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The Effects of a Summer Math Program on Academic Achievement

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COLLEGE OF EDUCATION

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Kermit Snyder

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Walden University
2016

Abstract

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Kermit Snyder

MA, Adams State College, 2004

BA, Adams State College, 2002

Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Education

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Abstract

The math achievement of students is low in a small rural district in Colorado. The purpose of this study was to explore the efficacy of a summer third through fifth grade math program in improving math scores. Piaget's theory of cognitive development was used as the theoretical foundation for the math instructional resource delivered to the struggling students in the program. A quasi-experimental design was used to address whether the math scores improved for the participating students (n = 145) and whether the participating students experienced a smaller summer loss in academic achievement than the students who did not participate (n = 457). Ex post facto data included pre- and post- math assessments. The math instruction and assessments were administered to third through fifth grade students as part of the school district's academic program during the 2012, 2013, and 2014 summer schools. A dependent samples t test was used to analyze the data to determine if the students' achievement scores improved for those attending summer school. The results did not indicate any significant improvement. An ANOVA was then used to determine if the summer math program decreased summer loss of learning in participating students. Participating students experienced significantly less summer loss than did non-participating students. Therefore, recommendations for the summer math program include more instructional time and moving the program closer to the beginning of the school year to avoid any summer loss. This study will have a positive social impact as it influences decisions made by the school district to improve the summer math program and produce students who are better prepared for postsecondary school options.

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Chapter 1: Introduction to the Study

Math Achievement

The National Assessment of Educational Progress (NAEP) has been used to track student achievement in the United States since 1969 (National Center for Education Statistics, 2014). The 2013 report on the NAEP results indicated a static trend in regard to the percentage of students scoring above basic level. In the reports for 2007, 2009, 2011, and 2013, the percentage of fourth grade students scoring above the basic level, at proficient or above, was 39%, 39%, 40%, and 42% respectively. Similarly, the percentage of eighth grade students scoring proficient or above was 32%, 34%, 35% and 35% for the last four reporting years (National Center for Education Statistics, 2014). The percentage of students scoring above the basic level in math has not improved much over the years, with only a 3% improvement in six years for both the fourth grade and eighth grade students.

Statement of the Problem

Math achievement in the United States remains a serious concern because of the lack of improvement. The percentage of students scoring above the basic level, as measured by the NAEP, has stayed nearly the same, and educators have been unable to significantly increase the percentage of students reaching the proficient level (National Center for Education Statistics, 2014). To attempt to resolve this problem, schools have used data driven interventions to identify deficiencies and to provide targeted instruction (Krawec, Huang, Montague, Kressler, & de Alba, 2013). Additionally, extended learning opportunities have been provided both beyond the scope of a single day’s learning and also beyond the term of the regular school year (Tichenor & Plavchan, 2010). However, the NAEP results indicated that recent efforts to increase the percentage of students scoring above the basic level have not resulted in large improvements (National Center for Education Statistics, 2014).

This problem with math achievement is also evident at the local level in a rural school district in southeastern Colorado. Low math scores contributed to a low accreditation rating for the district in 2010 (School View Data Center, 2014) and were the most glaring weakness within the district. District students on average scored 21 percentage points below the state average on the Transitional Colorado Assessment Program (TCAP; School View Data Center, 2014). The district attempted to address this problem of low math achievement by developing a summer school program that provided extra math instruction to students who were not scoring at the proficient level. However, these efforts did not improve the math scores. In fact, there was little difference in the achievement gap. Table 1 provides a summary of the math scores of the local district and the state of Colorado. This problem affects the K-12 students of the local district that struggle with mathematics by impacting their preparation for either post-secondary education or the workforce after they have graduated. The factors to consider with this problem include characteristics of successful summer programs and instructionally appropriate remedial materials for math.

Table 1

Colorado State Math Assessment

District / State	2010	2011	2012
Local District Proficient or Above	33.8%	34.1%	33.1%
Local District Not Proficient	66.2%	65.9%	66.9%
State Proficient or Above	54.8%	55.7%	55.8%
State Not Proficient	45.2%	44.3%	44.2%

Note. Retrieved July 31, 2014 from The School View Data Center website: http://www.schoolview.org

The school district made a decision to change the math instructional program for the 2012 summer to address this problem of low math achievement. Up until the 2012 summer school, the district had utilized the instructional materials from the regular school year with the teachers identifying which units of study would be delivered to the students. For the 2012 summer school, the district decided to use a new resource, Number Worlds, which was developed specifically for struggling math students (Griffin, 2007). This study will contribute to the body of knowledge needed to address the problem of low math achievement by determining if a new approach to the summer math program with Number Worlds helped to increase the math achievement in the local school district.

Nature of the Study

In this quasi-experimental quantitative study, I used a pre-test and post-test design with nonequivalent groups to measure the academic achievement of struggling math students in the third through fifth grades participating in a summer program in a rural region in Colorado. The school district administered the pre-test in May to all students before the start of the summer school program. The district administered the post-test in September, again to all students in the school district, after the summer school program was complete. I used a statistical analysis to determine if there was an increase in the math scores of the participating students. The pre-test and post-test design also allowed me to analyze summer loss and whether the participating students experienced a smaller loss due to the program. The summer program utilized Number Worlds, an instructional resource for math (Griffin, 2007). The teachers delivering the instruction received training on Number Worlds prior to the start of the summer program and regular administrative observations were used to ensure fidelity to the program. The school district measured the students' performance using the Northwest Evaluation Association (NWEA) Measures of Academic Progress (MAP) that was administered before the summer program began and again at the end of the summer program (Northwest Evaluation Association, 2014). Students participating in the summer program received 50 hours of additional instruction in math during June, the first month of the summer vacation. The students invited to summer school consisted of those that scored below the proficient level on the MAP during the regular school year. Scores were collected by the school district from the NWEA reports site that publishes the test results by individual students. I secured permission to use the scores for this study and then analyzed results using a statistical analysis. Details regarding the type of statistical analysis and the methodology used for this study are provided in chapter three.

Research Questions

1. Did students' math scores improve after participating in a summer math program that uses Number Worlds?
2. How did the students participating in the summer math program differ from the students who did not participate in the program in terms of summer loss of math academic achievement for the local school district?

The independent variable for the first research question was participation in the summer school program that uses Number Worlds. The dependent variable was the academic achievement in math of the students participating in summer school as measured by the MAP (Northwest Evaluation Association, 2014). The following are the null hypotheses (H_0), and the alternative hypotheses (H_1) for the first research question.

H_0: There is no change in the math achievement scores from the beginning of summer to the end of summer of third grade students who participate in a summer program that uses Number Worlds.

H_1: There is an increase in the math achievement scores from the beginning of summer to the end of summer of third grade students who participate in a summer program that uses Number Worlds.

H_0: There is no change in the math achievement scores from the beginning of summer to the end of summer of fourth grade students who participate in a summer program that uses Number Worlds.

H_1: There is an increase in the math achievement scores from the beginning of summer to the end of summer of fourth grade students who participate in a summer program that uses Number Worlds.

H_0: There is no change in the math achievement scores from the beginning of summer to the end of summer of fifth grade students who participate in a summer program that uses Number Worlds.

H_1: There is an increase in the math achievement scores from the beginning of summer to the end of summer of fifth grade students who participate in a summer program that uses Number Worlds.

The independent variable for the second research question was again the summer school program with Number Worlds as the instructional resource. The dependent variable was the change in academic achievement from May to September of students in math as measured by the MAP. I compared the change in academic achievement of the participating students to the change in academic achievement of the non-participating students. The group of non-participating students included all students who were part of the school district but were not identified for the summer program. Both groups of students, those participating in the summer program and those not participating, took the MAP math test in May and again in September. I used the change in scores to determine the summer loss or lack thereof for the participating and non-participating students. The following are the null hypotheses (H_0) and the alternative hypotheses (H_1) for the second research question.

H_0: The summer loss in academic achievement of the third grade students participating in the summer math program with Number Worlds is not significantly different than the summer loss in academic achievement as measured by MAP of the third grade students not participating in the summer program.

H_1: The summer loss in academic achievement of the third grade students participating in the summer math program with Number Worlds is different than the summer loss in academic achievement as measured by MAP of the third grade students not participating in the summer program.

H_0: The summer loss in academic achievement of the fourth grade students participating in the summer math program with Number Worlds is not significantly different than the summer loss in academic achievement as measured by MAP of the fourth grade students not participating in the summer program.

H_1: The summer loss in academic achievement of the fourth grade students participating in the summer math program with Number Worlds is different than the summer loss in academic achievement as measured by MAP of the fourth grade students not participating in the summer program.

H_0: The summer loss in academic achievement of the fifth grade students participating in the summer math program with Number Worlds is not significantly different than the summer loss in academic achievement as measured by MAP of the fifth grade students not participating in the summer program.

H_1: The summer loss in academic achievement of the fifth grade students participating in the summer math program with Number Worlds is different than the summer loss in academic achievement as measured by MAP of the fifth grade students not participating in the summer program.

Purpose of the Study

The purpose of this quantitative study with a pre-test and post-test design was to explore the efficacy of a summer math program that uses the Number Worlds resource to improve achievement in struggling math students. The NAEP results indicated that math academic achievement has remained stagnant in recent years (National Center for Education Statistics, 2014). Griffin designed Number Worlds to target struggling math learners in an intervention or extended learning environment, and developed the program using Piaget's theory of cognitive development (1950) applied specifically to mathematics in a way that the author referred to as the central conceptual structure theory (Griffin, 2009).

Theoretical Framework

Piaget's theory concerning cognitive development (1950) has been applied to the learning of mathematics by educators seeking a way to properly sequence concepts and ideas (Garcia & Pacheco, 2013). The theory has influenced the teacher to student relationship since it was first published (Bibace, 2013). Piaget's original theory of cognitive development included four stages: sensorimotor, preoperational, concrete operational, and formal operational (Garcia & Pacheco, 2013). In the sensorimotor stage, infants gain the ability to recognize objects and to find them even if they have been taken out of the field of vision, and they also gain the ability to connect numbers to objects (Garcia & Pacheco, 2013). For the second stage, preoperational, Piaget characterized it in part by a child gaining an ability to utilize language to communicate which would then allow a child to begin to talk their way through math problems (Garcia & Pacheco, 2013). The third stage, concrete operational, was described by Piaget as the stage with the most rapid increase in cognitive development which resulted in children being able to perceive multiple dimensions simultaneously (Garcia & Pacheco, 2013). The final stage, formal operations, was defined by Piaget as the stage when children began to gain the ability to think more logically, capable of developing and testing hypotheses (Garcia & Pacheco, 2013).

Griffin, the author of Number Worlds, maintained the four stages from Piaget's original theory and added three postulates to develop a program that could be used for remedial math instruction (Griffin, 2009). The first postulate added the idea that a child's thought processes will change depending upon the content area (Griffin, 2009). The second postulate identified transitions across age ranges and suggested that they would happen at an average of every two years (Griffin, 2009). The final postulate Griffin added described a growth in children's working memory that resulted in a rate of conceptual change.

Traditional math classrooms with a teacher delivering instruction to a large group of students through lecturing lack the components necessary to develop cognitive skills (Speelman, 2014). The approach used in Number Worlds has been identified by scholars of math education as one of the rare modern day approaches to develop cognitive abilities for students in the area of mathematics (Speelman, 2014). Through the development of their cognitive abilities, students are better able to attain basic numeracy skills which can lead to expertise in mathematics. Griffin (2009) designed the Number Worlds program to follow a developmental progression for mathematical concepts and ideas with a learning sequence that identifies central mathematical concepts and teaches these in a spiral manner. Each time a concept is taught, the depth of knowledge increases to parallel the cognitive development of the child (Griffin, 2009). Griffin measured the efficacy of the instructional sequence using a number knowledge test to assess the depth of knowledge that students had attained within the different mathematical concepts. She then used the data to make further revisions to the learning sequence within the instructional program (Griffin, 2009). The Number Worlds program holds to Piaget's original theory by arranging concepts to be taught in a sequence that matches up with children's cognitive development, which should result in an increase in the students' depth of knowledge in mathematics. In my study, I determined how effective Number Worlds was at increasing students' mathematical knowledge when participating in the instructional program during summer school.

Operational Definitions

Engagement Strategies: Instructional activities that are designed to actively involve students in the learning process (Park, Holloway, Arendtsz, Bempechat, & Li, 2012).

Learning Trajectories: Specific learning targets, the learning paths that will help students reach the targets, and a set of instructional activities intended to help students move along the learning paths (Clements & Sarama, 2011).

Measures of Academic Progress: A series of adaptive computerized assessments in reading, language usage, science, and math developed by the Northwest Evaluation Association (Northwest Evaluation Association, 2014).

Number Worlds: A math instructional program that was designed, using the central conceptual structure theory, to follow a developmental progression for mathematical concepts and ideas (Griffin, 2009)

Summer school: an instructional program to remediate learning deficits during the extended break between school years for schools on a traditional nine-month calendar (Zvoch & Stevens, 2013).

Scope

The scope of this study on a math summer school program using Number Worlds was limited to third, fourth, and fifth graders in a rural school district in Colorado. I chose this specific grade span because of the number of students involved, the target grade span for Number Worlds, and the transition from one building to another for students enrolled in this rural district in Colorado. The average number of students that attended summer school was 15 per grade level. This was too small of a sample size to prove that increases in scores are statistically significant. Therefore, I analyzed results over a three-year span, 2012 through 2014. I included multiple grade levels in the sample to contribute to the credibility of the results. However, I evaluated each grade level independently because of the inability to combine results from the different grade level assessments. The MAP assessments are not the same for each grade level; therefore, I could not combine the results from the assessments for a single statistical analysis. Number Worlds includes many instructional levels that are appropriate for Kindergarten through eighth grade (Griffin, 2007). In order to decide upon the grade span, I considered three different groupings: primary grades (Kindergarten through second grade), intermediate grades (third grade through fifth grade), and middle school (sixth grade through eighth grade). I selected the intermediate grade span because the sample size would be larger than the middle school group, and the primary grade span would not be ideal because Kindergarten students would be unfamiliar with the MAP assessment that was used for the pre-test and post-test. By including third, fourth, and fifth graders, I estimated the sample size to be approximately 15 students per grade level per year.

Students in this rural Colorado district were invited to summer school when the district identified them as non-proficient in math using the annual Colorado state assessment reports. The MAP test, which is correlated to the Colorado state assessment proficiency ratings, was also administered to students three times during the school year, and the district used the scores to help identify the students' proficiency levels. Students who were non-proficient according to the Colorado state assessment and the MAP were invited to attend the summer math program with Number Worlds.

Delimitations

The delimitation of the study was that it did not have a control group. The reason for this is that it would have been imprudent to withhold the benefits of attending summer school to struggling learners. Morally, I could not identify a group of students that needed summer school and then deny the services to half of them. All students that were identified as non-proficient were invited to attend.

Limitations

The results of this study cannot be generalized for all school districts and populations because various factors may be different between the school district in this study and other school districts including the experience level of the teachers, the classroom environment, and other similar factors that cannot be controlled with this study. The results are specific to a rural school district with class sizes of approximately 15 students. Also, the summer math program included 50 hours of math instruction so results cannot be generalized for summer programs that have smaller or larger amounts of instruction time.

Another limitation was the lack of a control group. Because the traditional summer math program produced undesirable results, the school district could not ethically assign a group of students to continue with the traditional program while another group of students received their instruction from a new program. The lack of a control group limited this study from being able to definitively conclude that the differences in the pre-test and the post-test results were causally related to the new math program. I used the results from three different grade levels to support any conclusion regarding the new summer program being a factor in the difference between the pre-test and post-test.

This study also had relatively small sample sizes, approximately 45 students per grade level. The small sample sizes led to limitations with regard to power in the statistical analyses used to test the hypotheses. Low power in statistical analysis results in an inflated type II error rate and increases the possibility of failing to reject the null hypotheses when indeed you should have. To address this limitation, I conducted a power analysis after the data had been analyzed but prior to the interpretation of the results. I used the power analysis to determine if the result was due to a weak relationship between the groups or due to low power (Suresh & Chandrashekara, 2012).

Assumptions

I assumed that the students would have the computer skills necessary to take the MAP. The MAP is an adaptive computerized assessment and requires minimal computer skills including using a mouse to select answers and objects, and using a scroll bar to view reading passages in their entirety (Northwest Evaluation Association, 2014). This assumption was necessary to rule out computer skills as a reason for differences in scores. Satisfactory completion of the technology learning assignments in the computer lab during the regular school year supported this assumption. I also assumed that the students performed their best on both the pre-test and the post-test. The teachers helped the students develop goals for the assessments based on their previous scores and their classroom performance.

Significance of the Study

Math achievement has been a focus in the United States for many years (National Center for Education Statistics, 2014). There is a continuing need to find instructional tools that assist struggling math learners. This study contributes to the body of literature by helping identify if Number Worlds can be used for supplemental education and extended year services. The local school district in rural Colorado benefits from this study by learning of factors that can be adjusted to make the program more effective.

Although the program did not produce the desired math achievement results, there are positive aspects that can be built upon to help the program produce higher achievement scores. This study may lead to adjustments such as the amount of instruction time or the timeframe during the summer vacation in which the program takes place.

Summary

There is a need to continue to identify math instructional tools that can contribute to the increase in academic achievement for struggling math students. The 2013 results of the National Assessment for Educational Progress indicated that 58% of fourth graders and 65% of eighth graders were not able to make it to the proficient level or above (National Center for Education Statistics, 2014). Number Worlds was developed, using the conceptual structure theory, to target struggling math learners (Griffin, 2009). For this study I used a summer program that provides 50 hours of math instruction to test the effectiveness of the Number Worlds program for third, fourth, and fifth grade student learning. I used the MAP as a pre-test and post-test to measure the increase in academic achievement of the participating students and also to measure the change in academic achievement in the area of math for the remainder of the students not participating in the summer program. I analyzed the results for each grade level independently over a three-year span of 2012, 2013, and 2014.

Chapter two includes a literature review of instructional strategies for math and effective practices for summer school programs. In it I review research-based instructional strategies for math, specifically for students that have been identified as performing at a level that is lower than their peers. I also review summer school practices found within the literature, including the amount of instruction time, group sizes for optimum results, and other aspects of summer school that lead to success for students.

Chapter 2: Literature Review

Introduction and Research Strategies

Math scores in the United States, as measured by the NAEP, indicate that the percentage of students scoring below the basic level has not improved (National Center for Education Statistics, 2014). The lack of improvement demonstrates a need for math instructional strategies and interventions that can help struggling students increase their math achievement from a level that is below the basic level to at least the basic level or above. This same problem with math achievement is also evident at the local level in the school that served as my study site. Students in this school district in southeastern Colorado scored, on average, 21 percentage points below the state average on math in the 2010 Transitional Colorado Assessment Program (TCAP; School View Data Center, 2014). To address this problem, the school district provided remedial math instruction through a summer school program. However, the results were not favorable. Table 1 in the previous chapter contains the results that showed little difference in the achievement gap between the local school district and the state. Thus, the district decided to change the summer school curriculum by selecting a new math program called Number Worlds (Griffin, 2007). In this study I attempted to determine if Number Worlds was effective at helping students reach higher levels of proficiency and if it helped to reduce the summer loss of math skills generally experienced by K-12 students.

In this chapter I offer a literature review of math instructional strategies for struggling math students. Because summer school is the main venue where these strategies are delivered to the students in the local district, I also include a review of literature on summer school practices. I conducted the research for this literature review using electronic databases including the Education Resources Information Center (ERIC), Education Research Complete, and ProQuest Central. Math instruction and summer school programs were the two main categories that I researched for this literature review. The key search terms for math instruction included *math instructional resources, standards, effective math instructional strategies, math instruction for English language learners,* and *math assessment practices.* The key search terms for summer school programs included *summer loss, characteristics of successful summer programs,* and *recruiting teachers for summer school*. In the following review, I will first focus on math instructional strategies and will then review summer school programs.

Math Instructional Strategies

Math Instructional Resources

Before switching to the Number Worlds math program for their summer school, my study site used their curricular resources from the regular school year. The summer school teachers considered the students that were assigned to them and then chose the specific units from the regular school year that they wanted to reteach in the summer school program. As I previously mentioned, the math achievement scores did not increase; in fact, the gap between the state and the school district scores increased (School View Data Center, 2014). Using the curricular resources from the regular year to provide remedial instruction during the summer program did not appear to be an effective strategy.

When textbooks are used as the primary instructional resource, instruction tends to emphasize rote memorization more than critical thinking skills (Saritas & Akdemir, 2013). Saritas and Akdemir (2013) have advised that teachers conduct an alignment process between the math textbook and the math standards to ensure that all of the learning objectives are covered in order to optimize the instruction and avoid an overreliance on textbooks. Linder (2010) emphasized this as a particularly necessary strategy for students who struggle with mathematics and explained that completing an alignment process between the textbook and the math standards helped teachers focus more on the individual student, design specific strategies for connecting students to a lesson, and help them experience success in each lesson. Using the central conceptual structure theory, the Number Worlds program has a defined learning sequence that is designed to strengthen the cognitive abilities of the students (Griffin, 2007). In keeping with the findings in these studies, the Number Worlds resource provides a defined progression of lessons and learning objectives instead of having summer school teachers identify a few units of study from textbooks used during the regular school year.

Math Standards

The same concepts of standards alignment apply when considering both younger and older K-12 students. Successful instruction at the primary grade levels has been described as having learning trajectories and lessons that are both challenging and interesting, thus preserving the ideas of alignment and engagement (Clements & Sarama, 2011). In a study that compared the math achievement of elementary students in districts where a new comprehensive curriculum was implemented that was aligned to national standards to the achievement of elementary students in districts that maintained the previous textbook as the main resource for instruction, Desimone, Smith, and Phillips (2013) showed the effectiveness of maintaining both alignment and engagement. In a period of five years, students receiving their instruction from the aligned curriculum increased their average scores at more than four times the rate of the control group that used the traditional textbook. Harris & Sass (2011) have also suggested that, because most elementary teachers are expected to teach several different content areas instead of just focusing on math, they should continue to practice their own math skills and deepen their content knowledge. I found that the themes of aligning the teaching resource to the intended learning objectives and delivering engaging lessons were key concepts in the literature related to basic math instruction for all students.

My research site had taken steps to ensure that there was alignment during the regular school year between their intended learning objectives and the math instructional resources; however, this same process had not occurred with the summer math program. Assumptions were made that if a unit of learning was appropriate for students during the regular school year, they should also be appropriate for the summer remedial program. The error in this approach was that the learning trajectories were not redeveloped for the remedial instruction in the summer. Instead, only pieces of the learning trajectories from the regular school year were being used. The Number Worlds resource should solve this problem because it has complete learning trajectories within its units (Griffin, 2007).

Effective Math Instructional Strategies

Remedial instruction for students that do not achieve the basic level of math proficiency after participation in the general classes has been described by Doabler, Fien, Nelson-Walker, and Baker (2012) as a tiered system. They described tier one as consisting of the instruction that was delivered to all students on a universal level, and tiers two and three as additional supports and remedial instruction for struggling students that use extra instruction time and research-based instructional strategies.

Two such strategies suggested for remedial math instruction by Mulcahy, Krezmien, and Maccini (2014) are direct teaching and computer assisted instruction. Direct teaching consists of a teacher to student delivery that is precise and explicit. The teacher first demonstrates the skill, then the students and teacher perform the skill together, and finally the students practice the skill on their own (Mulcahy et al., 2014). Computer assisted instruction simply uses technology and multimedia instructional supports to individualize the learning path for each student. However, the researchers found that these two methods produced inconsistent results (Mulcahy et al., 2014).

Other strategies that have been suggested for struggling math students include using games and mental models to build number sense (Gersten, Clarke, Jordan, Newman-Gonchar, Haymond, & Wilkins, 2012). Number sense is not just recognition and memorization of math symbols, but rather is an understanding of relationships between different quantities and an ability to manipulate those relationships (Nickerson & Whitacre, 2010). Gersten et al. (2012) suggested that games involving numbers and quantities help students gain an understanding of numbers, the values they represent, and their comparison to other numbers and values. Similarly, Gersten et al. explained that mental models help students to quantify and compare numbers. Jung & Conderman, (2013) encouraged allowing students to work with physical math manipulatives as a way to help students create mental models. They recommended building blocks, counting rods, geometric shapes, fake money, and measuring tools as instructional tools to help students understand the meaning of numbers and quantities. Other researchers have noted that teaching students number sense and using math manipulatives in the instruction is a break from traditional teaching (McNeil & Fyfe, 2012). Instead of the traditional approach of teaching students to memorize math facts and algorithms, McNeil and Fyfe (2012) suggested that number sense and math manipulatives would bring about engagement in math lessons and a more comprehensive understanding of the world of mathematics.

The engagement of students within a math lesson has been cited in many studies as a major factor in the success of basic math instruction (Park, Holloway, Arendtsz, Bempechat, & Li, 2012). George (2010) described simple techniques for engaging students as either whole class or individual communication which explains to students the benefits of successful participation and completion of the assigned math tasks. This concept relies on students gaining an intrinsic motivation to learn and succeed in math. Park et al. (2012) proved that increased engagement was a successful way of increasing math scores to varying degrees, depending upon the different backgrounds of students. Because of the varying backgrounds and interests of the students involved, Walshaw and Brown (2012) pointed out that there is not just one approach to bring about the engagement of all students. Instead, math educators should employ a variety of engagement strategies including behavioral, emotional, and cognitive engagement strategies (Park et al., 2012).

Engaging students in the math lessons is also a theme in the literature for students in the middle grades. Pogrow (2010) explains that using real-life application problems increases the engagement of students in the lesson. Pogrow (2010) found an increase in math achievement scores when a traditional math program includes engagement strategies through the use of real-life application problems. At the high school level, Dawson, Ritzhaupt, Liu, Rodriguez, and Frey (2013) suggest exploring real-life applications with technology to increase student engagement. Students are better able to retain math knowledge and become engaged with lessons that are presented through technology. A basic math instruction program should include an appropriate teaching resource that is aligned to the intended learning objectives and engaging lessons need to be planned for and delivered.

In addition to the engagement strategies described above, cooperative learning is an effective instructional strategy for remediation in the primary grade levels. Shayer and Adhami (2010) conducted a study in which cooperative learning increased the cognitive potential of primary students receiving remedial instruction. In a pre-test to post-test comparison between the control and experimental groups over a five-year period, the average experimental group score gained 0.3 standard deviations more than the control group (Shayer & Adhami, 2010).

Although cooperative learning is identified as a major strategy for engaging students in math lessons, other strategies also increase students' interests in math and their motivation to succeed. These include preventive tutoring, multi-level classrooms, and math clubs. Preventive tutoring is a developmental math program that is provided to students who score just below the basic level (Fuchs, S., Compton, Fuchs, D., Hollenbeck, Hamlett, & Seethaler, 2011). In one study conducted by Fuchs et al. (2011), identified students received 15 hours of remedial instruction in addition to their basic math class over a 12-week period. The tutoring resulted in increased math scores with an effect size of 1.8 standard deviations. Another developmental program to increase math achievement is the use of multi-level classrooms. Multi-level classrooms are student groupings that are based on ability level rather than age. Students grouped by ability are placed within a class that has students with a variety of ages. Wang and Eccles (2014) suggested that this strategy provides more opportunities for success which result in an increase of student motivation. In a similar way, after school math clubs increase student engagement through fun activities and help students to experience success in math (Klanderman, Webster Moore, Maxwell, & Robbert, 2013). Klanderman et al. (2013) administered a survey to students and found that the participants in the math clubs experienced an increase in their positive attitude toward math which then resulted in higher achievement in their regular math classes. Developmental math programs have the potential to increase student motivation and achievement in math.

Retaining students in a grade level because of poor performance is another strategy that is used to improve academic achievement in math. Moser, West, and Hughes

(2012) hypothesized that retention coupled with participation in developmental math programs, such as tutoring or after school math clubs, would accelerate students' academic achievement. The study found that students experience an increase in academic achievement the first year after retention; however, this benefit slowly dissipates and is nonexistent after four years. While my study site does have a retention policy for students, it is not based solely on the student's performance level in academics. Less than 1% of students are retained on an annual basis in the school district used for my study.

Aligning instructional resources to the learning objectives, teaching number sense rather than memorization, using cooperative learning to deliver lessons, and integrating technology and math manipulatives into the instruction are all effective strategies for increasing students' math achievement. Zhang and Xin (2012) conducted a review of studies related to math interventions for struggling students from 1996 to 2009 and identified these effective strategies. However, the study also pointed out that the increased scores on the assessments used for the studies have not translated into an improvement in scores on the NAEP.

The final area of effective math instructional strategies that I discovered within the literature dealt with parental involvement. There is evidence that parental activities are able to accelerate the academic achievement of the children involved because of structured activities in the home related to math, the presence of workbooks and other math materials in the home, and the involvement of the parents in school activities and events (Roksa & Potter, 2011). Roksa and Potter (2011) provided evidence for the relationship between home learning activities and successful academic progress as students begin school at a young age. This correlation remains strong as students grow older and enter upper grade levels. There was a coefficient of 0.791 for the correlation between these types of parenting activities and high academic achievement for students between the ages of six and fourteen (Roksa & Potter, 2011). As further evidence, Schielack and Seeley (2010) found that the simple act of parents expressing their expectations influences middle school students to perform better and to be placed within advanced math courses. Raizada and Kishiyama (2010) recommended that schools hold parent activity nights to present math activities that parents can do at home with their children. Also, schools should provide more opportunities for children to interact with others utilizing math activities to help make up for the lack of opportunities at home (Raizada & Kishiyama, 2010). Schools cannot replicate the advantages of having a home environment that supports education however, extra time and effort can be put forth to provide additional learning opportunities.

The Number Worlds program contains recommended instructional strategies for teachers including ways to involve parents (Griffin, 2007). The local school district provides training for the summer school teachers to help them become familiar with the math instructional resources and how to use the resources to develop lesson plans. The teachers are held accountable for implementing the instructional strategies through the teacher evaluation process and through classroom walkthroughs by the administrators. If the appropriate instructional strategies are not observed during the administrator classroom walkthroughs, additional support is provided to the teacher and is followed up by a longer walkthrough to ensure implementation.

Math Instruction for English Language Learners

Another area to consider when developing a remediation program for math is the language barrier for English language learners and the multi-cultural background of the variety of students involved. This is particularly important to my study site where approximately 30% of students in the school district are identified as English Language Learners. Pais (2011) explained that math instruction should be tailored for the different experiences and backgrounds of the students. Although the education community has increased the multi-cultural instruction involved in math, Pais (2011) questioned whether these strategies have been used to their fullest. Instruction that is more closely tied to students' backgrounds and experiences helps students grasp the concepts more quickly and helps to maintain their interest in the topics being presented. Similarly, Tan (2011) encouraged the inclusion of students' cultures within the classroom. Vocabulary development of just the mathematical terms is not enough to help English language learners overcome the communication barrier. Instead, teachers should find different ways of communicating with students including the use of non-linguistic representations to help students visualize concepts in their minds without the need for accompanying English phrases or terminology. Chval and Chávez (2012) explained that after non-linguistic representations are used to teach concrete models that can be visualized, vocabulary strategies and technology should be used to help English language learners build their math terminology. Instructional strategies that target language barriers and access to lessons through a multi-cultural approach should be used to increase the probability of success for remedial math programs. The Number Worlds program uses a multicultural approach by utilizing a variety of non-linguistic representations of concepts within each lesson as well as multiple vocabulary development activities (Griffin, 2007).

Math Assessment Practices

Assessment is also a critical component of math instruction to determine how well students understand the concepts that have been taught and to guide future instruction by identifying skills and concepts that students have not completely grasped. White and Anderson (2012) defined summative assessments as tests given periodically to check knowledge across a broad set of standards. The benefits of analyzing results of summative assessments are the ability to measure the growth of individual students from one summative assessment to the next, the ability to compare sub-groups of students, and the ability to compare the scores earned within the different standards to determine gaps within the instruction (White & Anderson, 2012). Ciullo, SoRelle, Kim, Seo, and Bryant (2011) explained that, in between the summative assessments, more informal assessments should be administered to gauge the students' progress. The informal assessments administered on a more frequent basis provide teachers consistent guidance in their daily planning of math lessons (Ciullo et al., 2011). While both summative and formative assessments are suggested for all students, Burns, Codding, Boice, and Lukito (2010) identified further assessments as being an integral part of remedial instruction for struggling math learners specifically curriculum based measurements and fluency progress monitoring. Curriculum based measurements are brief checks for understanding directly related to recent instruction and fluency progress monitoring is an assessment used to determine how quickly students are able to apply basic math operations strictly with numbers instead of within the context of a word problem. Burns et al. (2010) conducted a meta-analysis of programs that used curriculum based measurements and fluency progress monitoring and found that these assessments had an effect size of 0.47 for remedial students. These assessments provide information about students' understandings that assist the teacher in developing the next lesson to target any gaps in the learning. Assessment must be a part of any program designed to improve the academic achievement of struggling math learners.

In my study site, the math fluency of the students is measured once a week. Additionally, curriculum based measurements that accompany the Number Worlds program are used. The summative assessment used to measure the overall success of the program is the MAP (Northwest Evaluation Association, 2014).

Summer School Programs

This study focuses not only on a remedial math program but also delivering it during a summer school program. Therefore, effective summer school practices were also reviewed within the literature. The topics reviewed included summer loss, characteristics of successful summer school programs, and recruiting teachers for summer school.

Summer Loss

Cooper (2003) reported that the average summer loss for students is one month. Cooper's meta-analysis compiled standardized test scores administered before and after the summer break which revealed a decrease equivalent to one month's worth of learning. In a similar study, Slates, Alexander, Entwisle, and Olson (2012) found that the loss was more pronounced in the area of math skills than any other content area or topic. Moore

(2010) explained that struggling math students typically participate in fewer activities at home during the summer months and therefore experience more of a loss than other students. McMullen and Rouse (2012) suggested different interventions including an extended year calendar, summer school, and a year-round academic calendar to prevent summer loss from occurring. However, Slates et al. (2012) indicated that summer school programs produce the most success in terms of academic achievement gains on standardized tests. Students that participated in a remedial summer program scored approximately one-fifth of a standard deviation higher (Slates et al., 2012). Effective summer school programs have the ability to reverse the summer loss phenomenon and to increase academic achievement.

Characteristics of Successful Summer Programs

Jesson, McNaughton, and Kolose (2014) explained that summer school programs should differ from math classes during the regular year. If students are already performing below the proficient level with the core instruction then different approaches should be used to provide the remedial instruction. Jesson et al. (2014) recommended changes including smaller class sizes, individualized instruction, cooperative learning, rewards, and standards based report cards. All of these strategies are built into the Number Worlds program utilized by the local school district for their summer remedial math program (Griffin, 2007). Smaller class sizes offer more opportunities for teacher guidance. Also, the smaller classes make it possible for teachers to focus more on individual students and prepare lessons that allow individuals to experience success. Another difference from the regular school year should be a focus on cooperative learning that moves away from teacher lecture to a more engaging style of instruction that involves interaction with other students and hands-on activities. However, accountability for the learning objectives is still necessary for a successful program and traditional grading systems should be replaced with standards based reports that offer the students and their parents more details about their progress with the assigned math skills. Also, in regards to accountability, Mariano and Martorell (2012) suggested that successful completion of summer school should not be a prerequisite to pass to the next grade level. Through their study, Mariano and Mortorell (2012) found that students and parents feel more successful and prepared for the next school year when summer school does not dictate whether the student is retained or promoted. In my study site, retention is decided before the end of the regular school year, before students are identified for summer school. Thus, students and their parents already know if they are being retained before the summer school program begins.

Zvoch and Stevens (2013) provided two other recommendations for successful summer programs. The first recommendation is to teach complex topics early in the program and the second is to reconfigure assignments to fit the shorter time frame of summer programs. By teaching complex topics early in the program, teachers are not forced to rush through the instruction to fit it in before the end of the compressed summer program. Similarly, the shorter time frame does not allow for the completion of larger assignments. Assignments should be shorter in order to not focus too much time on any one task. Because Number Worlds was designed to be a remedial program that could be used for summer school, the assignments are shorter and the learning sequences maximize the cognitive development of the students (Griffin, 2007). Also in regards to the instruction time available during summer school, Zvoch and Stevens (2013) found that the minimum amount of instruction time for a summer program should be 30 hours (Zvoch & Stevens, 2013). My study site scheduled 50 hours of math instruction. The program consisted of five weeks of instruction from the first week of June through the first week of July, five days per week, and two hours per day focused specifically on math instruction.

Recruiting Teachers for Summer School

One problem with providing a quality summer school is with finding qualified math teachers. Rosas and Campbell (2010) estimated that only 38% of secondary students during the regular school year are being taught math by teachers who did not earn either a major or minor in mathematics. Rosas and Campbell (2010) added that elementary teachers typically are not required to take many math education classes during their teacher preparation program and the few classes they are required to take are often not taught by math specialists. The lack of content knowledge prevents teachers from being able to deliver math instruction to struggling students. Desimone and Long (2010) explained that it is even more difficult to recruit high quality teachers for a summer program. In many cases there is a stigma related to teaching in a summer school program. Teachers have little desire to be part of the summer school program and feel that there is little incentive to teach in the program beyond receiving a small stipend. Desimone and Long (2010) suggested that summer school teachers should be recruited with the idea that they can develop their craft, try new fun activities, and gain leadership experience.

Regardless of the means that are used to recruit high quality teachers, they are necessary to have a successful summer program. According to a meta-analysis conducted by Desimone, Smith, and Phillips (2013), when teachers participate regularly in professional development that focuses on math content or math instructional strategies, the effect sizes on student achievement growth ranges from 1% to 15% of a standard deviation . Students gain more out of the instruction if it is delivered by knowledgeable and skilled teachers. In an effort to address the concern of recruiting high quality teachers for summer school, my study site increased the pay and provided professional development for the use of the Number Worlds program. The school district has not had any problems filling the summer school teaching positions since the introduction of the Number Worlds program.

Consideration of Methodologies

The studies reviewed in the literature used three different methodologies including quantitative, mixed methods, and a meta-analysis of other quantitative studies. A mixed methods approach was used only once. The one mixed methods study reviewed used a survey to collect data on parenting practices and then correlated those results with the assessment scores of students. Only two of the studies reviewed used a meta-analysis. One compiled the results of several studies on the effectiveness of different aspects of summer schools while the other meta-analysis gathered data on teachers' participation in professional development to correlate it to the achievement growth of the students. The remaining studies reviewed, representing the large majority of the literature review, were quantitative studies with a quasi-experimental approach. Most of these studies involved only one treatment with a single group and a *t* test was used to measure the change in scores from before and after the treatment. An ANOVA was used in the studies that involved more than one sample group.

The purpose of this quantitative study with a pre-test and post-test design was to explore the efficacy of a summer math program that uses the Number Worlds resource to improve achievement in struggling math students. The summer school program was the independent variable and the math academic achievement scores of the participating students were the dependent variable. Creswell (2014) explained that a quantitative research design is most appropriate for comparing the results in a study involving different treatments and variables. I could not use random sampling because of the identification process for inviting students to attend the summer school program. My study site identified students through a body of evidence including recent results on a state standardized assessment and performance on the MAP math assessment. Creswell (2014) also taught that this type of sampling where participants are not randomly chosen is referred to as quasi-experimental. The methodologies of the studies reviewed in the literature supported the choice of a quasi-experimental design for this quantitative study on the effectiveness of a summer math program.

Summary

The NAEP math results have shown little improvement in the percent of students scoring below the basic level (National Center for Education Statistics, 2011). It is important for schools to continue to seek ways to help struggling math students reach the basic level or above. A review of best practices for effective math instruction revealed that an alignment process between the math textbook and the math standards is necessary.

This is to ensure that all of the learning objectives are covered in order to optimize the instruction and avoid an overreliance on textbooks (Saritas & Akdemir, 2013). Strategies to increase student engagement are a concern for core math classes. The engagement strategies suggested include the integration of technology, direct teaching, math manipulatives, math games, and cooperative learning (Gersten et al., 2012; Mulcahy et al., 2014; Shayer & Adhami, 2010). Another component of successful math remediation programs was identified as assessment. Both summative and informal assessments help identify the gaps in students' understandings and help to direct the daily instruction (Ciullo et al., 2011; White & Anderson, 2012). Finally, strategies for English language learners and family involvement were discussed. These strategies include teaching math concepts in a concrete way that can be visualized by students, vocabulary development, home activities, and parents communicating their expectations to children (Chval & Chávez, 2012; Roksa & Potter, 2011; Schielack & Seeley, 2010; Tan, 2011).

Summer school practices were also reviewed to identify effective strategies for increasing the academic achievement of struggling students. The need for summer school programs is clearly defined in the research which indicates that students experience approximately one month's worth of academic loss in math during the three months of summer vacation (Cooper, 2003). However, specific strategies were suggested to not only negate the summer loss phenomenon but to also show academic gains. These strategies include small class sizes, individualized instruction, cooperative learning, rewards, and standards based report cards (Jesson et al., 2014). Additionally, because of the shorter time frame available during a summer program, it was pointed out that complex topics should be taught early in the program, assignments should be shortened to an appropriate length, and a minimum of 30 hours of instruction should be delivered over the course of the summer program in order for students to experience an increase in math achievement (Zvoch & Stevens, 2013). The final major concern for developing a successful summer program is the recruitment of high quality teachers. The recruiting techniques that were recommended encouraged administrators to advertise that teachers will be able to develop their craft, try new fun activities, and gain leadership experience. Preference should be given to experienced teachers with a strong background in content knowledge (Rosas & Campbell, 2010; Desimone & Long, 2010).

Through this study, I analyzed the results of using the Number Worlds program in a summer school setting to increase the math achievement of the students involved. The Number Worlds instructional resource is a math program that was created based upon the conceptual structure theory (Griffin, 2007). The program involves the characteristics of successful math programs that have been discussed including alignment of the learning objectives to the standards, involvement of technology and math manipulatives, cooperative learning, and regular feedback for students through a variety of assessments. The program was delivered in a summer school format to struggling math students that had been identified through assessment scores. I measured the efficacy of the program through a pre-test/post-test quasi-experimental study. I identified a quasi-experimental design as the most appropriate method for measuring the growth of scores of a non-random sampling (Creswell, 2014).

Chapter two provided a review of the literature regarding effective strategies for teaching struggling math students and best practices for summer school programs. I also discussed the rationale for choosing a quantitative study with a quasi-experimental design. Chapter three provides a more in depth description of the research method including the design and approach, the setting and sample, instrumentation and materials, and the proposed data analysis.

Chapter 3: Research Method

Introduction

The math achievement of K-12 students across the nation is a concern because the United States continues to perform at lower levels than several other countries. Despite a variety of education programs, student performance on standardized tests remains static. The results from the NAEP showed little improvement between 2007 and 2013 in the percentage of students scoring at the proficient level or above (National Center for Education Statistics, 2014). Although school districts have provided extra math instruction during the regular school day, through tutoring after school, and through summer school programs, math achievement still has not increased (Krawec, 2013).

This same problem with math achievement was evident at the local level of my study site. This school district in southeastern Colorado scored, on average, 21 percentage points below the state average on math in the 2010 TCAP (School View Data Center, 2014). The school district provided remedial math instruction through a summer school program to address the problem of low math achievement. However, there was little difference in the scores as shown in Table 1 in the first chapter. The school district then decided to change the summer school by selecting a new math program called Number Worlds (Griffin, 2007) to guide the instruction.

In this study, I addressed this problem at the local level by evaluating the academic achievement of students after participating in a math program, Number Worlds, which was administered during a summer school program to non-proficient third through fifth grade students (Griffin, 2007). Students that did not participate in the summer program were also tested by the school district, and I compared the change in scores from the end of the school year to the beginning of the next school year of the two groups of students. The pre-test was an assessment that was administered to all students in the school district at the end of the school year. The post-test was the same assessment that was once again administered to all students at the beginning of the school year. The participation in the summer math program by a group of struggling math students was the treatment. The change in scores between the pre-test and post-test served as the basis for the two research questions.

Research Question 1: Did students' math scores improve after participating in a summer math program that used Number Worlds?

The following were the null hypotheses (H_0) and alternative hypotheses (H_1) for the first research question.

H_0: There is no change in the math achievement scores from the beginning of summer to the end of summer of third grade students who participate in a summer program that uses Number Worlds.

H_1: There is an increase in the math achievement scores from the beginning of summer to the end of summer of third grade students who participate in a summer program that uses Number Worlds.

H_0: There is no change in the math achievement scores from the beginning of summer to the end of summer of fourth grade students who participate in a summer program that uses Number Worlds.

H_1: There is an increase in the math achievement scores from the beginning of summer to the end of summer of fourth grade students who participate in a summer program that uses Number Worlds.

H_0: There is no change in the math achievement scores from the beginning of summer to the end of summer of fifth grade students who participate in a summer program that uses Number Worlds.

H_1: There is an increase in the math achievement scores from the beginning of summer to the end of summer of fifth grade students who participate in a summer program that uses Number Worlds.

Research Question 2: How did the students participating in the summer math program differ from the students who did not participate in the program in terms of summer loss of math academic achievement for the local school district?

The following were the null hypotheses (H_0) and alternative hypotheses (H_1) for the second research question.

H_0: The summer loss in academic achievement of the third grade students participating in the summer math program with Number Worlds is not significantly different than the summer loss in academic achievement as measured by MAP of the third grade students not participating in the summer program.

H_1: The summer loss in academic achievement of the third grade students participating in the summer math program with Number Worlds is different than the summer loss in academic achievement as measured by MAP of the third grade students not participating in the summer program.

H_0: The summer loss in academic achievement of the fourth grade students participating in the summer math program with Number Worlds is not significantly different than the summer loss in academic achievement as measured by MAP of the fourth grade students not participating in the summer program.

H_1: The summer loss in academic achievement of the fourth grade students participating in the summer math program with Number Worlds is different than the summer loss in academic achievement as measured by MAP of the fourth grade students not participating in the summer program.

H_0: The summer loss in academic achievement of the fifth grade students participating in the summer math program with Number Worlds is not significantly different than the summer loss in academic achievement as measured by MAP of the fifth grade students not participating in the summer program.

H_1: The summer loss in academic achievement of the fifth grade students participating in the summer math program with Number Worlds is different than the summer loss in academic achievement as measured by MAP of the fifth grade students not participating in the summer program.

I used a pre-test/post-test quasi-experimental research design that utilized data from a summer school math program that used Number Worlds during the years of 2012, 2013, and 2014. The pre-test was administered by the school district in May, just before the summer vacation, and the post-test was administered in September, just after the summer vacation. The setting was a rural school district in Colorado, and the sample included students in the third, fourth, and fifth grades. I analyzed each grade level separately over a period of three years. The purpose of the three-year time frame was to increase the sample size. Approximately 15 students per grade level, per year participated in the summer math program. If I could show that the Number Worlds program was effective for each of the three years for each of the three grade levels, the study could have more impact on the local school district than if it was successful for only one year with just 15 students. The identified students were taught math during a summer school program using the Number Worlds resource (Griffin, 2007). The district measured their outcomes using the MAP math assessment, a computerized adaptive test that was developed by the NWEA (Northwest Evaluation Association, 2014). The same test was given as both a pre-test and a post-test to the two groups of students, those participating in summer school and those not participating in summer school.

Research Design and Approach

The purpose of this quantitative study was to explore the efficacy of a summer math program that uses the Number Worlds resource to improve achievement in struggling math students. The summer school program was the independent variable and the math academic achievement scores as measured by MAP of the participating students was the dependent variable. The diagram below illustrates the research design I used for this study.

Students that did not participate in the summer program: O------------------------O

Students that were part of the summer program: O------------X-----------O

The O represents the NWEA MAP pre-test and post-test. The X represents the summer school program that utilized the Number Worlds program to provide math instruction to the students. Creswell (2014) explained that a quantitative research design is most appropriate for comparing the results in a study involving different treatments and variables. Furthermore, because I could not use random sampling for this study, it was quasi-experimental. The absence of randomization and the absence of a control group prohibited the use of an experimental or causal comparative design. As a final point of clarification, all the data for this study were ex post facto; the summer school programs and the associated MAP tests were administered in 2012, 2013, and 2014.

Treatment

For this study I used a non-equivalent pre-test and post-test design. All students in the school district were tested with the NWEA MAP math assessment in the spring, just before the close of the school year. Then the district invited a group of students to participate in a summer school program where they received math instruction using the Number Worlds resource. The students were identified for this program based on their scores on the state math assessment and the math MAP assessment. If students scored below the established cut-off for proficiency, they were invited but not required to attend the summer program. No more than 1 or 2 students at each grade level declined to participate during each of the three years involved with this study. The Number Worlds resource was used for the 2012, 2013, and 2014 summer programs. After the summer program, at the beginning of the school year, all students were tested once again using the MAP math assessment. Because the school district tested all students, I was able compare the scores of the students participating in the program to the scores of the students not participating.

Setting and Sample

The school district identified students for the summer program using a body of evidence including results on the state math assessment and the results on the math MAP test. Cut-scores were used to determine if a student was below grade level on the state math assessment and the math MAP test. Similarly, if the student earned a grade below a "C" average for the year, they were considered to be below grade level for their classroom performance. To be invited to participate in summer school, a student needed to be below grade level in two out of the three pieces of evidence. Out of the students who were identified for summer school in 2012, 3013, and 2014, no more than two students each year denied the summer services.

The group that I used as a point of comparison for this study was the group of students who were performing at grade level or above and therefore were not identified for the summer school program. The district did not have a second summer school program that ran concurrent with the program that provided math instruction using the Number Worlds resource. Therefore, I could not compare the scores of an experimental group that received the new instruction to a control group that received the traditional type of summer instruction. Instead, I compared the achievement of the participating students to the achievement of the non-participating students. In this manner I determined if the summer math program with Number Worlds helped students to experience a smaller summer loss. If that was true, then the students who participated in summer school were starting the next school year closer to grade level and better prepared for the math instruction during the regular school year.

My study focused on three separate grade levels in the study site: third grade, fourth grade, and fifth grade. The district's students were 70% Hispanic and the remaining students were identified as primarily Caucasian. Approximately 30% of the students were identified as English language learners. Also, 80% of the district's students were eligible for the free or reduced lunch federal program. Table 2 provides the number of students in the third, fourth, and fifth grades, both those that participated in the summer school and those that did not, for the three years in which data was collected. All of the students came from the same rural school district in southeast Colorado. The summer program and the assessment administered as the pre-test in May and the post-test in September were part of the regular educational process for the district. No new assessment was introduced as part of this study.

Table 2

Number of Students in Grade Levels and Participation in Summer School

	School Year 2011-12	School Year 2012-13	School Year 2013-14	Total for 3 Years
Grade 3 Participants	24	12	17	53
Grade 3 Non-Participants	32	63	51	146
Grade 3 Total	56	75	68	199
Grade 4 Participants	16	15	14	45
Grade 4 Non-Participants	52	57	59	168
Grade 4 Total	68	72	73	213
Grade 5 Participants	15	16	16	47
Grade 5 Non-Participants	48	50	45	143
Grade 5 Total	63	66	61	190

Note. Retrieved January 21, 2015 from District Accountability minutes, October 2014.

One concern with my study was a small sample size. To address this concern, I used all available data for three years, from the summer of 2012 through the summer of 2014, as part of the analysis. Central Limit Theorem states that as the sample size increases, the distribution of the sample means will approach a normal distribution. “By the time the sample size reaches n= 30, the distribution is almost perfectly normal" (Gravette & Wallnau, 2008, p. 165). Because I used the total number of participants for the three years combined, the sample sizes were all larger than 30 with 45 being the smallest sample size.

I considered using a power analysis to determine the necessary sample size prior to the collection of data; however, I decided that it would not be appropriate. One of the main purposes of a power analysis is to be able to adjust the sample size prior to the data collection if it is shown that the sample size is too small (Suresh & Chadrashekara, 2012). However, I was collecting the data for this study ex post facto and the sample size could not be changed. Instead of conducting a power analysis prior to the data collection, I used a post hoc power analysis to determine if the result was due to a weak relationship between the groups or due to a small sample size (Suresh & Chandrashekara, 2012).

Instrumentation and Materials

I used the MAP by NWEA to measure the math achievement level of all students, both those participating and those not participating in the summer school program. The MAP is a computer based adaptive test that results in a scale score earned by the student. Each item on the test corresponds with a Rasch Unit, abbreviated as RIT. A student’s overall score is determined by the number of RIT points earned, a range from 0 to 300.

The RIT scale is an equal interval and continuous scale so the difference between the scores is the same regardless of where the student falls on the scale or the grade level (Northwest Evaluation Association, 2014) My study site administered the math MAP assessment in May and again in September. I used the May administration as the pre-test for all students because it was administered at the end of the preceding school year, before the beginning of the summer school program. I used the September administration as the post-test because it was administered at the beginning of the succeeding school year, after the end of the summer school program. My study site used the NWEA reports website to collect the results. I obtained permission to use the data for this study and the school district for my study site provided the de-identified data.

The NWEA MAP tests have concurrent validity with the Colorado State Assessment Program with values ranging between .84 at the lowest and .91 at the highest (Northwest Evaluation Association, 2011, p. 53). Also, the NWEA reported the following reliabilities for MAP tests administered to Colorado students in the spring and fall of 2008 and spring of 2009: 64,608 third graders were tested with a reliability of 0.935, 66,136 fourth graders were tested with a reliability of 0.937, and 65,284 fifth graders were tested with a reliability of 0.938 (Northwest Evaluation Association, 2011, p. 55). For the purposes of testing the academic achievement and growth of students from a Colorado school district, the NWEA MAP tests are valid and reliable assessments.

Data Analysis

I collected the results from both the pre-test and the post-test for the statistical analysis. The NWEA reports website provided reports for the scores. The score reports and attendance records were requested from the district. The Board of Education for my study site granted permission and the data was de-identified by the school district before it was provided for my data analysis. The difference between the pre-test scores and the post-test scores was the dependent variable for the study while the participation in the summer school math program was the independent variable.

Because my first research question considered just one group of students which was tested twice on the same dependent variable, I used a *t* test to measure the change in scores from the pre-test to the post-test. Gravetter and Wallnau (2008) recommended use of the repeated–measures *t* test, “A repeated–measures design or a within–subject design is one in which a single sample of individuals is measured more than once on the same dependent variable. The same subjects are used in all of the treatment conditions” (p. 288). In a *t*-test analysis, “Typically, the difference scores are obtained by subtracting the first score (before treatment) from the second score (after treatment) for each person: difference score = $D = X_2 – X_1$” (Gravetter, & Wallnau, 2008, p. 290). I compared the mean difference in scores, from May to September, to zero for the students who participated in the Number Worlds program. I considered using an ANOVA; however, “Analysis of Variance (ANOVA) is a hypothesis–testing procedure that is used to evaluate mean differences between two or more treatments (or populations)” (Gravetter, & Wallnau, 2008, p. 336). Since my analysis had only one group, an ANOVA was not considered to be appropriate.

My second research question involved a comparison of the participating group of students to the non-participating group of students. I used an ANOVA to compare the change in scores of the two groups of students on the pre-test and post-test. Gravetter and Wallnau (2008) explained that, "In a repeated–measure design, on the other hand, the same sample is tested in all of the different treatment conditions" (p. 337). ANOVA is used for one or more categorical independent variables and one continuous dependent variable (Creswell, 2014, p. 191). The independent variable for the second research question was participation in the summer school intervention using Number Worlds. The dependent variable was summer loss. Summer loss was defined as the difference between May and September scores on the MAP assessment; difference score = D = MAP Score (September) – MAP Score (May). "Typically, the difference scores are obtained by subtracting the first score (before treatment) from the second score (after treatment) for each person: difference score = D = $X_2 - X_1$" (Gravetter, & Wallnau, 2008, p. 290). Therefore, I identified an ANOVA as the most appropriate analysis for the second research question. I used SPSS software to calculate the statistical analysis.

Participants' Rights

For my study, I collected data from a summer school program administered in the summers of 2012, 2013, and 2014 in a rural school district in Colorado. Students were identified for the summer school program if they were not proficient in math as determined through scores on the state math assessment and the MAP math assessment. The instrument that was used for the pre-test and post-test, the MAP math assessment which resulted in a RIT score for each student, was the instrument in place by the district of my study site to measure the progress of all students. The assessment was administered at the end of the school year, before the beginning of the summer program, and again at the beginning of the school year, after the completion of the summer school program. The summer program and the assessments were established components of the school district's instructional program; the assessments were required of all students in the district. Therefore, I collected all of the data for this study ex post facto, from assessments that had already been administered. I did not ask for any changes to the district's practices or to the students during the duration of the study. Together with the school district, I protected students' rights by ensuring that all personal information was removed before the data was made available for the statistical analysis.

My role in the data collection was limited to receiving the reports prepared by the school district's data specialist. I am the superintendent of the school district that was used for my study site. While this role placed supervisory responsibilities on me, the day-to-day operation and classroom instruction was overseen by a principal in coordination with the summer school teachers. At the completion of each testing window, reports were provided by the NWEA. I collected the RIT scores from the tests through the reports provided by the school district and then used the scores for my data analysis. The data was de-identified by the district before it was shared with me for the data analysis.

Summary

The lack of academic progress in math across the nation is a problem. My research study analyzed one school district's approach at overcoming this problem by providing a summer math program for remediation. I compared students' scores after participating in a summer math program that utilized the Number Worlds program. I also compared the achievement scores of students who participated in the summer program to students who did not participate. I used a data analysis to determine if Number Worlds affected the math academic achievement of third, fourth, and fifth graders in my study site. This chapter explained why I chose a pre-test/post-test quasi-experimental approach to conduct this study. In the next chapter, I provide the results of the data analysis.

Chapter 4: Results

Introduction

The purpose of this quantitative study with a pre-test and post-test design was to explore the efficacy of a summer math program that uses the Number Worlds resource to improve achievement in struggling math students. I addressed the following two research questions:

Research Question 1: Do students' math scores improve after participating in a summer math program that uses Number Worlds?

Research Question 2: How do the students participating in the summer math program differ from the students who do not participate in the program in terms of summer loss of math academic achievement for the local school district?

This chapter discusses the data analysis that I conducted to answer these two research questions. Prior to the collection of the data and the analysis, the proposed study was reviewed by the Walden University Institutional Review Board (IRB). The IRB approval number for this study was 09-22-15-0141735. In this chapter, I present the descriptive statistics first, followed by the specific analysis for each of the two research questions. Because the assessments the district used as the pre-test and post-test were unique for each grade level, I performed the data analysis separately for each grade level. Therefore, in this chapter I report the data analysis for both research questions for each of the three different grade levels. I conclude the chapter with a summary of the results.

Descriptive Statistics

Table 3 shows the mean pre-test and post-test scores along with the standard deviation for both the students who participated in the summer math program and those who did not participate. Table 4 shows the mean change in scores from the pre-test to the post-test. The minimum and maximum changes in scores are also displayed along with the standard deviation.

Table 3

Descriptive Statistics for the Pre-Test and Post-Test Scores

	Mean Pre-Test Score	Pre-Test SD	Mean Post-Test Score	Post-Test SD
Grade 3 Participants	171.6	11.2	170.1	13.0
Grade 3 Non-Participants	193.5	9.7	187.8	9.2
Grade 4 Participants	178.7	12.0	178.2	11.2
Grade 4 Non-Participants	200.5	10.6	196.3	10.2
Grade 5 Participants	192.2	7.3	193.3	10.0
Grade 5 Non-Participants	211.7	8.3	209.0	9.3

Note. The pre-test was administered in May each year, prior to the start of the summer math program. The post-test was administered in September each year, after the end of the summer math program.

Table 4

Descriptive Statistics for the Change in Scores from Pre-Test to Post-Test

	Mean Change in Score	Min	Max	SD
Grade 3 Participants	-1.6	-16.0	8.0	5.8
Grade 3 Non-Participants	-5.7	-31.0	9.0	7.7
Grade 4 Participants	-0.5	-17.0	17.0	6.3
Grade 4 Non-Participants	-4.2	-27.0	12.0	7.0
Grade 5 Participants	1.1	-24.0	26.0	8.1
Grade 5 Non-Participants	-2.7	-19.0	11.0	6.0

The only sample that had a mean increase in scores from the pre-test to the post-test was the fifth grade students who participated in the summer school program. The students in that same grade level who did not participate in the summer school program had a mean decrease in scores. The third and fourth grade students who participated in the summer school program had a mean decrease in scores from the pre-test to the post-test; however, their mean decrease was smaller than the decrease in scores from their counterparts who did not participate in the summer school program. I considered the group of students who did not participate in the summer school as a point of comparison rather than a control group. Out of the students who were identified for the summer program, no more than two students per year refused the services. This number was not large enough to constitute a control group. Also, the district did not have a second summer school program that ran concurrent with the program that provided math instruction with the Number Worlds resource. Therefore, I could not compare the scores of an experimental group that received the new instruction to a control group that received the traditional type of summer instruction. Instead, I compared the achievement of the participating students with the achievement of the non-participating students who were not eligible for the summer program because they were not struggling in math. In this manner I worked to determine if the summer math program with Number Worlds helped struggling students to experience a smaller summer loss than students who were not struggling and did not receive the summer intervention.

Research Question 1

The first research question was: Did students' math scores improve after participating in a summer math program that uses Number Worlds? The descriptive statistics indicate that scores did not increase in the third and fourth grade levels. The fifth grade students had only a small mean increase in scores. I used a *t* test to analyze the change in scores in order to answer the first research question. I used alpha levels of 0.05 and one-tailed tests for all analyses. Also, I entered the pre-test score as the first variable and the post-test as the second variable for all analyses.

The following were the null hypotheses (H_0) and the alternative hypotheses (H_1) for the first research question for the third grade students:

H_0: There is no change in the math achievement scores from the beginning of summer to the end of summer of third grade students who participate in a summer program that uses Number Worlds.

H_1: There is an increase in the math achievement scores from the beginning of summer to the end of summer of third grade students who participate in a summer program that uses Number Worlds.

Since this was a one-tailed test, the critical value for the test was $t(52) = 1.67$ (Vassar Stats), meaning that the t value must have been greater than or equal to positive 1.67 to reject the null hypothesis. Since the SPSS calculated t value is negative, $t = -1.964$ with $df = 52$ and $p = 0.972$, I did not reject the null hypothesis. The scores did not show a significant increase from the pre-test to the post-test.

The following were the null hypotheses (H_0) and the alternative hypotheses (H_1) for the first research question for the fourth grade students:

H_0: There is no change in the math achievement scores from the beginning of summer to the end of summer of fourth grade students who participate in a summer program that uses Number Worlds.

H_1: There is an increase in the math achievement scores from the beginning of summer to the end of summer of fourth grade students who participate in a summer program that uses Number Worlds.

The critical value for the test was $t(44) = 1.68$ (Vassar Stats). The results of the t test were not statistically significant, $t = -0.534$ with $df = 44$ and $p = 0.702$, and thus I did not reject the null hypothesis. The fourth grade scores did not show a significant increase from the pre-test to the post-test.

The following were the null hypotheses (H_0) and the alternative hypotheses (H_1) for the first research question for the fifth grade students:

H_0: There is no change in the math achievement scores from the beginning of summer to the end of summer of fifth grade students who participate in a summer program that uses Number Worlds.

H_1: There is an increase in the math achievement scores from the beginning of summer to the end of summer of fifth grade students who participate in a summer program that uses Number Worlds.

The critical value for the test was $t(46) = 1.68$ (Vassar Stats). Results of the *t* test were not statistically significant, $t = 0.964$ with $df = 46$ and $p = 0.170$, and I thus did not reject the null hypothesis. The fifth grade scores did not show a significant increase from the pre-test to the post-test.

The results of the analyses support the null hypotheses since they were not rejected for third grade ($t(52) = -1.964$, p = 0.972); fourth grade ($t\ (44) = -0.534$, p = 0.702); or fifth grade ($t(46) = 0.964$, p = 0.170). However, although the null hypothesis was not rejected, I performed a post hoc power analysis on the data for each of the three grade levels to investigate the possibility of a type II error because, and Gravetter and Wallnau (2008) note, “the power of a statistical test is the probability that the test will correctly reject a false null hypothesis” (p. 219). The observed power was 0.615, 0.147, and 0.248 for the third grade, fourth grade, and fifth grade respectively. Anything below a 0.8 for the observed power is considered low (StataCorp, 2013). A small sample size could have been a factor in the low power value. The low power indicated that a type II error (fail to reject a false null hypothesis) could not be ruled out. However, all possible scores for the three grades were included, so a larger sample size was not possible.

I concluded that the summer math program with Number Worlds did not produce a significant increase in scores for any of the three grade levels. The descriptive statistics indicated that the scores for the third grade and fourth grade participants decreased.

Although the descriptive statistics indicated that the scores for the fifth grade participants increased, the data analysis showed that the increase was not significant, suggesting the summer math program did not cause a significant increase in scores for any of the three grade levels. However, since low power indicated that a type II error could not be ruled out, these results should be interpreted with caution.

Research Question 2

The second research question was: How did the students participating in the summer math program differ from the students who did not participate in the program in terms of summer loss of math academic achievement for the local school district? The descriptive statistics indicated that the mean decrease in scores for third grade and fourth grade students who participated in the summer math program was smaller than the mean decrease in scores for the students who did not participate. The participating fifth grade students had only a small mean increase in scores while the non-participating fifth grade students had a mean decrease in scores. I used an ANOVA analysis to determine if the change in scores of the two groups of students from the pre-test to the post-test was significant so that I could answer the second research question. I used alpha levels of 0.05 and two-tailed tests for all analyses.

The following were the null hypotheses (H_0) and the alternative hypotheses (H_1) for the second research question for the third grade students.

H_0: The summer loss in academic achievement of the third grade students participating in the summer math program with Number Worlds is not significantly different than the summer loss in academic achievement as measured by MAP of the third grade students not participating in the summer program.

H_1: The summer loss in academic achievement of the third grade students participating in the summer math program with Number Worlds is different than the summer loss in academic achievement as measured by MAP of the third grade students not participating in the summer program.

The data for the third grade students indicated a difference in summer loss between the students who participated in the summer math program and the students who did not participate. The mean change score for the participating students was -1.6 with a standard deviation of 5.8 while the mean change score for the non-participants was -5.7 with a standard deviation of 7.7. The ANOVA analysis of the third grade data revealed that this difference was significant, $F(1, 198) = 12.319$, $p = 0.001$. Therefore, I rejected the null hypothesis. Although the scores for the third grade students did not increase after attending summer school, the summer loss appears to be less for participating students than those not attending summer school so summer attendance may help students be better prepared to start the next school year.

The following were the null hypotheses (H_0) and the alternative hypotheses (H_1) for the second research question for the fourth grade students.

H_0: The summer loss in academic achievement of the fourth grade students participating in the summer math program with Number Worlds is not significantly different than the summer loss in academic achievement as measured by MAP of the fourth grade students not participating in the summer program.

H_1: The summer loss in academic achievement of the fourth grade students participating in the summer math program with Number Worlds is different than the summer loss in academic achievement as measured by MAP of the fourth grade students not participating in the summer program.

The data for the fourth grade students indicated a difference in summer loss between the students who participated in the summer math program and the students who did not participate. The mean change score for the participating students was -0.5 with a standard deviation of 6.3 while the mean change score for the non-participants was -4.2 with a standard deviation of 7.0. The ANOVA analysis of the fourth grade data revealed that this difference was significant, $F(1, 212) = 9.993$, $p = 0.002$. Therefore, I rejected the null hypothesis. Although the scores for the fourth grade students did not increase after attending summer school, the summer loss appears to be less for participating students than those not attending summer school so summer attendance may help students be better prepared to start the next school year.

The following were the null hypotheses (H_0) and the alternative hypotheses (H_1) for the second research question for the fifth grade students.

H_0: The summer loss in academic achievement of the fifth grade students participating in the summer math program with Number Worlds is not significantly different than the summer loss in academic achievement as measured by MAP of the fifth grade students not participating in the summer program.

H_1: The summer loss in academic achievement of the fifth grade students participating in the summer math program with Number Worlds is different than the summer loss in academic achievement as measured by MAP of the fifth grade students not participating in the summer program.

The data for the fifth grade students indicated a difference in summer loss between the students who participated in the summer math program and the students who did not participate. The mean change in score for the participating students was 1.1 with a standard deviation of 8.1 while the mean change in score for the non-participants was -2.7 with a standard deviation of 6.0. The ANOVA analysis of the fifth grade data revealed that this difference was significant, $F(1, 189) = 11.907$, $p = 0.001$. Therefore, I rejected the null hypothesis. Although the scores for the fifth grade students increased by only 1.1 points after attending summer school, they appeared to experience a smaller summer loss than the non-participating students so summer attendance may help students be better prepared to start the next school year.

I also conducted a post-hoc power analysis on the data for the second research question to help confirm that my decisions to reject the null hypotheses were correct. "The power of a statistical test is the probability that the test will correctly reject a false null hypothesis" (Gravetter & Wallnau, 2008, p. 219). The observed power was 0.937, 0.882, and 0.930 for third grade, fourth grade, and fifth grade respectively which are all relatively high for power. The statistical analysis along with the high power led to my conclusion that the students who participated in the summer math program with Number Worlds did experience a smaller summer loss than the students who did not participate.

Summary of Findings

My study examined the results of a summer math program that used Number Worlds as the instructional resource. To answer the first research question, I compared the pre-test and post-test scores of third, fourth, and fifth grade students who participated in a summer math program to see if there was an increase in the academic achievement. The data analysis did not reveal a significant increase. The mean scores for the third and fourth graders actually decreased. While the mean scores for the fifth graders increased, the difference was slight and the data analysis did not indicate that it was significant.

I also compared students who participated in the summer math program to students who did not participate in order to answer my second research question. The third grade participants decreased by 1.6 RIT points while the non-participants decreased by 5.7 RIT points. The fourth grade participants decreased by 0.5 RIT points while the non-participants decreased by 4.2 RIT points. The fifth grade participants increased by 1.1 RIT points while the non-participants decreased by 2.7 RIT points. In each of the three grade levels, the summer loss experienced by the group of students who did not participate was larger than the summer loss experienced by the participating students. I compared the change in scores from the pre-test to the post-test for both groups of students using an ANOVA analysis. The data analysis found that the difference in summer loss was statistically significant. The summer school program appeared to be a factor in reducing summer loss for the participating students. Overall, the data indicated that the summer math program with Number Worlds did not improve students' scores, but it did reduce the summer loss that students experienced. In chapter five, I provide an interpretation of these findings as well as the implications for social change and recommendations for action.

Chapter 5: Discussion, Conclusions, and Recommendations

Introduction

The purpose of this quantitative study with a pre-test and post-test design was to explore the efficacy of a summer math program that uses the Number Worlds resource to improve achievement in struggling math students. I used the following two research questions to guide this study:

Research Question 1: Did students' math scores improve after participating in a summer math program that uses Number Worlds?

Research Question 2: How did the students participating in the summer math program differ from the students who did not participate in the program in terms of summer loss of math academic achievement for the local school district?

I used a quasi-experimental quantitative research design to conduct this study. The MAP developed by the NWEA was administered to all students in the school district in September and May of each year to measure the growth in academic achievement (Northwest Evaluation Association, 2014). I used the results from the assessment in May as the pre-test and the results from the assessment in September as the post-test. The summer math program was the treatment and it was administered during a five-week period at the beginning of the summer vacation. All data was ex post facto. The school district had already administered the assessments and the summer school program. The school district granted me permission to analyze the existing data for the purposes of this study. I used three years' worth of data, from 2012 through 2014, in order to increase the sample the size. Also, the study focused on the third, fourth, and fifth grades because of the larger sample size available through that particular grade span and the targeted instruction delivered to those grade levels using the Number Worlds math program.

Only students who were identified as performing below proficiency were invited to attend the summer math program. Over the three years, there were approximately 45 students at each grade level who participated in the summer math program and approximately 150 students at each grade level who did not participate. I used a *t*-test analysis to determine if students' scores increased for those that participated in the summer math program, and an ANOVA analysis to compare the summer loss between participating and non-participating students. My data analysis found that the students who participated in the summer math program with Number Worlds did not increase their academic achievement scores. However, the students who participated in the summer math program experienced a smaller summer loss than the non-participants.

Interpretation of Findings

The first research question asked whether students' assessment scores would improve after participating in a summer school math program with the Number Worlds instructional resource. The analyses demonstrated that students' assessment scores did not increase from pre- to post-intervention. The power analysis resulted in a low observed power which indicated that a Type II error might exist and the sample size may have been too small. However, the results were in the opposite direction of what I had hypothesized, so it is unlikely this was impacted by power. Given the small sample size, these results should be replicated in a larger sample before any inferences can be made. Because I utilized all of the available data at this site, it was not possible to increase the sample size in this study. However, the data indicated that even though a group of students participated in a five-week summer math program, they were not returning to school in September with higher achievement scores.

Interestingly, the summer math program did seem to influence students' achievement scores when the participating students were compared with the non-participating students. Even though the participating students' scores did not increase, the analyses indicated that the participants did not experience as large of a summer loss as the students who did not participate; the decrease in participants' scores was smaller than the decrease in non-participants' scores. My analysis revealed that this difference was significant. The power analysis resulted in a high observed power; therefore, the sample size was sufficient enough to conclude that the summer math program did result in a decreased summer loss for the participating students. However, it is important to point out that the group of students who did not participate in the summer program was not a true control group. They were not identified by the school district for the summer program because they were considered proficient in math. The non-participating students were already scoring higher than the summer school participants, and they continued to score higher on the post-test by approximately 17 RIT points in third grade, 18 RIT points in fourth grade, and 16 RIT points in fifth grade. The summer school program did not help the participating students to overcome the gap in performance. However, the analysis did show that Number Worlds helped the participating students to experience a smaller summer loss than the non-participating students, which resulted in a smaller gap between the two groups on the post-test. The gap decreased by 4.1 RIT points in third grade, 3.7 RIT points in fourth grade, and 3.8 RIT points in fifth grade.

The Number Worlds program was developed using Piaget's theory of cognitive development (1950) as the foundation. The maker of the program thought that if the program developed a sequence of learning that aligned with students' cognitive abilities, then they would be able to learn basic numeracy skills more effectively which would lead to mastery in more challenging mathematical skills (Griffin, 2009). This study did not show that the Number Worlds instructional program increased the students' mastery of mathematical skills. However, it did show that the students in the program were able to retain more knowledge than the non-participants, as represented by the smaller summer loss in academic achievement. The findings do not provide a definitive conclusion as to whether the Number Worlds program is the solution for the local problem of low math achievement.

Clearly, other factors of the summer program should be considered to determine if the summer program can be developed into an intervention that does increase students' achievement scores. My review of the literature revealed that effective math instruction should avoid the overreliance on textbooks in order to focus more on skill application rather than rote memorization (Saritas & Akdemire, 2013). The Number Worlds program does not have teachers focus on a textbook with rote memorization and it does provide opportunities for students to apply their knowledge. The engagement level of students has been identified as a major factor in student learning (Sayer & Adhami, 2010), and the small groups combined with the focus on application seemed to create an environment that was conducive to student engagement in the summer program at my study site. Instead of focusing on the factors that would affect the learning environment or the way the instruction was delivered, it seems pertinent to review other important aspects of a summer program.

I turned to the body of literature on effective summer schools to identify factors that may have contributed to the results because the summer program was effective at reducing the summer loss, but in the end it did not help students increase their scores. One suggestion within the literature was to consider the academic calendar, including when the summer school should take place (McMullen & Rouse, 2012). The summer school for this study was a five-week program that started at the beginning of June and finished at the end of the first week in July. The start date was the first Monday after students finished the regular academic year. Because the next school year started at the end of August, that left at least a month and a half of summer vacation before the participating students returned to school. Thus, summer loss could have still been a factor in the outcome of the achievement scores. Additionally, the research indicated that a summer program should have at least 30 hours of instruction (Zvoch & Stevens, 2013). Even though the summer program with Number Worlds provided 50 hours of instruction, two hours per day, five days per week, for five weeks, it should still be questioned whether there was enough instructional time. In my literature review, I found that the variability of the amount of instructional time provided in different summer school programs is one of the challenging design issues with summer school programs that limits the generalizability of most studies (Zvoch & Stevens, 2011).

Implications for Social Change

The problem with math achievement is both a national and a local problem. The longitudinal results from the NAEP showed that there has been little if any progress with math achievement at the fourth and eighth grade levels (National Center for Education Statistics, 2014). The state assessment results for the local school district indicated that the problem with math achievement was even larger locally than it was nationally because the percent of proficient students lagged behind the averages for the state of Colorado by more than 20 percentage points (School View Data Center, 2014). If a summer math program could be designed to effectively address the problem of math achievement at the local level, it would have a great impact for positive social change within the local district. The school district attempted to move in this direction by revising the summer math program to use Number Worlds, which was developed specifically for remedial instruction in math, as the instructional resource. Ultimately, I found that the summer math program did not have the effect on academic achievement that the local school district had hoped. Although the participating students experienced a smaller summer loss than the non-participating students, their scores still did not show a significant increase. However, this study can still lead to social change locally by identifying aspects of the program that can be changed to increase its effectiveness.

As the local school district improves its math instructional program, students will be better prepared for life after high school. Proficiency in math will be beneficial whether students extend their education by enrolling in an institution of higher education or enter the workforce directly after high school graduation. Math skills will open up educational opportunities for them as well as create more informed citizens. An effective summer school math program has the potential to generate a great deal of social change for the students involved and for the local community.

Recommendations for Action

The summer math program involved with this study was a five-week program that took place at the beginning of the summer vacation. My data analysis revealed that the program was successful in helping students experience a smaller summer loss than the students who did not participate; however, the students' achievement scores did not increase. To improve the results of the summer math program, a later placement within the summer vacation should be considered (McMullen & Rouse, 2012). Instead of scheduling the program to begin immediately after the end of the preceding school year, the district could schedule it for the end, or even middle, of summer vacation to minimize the summer loss that might happen before or after the summer program. By having a small or nonexistent gap of time between the summer math program and the beginning of the next school year, the risk of students experiencing a summer loss could be minimalized.

Another recommendation for improving the summer math program would be to increase the amount of instruction time (Zvoch & Stevens, 2013). The program in this study delivered math instruction two hours per day and five days per week for the five-week program. Overall, the program provided 50 hours of math instruction. In comparison, students received approximately 65 hours of math instruction during the first quarter of each school year. The schedule for the summer program could be adapted to increase the amount of instruction time each day in order to provide the same amount as one quarter of the regular academic year. If the district lengthened the program by one week and added an extra 30 minutes to the instructional time for each day, the students would receive more than 65 hours of math instruction during the summer.

Recommendations for Further Study

One of the limitations for this study was the absence of an appropriate control group. Having a control group that was not offered an intervention would not be ethical in this situation because it would not have been beneficial for students who were at a non-proficient level to be assigned to a control group where they would not receive the extra instructional services from the summer math program. However, a control group could be formed if further study involved the scheduling of the math program during the summer vacation. The question would be whether a summer math program is more effective when it is placed at the end of the summer vacation rather than the beginning. Students in both treatment groups would receive the same amount of instruction and only the timing of the intervention would be different, which would eliminate the concern about not providing non-proficient students with the extra instructional services.

Another aspect that would need to be considered with further study is the sample size. I conducted this study in a small rural school district, which resulted in small sample sizes even though I used all available data. It would be beneficial to replicate the study in a larger school district. Concerns about a type II error could be minimized with a larger sample size of students to increase the power of the analyses.

Ultimately, I found that the summer math program with Number Worlds helped students to experience a smaller summer loss than if they had simply not received any instruction over the summer. However, students' scores did not increase, which means that the summer program did little to address the problem of math achievement in the local school district. Having the instructional services available during the summer program was certainly better than nothing, but improvements need to be made to the program before the school district can rely on it as a solution for the low math achievement.

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