive statements. For the first question, "What do you like the best about the CMP?" nine out of ten students (90%) provided positive comments. These include "I like all of it" and "I like the way we solve the problems". The second question asked what students like the least about the CMP. Three out of ten students (30%) answered "nothing", while two of the students (20%) indicated that there was a lot of writing required in the program. Two out of ten students (20%) also reported that the problems were long and they spent a lot of time to complete the task.

CHAPTER V

Discussion

The purpose of this study was to examine the effectiveness of the CMP for seventh-graders with learning disabilities in acquiring problem-solving skills in the areas of comparisons, percents, ratios, and rates. This study also investigated student opinions about their math learning in the CMP. Data were collected using pre-tests and post-tests as well as a student survey.

The first research question was to examine if students with learning disabilities gain scores on their math tests when the CMP is used as mathematics instruction. As shown in Table 4, students gained scores in each post-test comparing to each pre-test. The only exceptions were for the second pre- and post-tests, one student decreased scores and another student achieved the same without an increase. However, reviewing the averages of the pre-tests and posts-tests, it is found that all students gained scores, with an average increase of 50.72%.

Even though there were increases in scores in most cases from the pre-test to the post-test, some of the increases may not be considered as a high percentage. In some cases, proficiency is considered 80% or higher, but it could also be regarded as a passing score. In this particular school, 70% is considered as a passing grade. The results show that of 10 participating students, only two did not reach 70%. However, the averages of the post-tests for all 10 students have reached 70%. In addition, an average of 79% for

the first marking period and 77% for the second marking period have been achieved to reach the passing grade.

Several studies have shown that regular education students can learn math problem solving skills using the CMP. For example, Cain (2002) found that average standardized test scores increased while using the CMP in schools of Lafayette Parish, Louisiana. In Ben-Chaim et al.'s study (1998), students learning math with the CMP outperformed those without participation in the CMP on problem solving skills when learning rate, density, ratio, or scaling. The students in the present study demonstrated their gain scores in solving ratio problems too. Thus, the findings in this study are consistent with those in the previous studies and add information about using the CMP for students with learning disabilities.

The second research question was to investigate the perceptions of students with learning disabilities on their mathematics learning when the CMP is provided. All students responded to a survey including four questions. Seventy-seven and a half percent of the students provided positive comments and selected "strongly agree" or "agree" when answering the questions. The first open-ended question, "What do you like the best about the CMP?" 90% of the students indicated that they were having a positive experience with the CMP. When responding to the second question, "What do you like the least about the CMP?" 40% of the students commented on the amount of writing the program required and the amount of time they spent to solve the problems.

This finding is consistent with that of Cain's study (2002), where 65% of students prefer the CMP comparing to previous methods of mathematics instruction they had received.

Limitations

This study has several limitations. The first is that there was not a control group taught by another mathematics instructional method to compare with the students in the CMP group. Even though, student performance was compared to their own pre- and post-test scores, other factors such as student motivation, class environment and instructional time may have impacted their learning. Second, the study had a small sample of participating students in a small rural school district. This has limited the findings to be generalized to other settings and geographic areas. A final limitation is that the pre- and post-tests only covered one unit out of the six CMP units that the students studied. Although the pre- and post-tests are reliable and valid and were given at the same time to each of the 10 students, a longer time period of instruction including more units may have be valid to the present study.

Recommendations

Considering the limited findings of this study, I would recommend a similar study to be replicated with a larger sample of learning disabled students from different schools. Further research on the CMP could include a control group of students with learning disabilities in learning the same math skills, but taught by a traditional teacher-directed approach. Thus, the effect of the CMP could be validated.

Conclusion

Students with learning disabilities have difficulty in learning mathematics, especially in learning problem solving skills. Because of their difficulty in learning, previous math instruction was often limited to basic skills, understanding concepts, and simulating operational procedures to complete the required assignments. The CMP has

provided an opportunity for these students to be involved in math problem solving activities. Within the CMP, students with learning disabilities are challenged to solve problems using higher level of thinking skills as well as problem-centered strategies facilitated by the teacher. The results of this study show that the CMP is an effective instructional approach. In the study, all students gained scores in their post tests, and most of them were satisfied with their learning experience in the math units. It demonstrates that students with learning disabilities can be successful and motivated if an appropriate instructional strategy is provided and their learning is supported.

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APPENDICES

APPENDIX A

Parent Consent Letter

Dear Parent/ Guardian:

I am a graduate student pursuing my Masters Degree at Rowan University. I will be conducting a research project under the direction of Dr. Xin as part of my master's thesis regarding children's learning mathematics using problem-solving based instruction (specifically the Connected Mathematics Project).

Each child will take a pre-quiz and a post-quiz for each of the four parts of the unit. At the conclusion of the unit each child will also complete a unit test as well as a student survey. All data will be reported anonymously in my research paper. At the conclusion of the study a summary of the group results will be made available to interested parents.

Your decision whether or not to allow your child to participate in the study will have absolutely no effect on your child's standing in his or her math class. I appreciate if you allow your child to participate in this study. If you have any questions please contact me at 965-1034 ext. 231 or you may contact Dr. Xin at 856-256-4734. Thank you.

Sincerely,

Melissa Axelsson

Please indicate whether or not you wish to have your child participate in this study by checking the appropriate statement below and returning this letter to your child's math teacher.

____ I grant permission for my child _____ to participate in this study.

____ I do not grant permission for my child _____ to participate in this study.

_____ _____

(Parent/ Guardian signature) (Date)

APPENDIX B

Connected Math Project Survey

This survey is being administered as part of graduate thesis project at Rowan University. While your participation is voluntary and you are not required to answer any of the questions herein, your cooperation and participation are important to the success of the project and are greatly appreciated. If you chose to participate, please understand that all responses are strictly confidential and no personally identifiable information is being requested. Moreover, whether you agree to participate or not, your decision will have no effect on your grades, your standing in class, or any other status.

Directions: For questions 1-4, circle the number that best represents your answer.

Key :
5 means ***Strongly Agree***
4 means ***Agree***
3 means ***No Opinion***
2 means ***Disagree***
1 means ***Strongly Disagree***

1. I like Connected Mathematics better than previous mathematics programs I have been taught.

   5 4 3 2 1

2. I am becoming a better math problem solver from working in Connected Mathematics.

   5 4 3 2 1

3. Connected Mathematics makes me think more than in other mathematics programs I have been taught.

   5 4 3 2 1

4. The problems and activities in Connected Mathematics help me to understand the mathematics concepts.

   5 4 3 2 1

5. What do you like the best about Connected Mathematics?

6. What do you like the least about Connected Mathematics?

APPENDIX C

Sample Test

Ms. Sandbourn, the student council advisor, is in charge of buying drinks for the school picnic. She conducted a survey that asked students what kind of soft drink they preferred: cola or lemon lime. Use the table for questions 1-3. Here are her results:

Drink Preferences

	Grade 6	Grade 7	Grade 8
Cola	180	175	185
Lemon Lime	170	190	180
Total students			

1. Fill in the row for total students at each grade level.

2. What percent of students at each grade level prefer lemon lime?

   a. 6^{th} grade

   b. 7^{th} grade

   c. 8^{th} grade

3. What percent of the students surveyed are eighth graders?

4. Of the 400 students in Chad's middle school, 40 percent participate in sports, 20 % play in the band, and 50percent take the bus to school.
   a. How many students in Chad's middle school play in the band?

   b. How many students in Chad's middle school take the bus to school?

   c. If you add up the percents if who play sports, play in the band, and take the bus to school, you get 110 percent. Explain why the percents do not add up to 100 percent.