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The Impact of Small Group Intervention Focusing on Operations With Rational Numbers on Students' Performance in the Florida Algebra I End-of-Course Examination

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Approval Page

This applied dissertation was submitted by Evelyn Dopico under the direction of the persons listed below. It was submitted to the Abraham S. Fischler College of Education and approved in partial fulfillment of the requirements for the degree of Doctor of Education at Nova Southeastern University.

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Statement of Original Work

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Evelyn Dopico
Name

March 3, 2017
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I am grateful for the Alvin Sherman Library, as the many hours spent there were always joyful. The staff at the library created an environment conducive to learning. From the cleanliness and physical comfort to the resources available for those pursuing knowledge, every detail has been adjusted to meet the needs of the diverse patrons. Such a wonderful environment could only have been accomplished through the combined efforts of those who maintain the facilities and those who make the decisions for running it. I believe those members of the staff who are never seen must be as caring and professional as the front desk clerks and the public safety personnel who, with kind smiles, were always eager to help. The Alvin Sherman library provided me with the perfect environment to conduct my research and to write my dissertation.

Abstract

The Impact of Small Group Intervention Focusing on Operations With Rational Numbers on Students' Performance in the Florida Algebra I End-of-Course Examination. Evelyn Dopico, 2017: Applied Dissertation, Nova Southeastern University, Abraham S. Fischler College of Education. Keywords: algebra, concept of fractions, end-of-course examination, exit examinations, guided inquiry, manipulatives in mathematics

In Florida, passing the Algebra I end-of-course examination (EOCE) is a graduation requirement. The test measures knowledge of basic algebra. In spring 2015, the Department of Education introduced a different version of the test. For the first two administrations of the new test, the failure rate for 9th-grade students in the state was almost 50%. In contrast, the failure rate for students in the school where this study was implemented exceeded 70%. The purpose of this study was to determine the outcome of small group intervention focusing on operations with rational numbers of high school students' performance on the Algebra I EOCE.

After analyzing several potential methods of instruction, small group instruction with the incorporation of the use of manipulatives, visuals, and guided inquiry was selected. In addition, the focus of the study was chosen to be operations with rational numbers, an area many researchers have identified as critical for student understanding of algebraic concepts. Twenty students from the target population of 600 10th and 11th grade students volunteered to participate in the study. These participants received three to six small group instruction sessions before retaking the test. In Sept 2016, all the students in the target population were administered the Algebra I EOCE again. A t-test yielded no significant difference in the learning gains of those who participated in the study and the other students in the target population. The implications of the results were that the interventions had no significant impact on student achievement. A possible reason for the lack of success could have been that six intervention sessions were not enough to produce significant results. It is recommended that future research includes a substantially larger number of interventions.

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Chapter 1: Introduction

Statement of the Problem

Passing the Algebra I end-of-course examination (EOCE) is a high school graduation requirement in the state of Florida for public school students. High school students who fail the Algebra I EOCE may substitute this requirement by achieving a minimum score of 97 on Florida's Postsecondary Education Readiness Test (PERT). This requirement is usually waived for students who are eligible for exceptional student education programs. Students in the regular program who accomplish all graduation requirements, except passing the Algebra I EOCE or the PERT, receive a certificate of completion (Florida Department of Education [FLDOE], 2017b). For those students who do not master basic algebraic skills, either passing the Algebra I EOCE or the PERT has proven to be a real challenge. Students who are not able to comply with this requirement are not awarded a regular Florida high school diploma.

The Algebra I EOCE measures students' ability to perform basic algebraic operations and to solve elementary mathematical problems by applying the concepts learned in Algebra I (FLDOE, 2012, 2013/2014). Most high school students in Florida have taken the first algebra course during freshman year and the Algebra I EOCE at the end of that year (FLDOE, 2014-2015). In spring 2015, the FLDOE introduced a new version of the test. The Algebra I EOCE that aligned with the Next Generation Sunshine State Standards was replaced by the examination that aligns with Florida Standards (FLDOE, 2017c).

The new Algebra I EOCE was administered for the first time in spring 2015. The mean score for students in the target school was 473 while the mean score for all students in the state of Florida was 497 (FLDOE, 2017a, 2017c). On the second administration of the test, in spring 2016, the results were similar. The mean score for students in the school was 479, and the mean score for all students taking the test was 498 (FLDOE, 2017c). The previous scores translated to a passing rate of 29% in both years for students in the school where the study had taken place. Students who took the test in the state of Florida were compared with a passing rate of approximately 55%. Students included in the previous data were taking the Algebra I EOCE for the first time after completing months of algebra instruction.

Results of the first two administrations of the Algebra I EOCE, for those students taking the test for the first time, demonstrated that a significant gap existed in achievement in algebra between students in the target school and the overall population of similar students in the state of Florida. Furthermore, because only 29% of students passed the test on a first attempt: thus, many students had not met one of the main graduation requirements. By failing the Algebra I EOCE, students were already behind schedule for graduation by the end of freshman year. When this study began in fall 2016, 587 students in 10th and 11th grades still needed to pass the Algebra I EOCE.

Many students who failed at the target school faced long-term devastating consequences. First, students did not get credit for Algebra I because the test accounts for 30% of the final grade. Second, students had to attend summer school or take extra classes to learn the skills needed to pass the Algebra I EOCE, thus limiting selection of other subjects. Third, all mathematics courses following Algebra I required knowledge of skills embedded in the Algebra I course. Students who did not develop skills necessary to pass the Algebra I EOCE by 11th grade were farther behind due to the sequential nature of mathematics courses. Fourth, college entrance examinations, such as the Scholastic Aptitude Test, American College Testing, and the PERT, measure students' abilities to perform many of the same skills as the Algebra I EOCE. Students who did not perform well on college entrance examinations lost the opportunity for dual enrollment courses in which both college and high school credits are earned. Low performers on college entrance examinations usually did not qualify for scholarship opportunities. Fifth, and perhaps more importantly, students who did not pass the Algebra I EOCE by the end of the senior year received a certificate of completion in lieu of a Florida high school diploma.

In addition to the devastating effects that failing the Algebra I EOCE had on students, consequences existed for many of the other stakeholders. Because young adults without high school diplomas face a future of low paying jobs or unemployment, parents had to continue with the burden of supporting them financially (Radcliffe & Bos, 2013). In Florida, a portion of teachers' performance evaluations is based on students' achievement within the classroom. Thus, for an Algebra I teacher, a large student failure rate deemed the educator as ineffective. Evaluations reflecting ineffective performance had serious consequences for the instructor, sometimes leading to dismissal. Other mathematics teachers were affected as students moved to higher grades and more difficult mathematics courses. Students lacking basic algebraic skills were likely to do poorly in other mathematics courses such as Geometry, Advanced Algebra, and Algebra II; in addition, poor student performance had a detrimental impact on mathematics teachers' evaluations.

The educational institution was also affected by low performances on the Algebra

I EOCE because schools in Florida were graded by the state. Student performance on state examinations and the graduation rate were two major components of these grades. Schools that had large numbers of students enrolled who were not passing end-of-course examinations were labeled as failing, bringing shame on both the school leaders and surrounding communities. Those students who were not able to meet all graduation requirements had a negative effect on the school graduation rate, a factor in schools' rating. In addition to affecting the prestige of the school, students' inability to pass the Algebra I EOCE affected the school budget. Funds were allocated to provide additional instruction to students who needed to pass these examinations. Otherwise, these funds would have been utilized to enhance other programs within the organization. In addition, elected classes were often eliminated to provide the extra mathematics classes designed to aid students in passing the Algebra I EOCE.

Students who had failed the Algebra I EOCE at least once could substitute this mathematics exit examination requirement with a score of at least 97 on the mathematics portion of the PERT. This option gave students another opportunity to demonstrate an understanding of basic algebraic operations by taking an examination different in format and style when compared with the Algebra I EOCE. Students had to demonstrate college- or career-readiness by passing either one of the examinations to earn a Florida high school diploma.

The PERT, created for the FLDOE by McCann Associates in 2011, was to be administered as a placement test for college entry level mathematics courses (FLDOE, 2017b). Per the FLDOE, the test was developed with the input of a committee representing Florida's educators with the purpose of aligning the benchmarks measured in the test with Florida's postsecondary readiness competencies (FLDOE, 2017b). The postsecondary readiness competencies were previously identified by the FLDOE as skills students must possess to be ready for a career. Scores from the PERT were used to place students entering college into a mathematics class. Scores on the PERT range from 50 to 150. In the past, students scoring below 97 were placed in developmental or remedial courses because they were not deemed as ready for college. Recent legislation stated that students graduating from a Florida public school would not be required to take extra developmental courses unless those students chose to take them, regardless of PERT scores (FLDOE, 2015).

A distinctive feature of the PERT is computer adaptive, meaning that initial responses on the test could determine the level of the subsequent questions (McCann Associates, 2011). Students' incorrect answers to initial questions resulted in lower-level questions. This made it more difficult to attain a high score. None of the other major tests that Florida high school students took were level adaptive, and the lack of familiarity with this type of test presented a challenge for some students. The adaptive computer feature of the PERT made it crucial for students to be skillful in basic algebraic operations, as incorrect initial answers resulted in very low scores.

The topic. Mastering arithmetic skills and basic algebraic skills was a challenge for many high school students. Those who were not able to demonstrate the ability to solve problems by applying basic algebraic knowledge in exit mathematics examinations were denied a Florida high school diploma. Several researchers determined that a strong correlation was evident between students' ability to understand algebraic concepts and the ability to understand operations with rational numbers (Booth & Newton, 2012;

Brown & Quinn, 2007; Charalambous & Pitta-Pantazi, 2007). A growing consensus among researchers was that operations with rational numbers, fractions, was not one concept but a combination of several concepts that needed to be addressed in order to help students understand rational numbers fully (Booth & Newton, 2012; Brown & Quinn, 2007; Charalambous & Pitta-Pantazi, 2007). Small group interventions were applied with success in some educational settings to help students acquire a better understanding of operations with rational numbers (Fuchs et al., 2013).

The research problem. Every high school student, by the end of freshman year, was expected to have the ability to solve basic algebraic problems as measured by the Algebra I EOCE. At the targeted school where this study took place, after the completion of the 2014-2015 and 2015-2016 school years, only 29% of the freshmen had met this requirement (FLDOE, 2017c). Almost 600 sophomores and juniors, at the beginning of the 2016-2017 school year, had not passed either the Algebra I EOCE or the PERT. This was determined by the number of students assigned to retake the test by the testing chairperson of the target institution. These students had failed the Algebra I EOCE after the completion of the Algebra I course in ninth grade; some of them had retaken and failed the test a few more times.

The sophomores in the study were taking Geometry and Intensive Mathematics in preparation for both the Algebra I EOCE and the Geometry EOCE. This group was expected to take algebra II followed with the algebra II EOCE in the 11th grade. If the 10th graders were, however, unable to perform basic algebraic operations by the 11th grade, performing well in the algebra II class would prove difficult. Students' performance on both the Geometry EOCE and the Algebra I EOCE had a major impact on the overall school grade. The projected outcome of students' performance on the Algebra II EOCE at the end of the junior year would likely negatively affect the performance grade of the school.

The juniors in the study not only failed the Algebra I EOCE several times but also had failed the Geometry EOCE. Students who failed were placed in a mathematics course called Liberal Arts Mathematics 2 with the hope of being adequately prepared for Algebra II by senior year. Though not required for high school graduation, Algebra II was a requirement for admission to many colleges.

Because a considerable amount of mathematical instruction had been provided to the students with no success, a new area of investigation was implemented as part of this study based on the connection between understanding rational number operations and understanding algebra (Booth, Newton, & Twiss-Garrity, 2014; Brown & Quinn, 2007; Charalambous & Pitta-Pantazi, 2007). This action research was designed to determine if the implementation of small group intervention, focused on helping students understand rational operations, would impact students' performance on the Algebra I EOCE.

Background and justification. The location for this study was an inner-city school located in a heavily populated Hispanic neighborhood in southeast Florida. The school is one of the oldest in the city with a long list of prominent alumni in the community. The strong support of community leaders, especially those of Cuban heritage, has made this school a pillar of the Hispanic community despite being in one of the most economically disadvantaged neighborhoods in the county.

The school was recently renovated with several new buildings added to accommodate the increasing population. The campus is, without a doubt, the most spectacular in the county. In addition to its beauty, the school is equipped with all the latest educational technology configurations. Every classroom has a Smart Board and wireless Internet can be accessed throughout the school. The school board administrators often chose to conduct press conferences and other board activities at this location because of these attributes.

Generally, most visitors are dazzled by the surroundings and few suspect that most students attending are poor. Of the students who were enrolled at the school, 89% qualified for free lunch. The federal government acknowledged that a great part of the student population and families were economically disadvantaged and provided additional funding to the school as a designated Title I school (Miami-Dade County Public Schools, Office of School Improvement, 2016-2017).

For the 2016-2017 school year, FLDOE reported that 2,986 students attended the target school. This figure included 340 students who were eligible for exceptional student education programs and 558 English language learners (FLDOE, 2017c). The majority of students and staff spoke both English and Spanish. Most classes were conducted in English: however, hearing students and staff speaking Spanish elsewhere in the school was not unusual.

The school is full of contrasts, both in the structural facilities and in academics. From the outside, people see a beautifully renovated historical building surrounded by several brand new wings blending with perfect harmony. Even in the oldest structure, observers would see rooms with huge exquisite Spanish windows next to a Smart Board. The contrast in academics is even greater than that of the physical location. Large numbers of students take remedial reading and math, while many others are enrolled in advanced placement courses and dual enrollment courses.

In 2013, the school had the national distinction of being the high school with the largest number of students taking the advanced placement Spanish Language and Culture examination. In addition to the advanced placement Spanish Language and Culture course, many other advanced placement courses were offered. These courses included English Literature and Composition, U.S. Government and Politics, and Biology. Other offerings in the curriculum included many vocational programs leading to such industry certifications as business, auto mechanics, cosmetology, and health-related fields. The school also hosted a law magnet program and an education magnet program for selected groups (Miami-Dade County Public Schools, 2016-2017). Students have the opportunity to graduate prepared for college or a career or both. While some do, others, either dropout or receive a certificate of completion instead of a diploma.

The gap between students who either graduated college or were career-ready and students who did not receive a diploma would potentially become even larger. At the same time, the school was increasing the number of dual-enrollment offerings, the mathematics exit examination requirements resulted in an increase in the number of students not receiving a regular diploma. Passing the Algebra I EOCE, or its equivalent, seemed to be one of the greatest obstacles to graduation, and perhaps, the biggest challenge of all the stakeholders at the school.

A major educational trend of the early 21st century had been the push to make school curriculum more challenging to produce high school graduates well prepared to enter either the work force or higher educational programs without the need of remediation or extra preparation (Mazzeo, 2010). This trend surfaced in response to government reports claiming a substantial number of American high school graduates did not possess the necessary skills to succeed in a 21st century workforce or at higher education institutions (Radcliffe & Bos, 2013). Furthermore, these reports indicated that a significant disparity existed in the levels of achievement between Caucasian students and some minority groups (Radcliffe & Bos, 2013). This achievement gap was specifically noted between groups of different economic levels: the poor were rapidly falling behind academically (Schmoker, 2012). To deal with both the high school graduate's lack of preparation and the growing achievement gap, many state leaders were increasing high school graduation requirements for all students (Mazzeo, 2010). Florida was one such state.

Florida's public high school students who entered ninth grade after August 2011 were now required to pass the Algebra I EOCE to earn a Florida high school diploma. This new requirement had become a significant problem for the stakeholders of the target school due to the slow rate of achieving passing scores among students. Research indicated that low student performance in Algebra I was a national problem, especially among minority students (Cortes, Goodman, & Nomi, 2013). Many studies have been conducted to test the effectiveness of strategies geared to improve student performance in the subject (Cortes et al., 2013; Huerta, Watt, & Butcher, 2013; Nomi, 2013; Viadero, 2009). Some researchers cited a lack of prerequisite skills as a major factor for Algebra I failure (Cortes et al., 2013).

In addition to the lack of prerequisite skills in mathematics, many students entered the ninth grade reading below grade level while some did not speak or understand English. This was a serious problem since many of the questions in the Algebra I EOCE require grade level reading skills. Several researchers attempted to show that a connection existed between reading comprehension and problem solving. Students obviously needed to be able to understand the question before solving it (Reikerås, 2009). According to Reikerås (2009), most findings in this area were not conclusive and new research was needed. In the meantime, Algebra I teachers had to teach students reading comprehension if the student was to succeed in the Algebra I EOCE because the test has a large number of word problems. Besides inadequate pupil preparation in both mathematics and reading, lack of motivation on the part of students was often cited as a cause for failure. Several researchers agreed that students' motivation to learn could have a significant effect on academic achievement (Elliott & Tudge, 2012; Fan, Lindt, Arroyo-Giner, & Wolters, 2009).

Fan et al. (2009) contended that students' self-efficacy played a major role in motivation and learning outcomes. Hispanic parents' lack of participation in the educational experience of the child had also been cited as a cause for a lack of achievement (Jasis, 2013). Lack of academic achievement was a complex issue that probably encompassed many factors. The precise causes of the lack of student achievement in Algebra I were unknown. The problem may have lay with the lack of (a) preparation on the part of students and teachers, (b) motivation of the students, (c) participation of the parents, or (d) in a combination of some of the previously mentioned factors.

Deficiencies in the evidence. Administrators at the school had already tried many strategies to solve the problem, but no data connected any intervention to the effect resulting from the interventions. Incoming ninth graders who identified with either language or mathematical skill deficiencies were given an additional mathematics class or an additional reading class. During the 2016-2017 school year, sophomores who had failed the Algebra I EOCE in ninth grade were assigned to both Intensive Mathematics and Geometry. All teachers in the school had received training in how to teach English language learners and students who were eligible for exceptional student education programs. All teachers had also received training in how to teach reading in their content area. Student progress in both reading and mathematics had been periodically assessed and resulting data have been analyzed to address emerging needs. Several reading coaches assisted teachers to interpret available data regarding student performance. These coaches designed school wide instructional strategies geared to help students become better readers.

In addition to the training that all teachers in the school had received, Algebra I teachers were extensively trained in pedagogy to help them deliver instruction more effectively. These teachers met weekly, as a team, to analyze the effect of the practices on students. They monitored student progress and adjusted instruction to meet student needs. A mathematics coach worked with mathematics teachers helping them process data and identify strategies to improve students' performance in mathematics.

Another initiative implemented in the school was the offering of free tutoring to all students. Such tutoring took place after school and on Saturdays. Despite many efforts by teachers and administrators to motivate students to attend tutoring, attendance was low. Both teachers and administrators tried to motivate students by offering extra credit, pizza, movie tickets, and other incentives. These external motivators worked for some students, but not all who attended were motivated to learn. Both administrators and teachers attempted to involve parents in the motivation of their children, but parent participation was low. Notwithstanding, most parents who got involved were able to persuade students to attend tutoring, but students were not motivated to learn.

Another strategy employed by school leaders was to hire part-time teachers to implement small group interventions for juniors and seniors who, after several attempts, had not been able to pass the Algebra I EOCE. These interventionists also helped the students review for the PERT. The topics of the intervention were many, ranging from general mathematics concepts to more advanced algebraic applications. Although these small group sessions appeared to have had some success, no data could be used to analyze the impact of the strategy. The lack of data made it impossible to establish if any correlation existed between the intervention and student scores on the Algebra I EOCE.

The many strategies implemented in the school to help students succeed in algebra, as demonstrated by a passing score in the EOCE, seemed to have had little success. Efforts continued to be made to help every student learn basic algebraic skills. For the 2016-2017 school year, students identified as being below grade level had been enrolled in extra mathematics or reading classes. The school had continued to offer tutoring and small group interventions. Algebra teachers had been researching and perfecting their craft. These teachers had also strategized, as a team, to develop academic plans that could address the needs of both the incoming ninth-grade students who needed to pass the Algebra I EOCE at the end of the academic year and of the upperclassmen who still needed to pass the test.

Audience. The audience of this study includes parents, teachers, administrators, other educators, and community members. Stakeholders interested in helping students attain a Florida high school diploma would benefit from the research presented in this study. Helping students acquire the necessary skills to pass the Algebra I EOCE would also help students gain the necessary skills to be college or career ready, thus, contributing to success after graduation. Those interested in success in postsecondary programs, or at a career, could also benefit from the findings of this study.

An increase in students' success in the mathematics exit examination would have a positive impact on the graduation rate. In addition to the students, parents, teachers, administrators, other educators, members of the community would also benefit from a rise in the graduation rate. Parents would not be embarrassed by having children who had attended school for 12 years without attaining a high school diploma. Teachers' and administrators' performance evaluations would also be impacted by the success of the students. Because the graduation rate was part of the school grade, an increase in the number of diplomas granted would enhance the prestige of the school and the surrounding community. All those just mentioned would benefit from the research described in this study.

Definition of Terms

Advance placement courses. Courses approved by the College Board (2016), in which students follow a specified curriculum and must take an examination at the end of the course, are advance placement courses. Students who do well on these examinations may earn college credit (College Board, 2016).

Achievement gap. A significant difference noted when comparing the performance level demonstrated on standardized tests by different populations of students is referred to as the achievement gap. The different populations are usually classified by the government using ethnicity, gender, and economic status. The tests are usually in reading and mathematics (National Center for Education Statistics, 2013).

Certificate of completion. In the state of Florida, students who complete all the required course work but fail to meet other graduation requirements, such as passing required examinations or accomplishing a grade point average of at least 2.0, will often receive a certificate of completion instead of a high school diploma (Florida Legislature, 2017).

College entrance examination. Most colleges have admission requirements that include a minimum score on examinations, which is referred to as a college entrance examination. (Center on Education Policy, 2010). Among these examinations are the Scholastic Aptitude Test, the American College Testing, and the PERT.

Common Core State Standards (CCSS). Standards that are proposed by the Federal Government and embraced by most state governors are CCSS. These standards are already being implemented in some states and plans exist to continue implementing them across the nation (Common Core State Standards Initiative, 2017a).

Dual enrollment. Advanced courses, in which students can earn both high school and college credit from a Florida public college or university, are referred to as dual-enrollment courses (Miami Senior High School, 2016).

End of course examinations (EOCE). A comprehensive assessment taken at the end of certain courses is an EOCE (Center on Education Policy, 2010).

Exit examination. An assessment that students must pass to get a high school diploma is an exit examination (Center on Education Policy, 2010).

Interventionist. A part-time teacher who helps small groups of students to attain specific academic objectives is an interventionist (Miami-Dade County Public Schools, 2017).

Magnet program. A program in which a group of students receives instruction in a specified curriculum, usually career-oriented, is a magnet program (FLDOE, 2017c).

Title I school. A public school in which most students and their families are considered economically disadvantaged is a Title I school. These schools receive additional funding from the Federal Government to implement academic programs (Miami Senior High School, 2016).

Postsecondary education readiness test (PERT). A test implemented via computer that measures how prepared students are for courses at the college level is a postsecondary education readiness test (McCann Associates, 2011).

Purpose of the Study

The purpose of this study was to determine the outcome of small group intervention focusing on operations with rational numbers of high school students' performance on the Algebra I EOCE. The focus of the instruction was the key element of the research that sought to determine if a relationship was evident between fractional knowledge and algebraic understanding. Another important feature of the study was the incorporation of a variety of pedagogical strategies such as the use of guided inquiry to lead students in the development of strategies to solve word problems.

Chapter 2: Literature Review

Introduction

The federal government acknowledges the existence of a disparity in academic achievement between Caucasian, African American, and Hispanic students. The government has tried to eliminate this achievement gap by promoting a rigorous curriculum across the nation for all learners (American Diplomat Project Assessment Consortium, 2010). Most researchers cited in this study support efforts to reduce the achievement gap, but not all researchers agree that demanding higher performance by all pupils would result in the elimination of the gap. Supporters of the government's position feel that providing rigorous instruction for all students will empower every child with the opportunity to take advanced courses and be prepared for college (Jonas, et al., 2012; Miller & Mittleman, 2012; Sparks, 2013). Other researchers feel this curriculum may increase the achievement gap, leaving behind those not able to meet the standards set (Fan & Lissetz, 2010).

Several of the studies cited in this paper show the concern of many educators regarding students' ability to accomplish the new requirements. Among those new requirements are mathematics exit examinations that require children to demonstrate competency in performing basic algebraic operations. Research presented in this section provides evidence of a trend toward a more rigorous academic curriculum in American schools. Mathematics and science are major components of any rigorous academic program.

To succeed at more advanced mathematics or science courses, students must be accomplished in basic algebra; hence, the preoccupation with student performance in basic algebra (Booth & Newton, Fractions: Could they really be the gatekeeper's doorman?, 2012; Chval, Lannin, & Jones, 2013). The implication of the continuing trend is that of a greater need to promote the understanding of basic algebraic concepts. The research presented also demonstrates that, in spite of the many efforts to increase academic success in basic algebra, a need for improvement still exists. One of the major problems associated with the lack of student understanding of basic algebra is that in some states, such as Florida, children are required to demonstrate knowledge of basic algebra on exit examinations to receive a high school diploma (Ujifusa, 2012).

To determine the underlying causes of poor performance in mathematics, exit examinations requiring basic algebraic knowledge, several areas of study have been investigated. As part of the research, the impact that motivation has on learning algebra, specifically the impact of cultural and familial identity in connection with student motivation, has been explored. How the lack of prerequisite skills affects students' abilities to learn algebra has been a major topic of research for this project. An important finding in this area has been that a significant number of researchers have identified the lack of understanding of operations with rational numbers as essential for algebraic skills development (Booth & Newton, 2012; Lee & Hackenberg, 2014).

The relationship between understanding how to perform algebraic operations and understanding how to perform operations with rational numbers appears to be a key factor for student success in algebra (Booth & Newton, 2012). This relationship is the conceptual framework within which this study was grounded. Lee and Hackenberg (2014) concluded, "that implicit use of powerful fractional knowledge can lead to more explicit use of structures and relationship in algebraic situations" (p. 975). Charalambous and Pitta-Pantazi (2007) also supported the idea of the importance of empowering students with fractional knowledge. According to Charalambous and Pitta-Pantazi (2007), the theoretical framework formulated by Kieren about the subject has been the basis for many studies, including their own. This investigation sought to explore the concepts and theorems developed by previous researchers about teaching fractions to determine if a connection exists between fractional knowledge and algebraic knowledge.

Movement Towards More Academic Rigor

By 2010, most of the states were already implementing more rigorous standards and had introduced tougher graduation requirements (American Diplomat Project Assessment Consortium, 2010). These requirements extend beyond academic courses and cross over to other areas of the curriculum. For example, some states have been reviewing the standards for career and technical education replacing each with more rigorous standards to meet 21st century demands (Often, 2011). Because of this trend, some educators have been promoting the introduction of more advanced topics in early grades. The introduction of Algebra I in eighth grade or even earlier has been proposed by some groups (Huerta et al., 2013; Viadero, 2009).

Other evidence that the nation is moving toward more academic rigor is the CCSS for mathematics and English language arts. The Council of Chief State School Officers introduced CCSS in 2010 with the support of representatives from 48 states who pledged to make CCSS the state's official standards (Council of Chief State School Officers, 2010). The new standards not only mandate Algebra I for all students, but they also prescribe Algebra II (Phillips & Wong, 2010). According to Phillips and Wong (2010), new CCSS assessments for these subjects will be more conceptual and therefore higher level thinking skills will be demanded from students to succeed on these evaluations.

Closing the Gap in Mathematics

The National Center for Education Statistics (2013) has been collecting data related to student achievement in mathematics since 1973. Representatives of the National Center for Education Statistics reported a moderate increase in achievement in mathematics for all students from 1973 to 2012. Additionally, minority students showed a larger increase than Caucasian students (National Center for Education Statistics, 2013). A report from the National Center for Education Statistics revealed that a statistical significant academic achievement gap in mathematics between Caucasian students and African American students and between Caucasian students and Hispanic students began in 1973. The National Center for Education Statistics uses standardized test scores to determine student achievement.

African American and Hispanic student scores on mathematics standardized tests have increased at a faster pace than the scores of Caucasian students; the achievement gap has become smaller but still statistically significant (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010). Furthermore, government data indicated that before 2006 not only were large numbers of minority students graduating with fewer credits in advanced mathematics classes, but in many cases, similar classes they had taken were less rigorous than those taken by Caucasian students (Sparks, 2013). To assure that all students receive equivalent instruction in key courses, Sparks (2013) advocated the implementation of national standards. To address the achievement gap, in addition to the implementation of CCSS, the government has been promoting comparative examinations evaluating mastering of standards (Phillips &

Wong, 2010).

Even though most stakeholders are in favor of closing the gap and agree that having all high school students ready for college or careers by graduation would be ideal, some stakeholders oppose the new requirements. They feel that these requirements may actually increase the gap. Research has found evidence to support this point of view. For example, in Chicago where the mandatory curriculum has been in place since 1997, a recent study reported both positive and negative results from the implementation of more rigorous requirements (Mazzeo, 2010).

According to Mazzeo (2010), all incoming ninth-grade students in Chicago are required to begin mathematics courses at the Algebra I level or above. Since the implementation of this mandate, the number of students failing Algebra I has increased significantly as well as the numbers of ninth graders not being promoted to 10th grade. Another consequence of this mandatory curriculum is a drop in ninth-grade attendance (Mazzeo, 2010). In general, large numbers of ninth-grade students failing the first mathematics course seems to have a negative effect on class graduation rates.

Implications of Tougher Standards for Algebra I

Expectations. In mathematics, the major focus of CCSS is Algebra I, which is the course that establishes the foundation for all other higher mathematics courses, as well as some science courses. Designers of the CCSS understand that without building the foundations in reading and Algebra I, students will not be able to take advanced courses during high school years. Some researchers believe that tougher standards will force teachers to demand more from students with the expectation that these students will strive to meet the new standards (Fan & Lissitz, 2010). Other supporters feel that the mandatory curriculum prevents the placement of students on other, less desirable, academic paths that that do not prepare them for college or careers (Miller & Mittleman, 2012). Some believe that by affording access to courses normally taken by college-bound students, all students will be able to access more opportunities to enter college or the work force better prepared to succeed (Achieve, 2009).

Other stakeholders are skeptical about government claims that increasing rigor will translate into a smaller achievement gap. Some feel the achievement gap is a result of the economic gap and not the curriculum; to close the achievement gap, stakeholders deem it necessary to first address the economic disparities in the country (Schmoker, 2012). The point of view that economics is probably more related to the gap than the curriculum itself, is supported by government reports indicating that students classified as economically disadvantaged almost always, if not always, are the lowest performing group of students academically (National Center for Education Statistics, 2013; Tienken, 2010).

Preliminary results. Results from some states in which more rigorous graduation requirements have already been implemented, and in which Algebra I is the lowest level course ninth-grade students can be enrolled, have been mixed. In some places, positive outcomes are evident due to the implementation of a more rigorous curriculum. For example, a report about Chicago's effect of mandatory Algebra I enrollment in Grade 9 shows a majority of students taking college preparatory classes before graduation (Mazzeo, 2010). In addition, algebra teachers in Chicago report that they have changed the way they teach because of the demands placed on both them and students (Mazzeo, 2010).

Results from more rigorous curriculum implementation, however, have not been all positive. For example, some believe that a consequence of placing all high school freshman students in Algebra I or higher in Chicago has resulted in an increase of the Algebra I failure rate (Viadero, 2009). Imposing higher requirements does not always yield the desired results. Data, from four states that administered the same Algebra I EOCE to students, showed that less than 30% of students were performing at proficiency level or above (Achieve, 2009).

The same report stated that out of over 40 thousand students in eight states who took the Algebra II EOCE, almost 80% were not proficient in the subject (Achieve, 2009). In Chicago, where the more rigorous academic requirements already existed for several years, most students who were eligible to enroll in advanced mathematics classes did not elect to do so (Mazzeo, 2010). The extra requirements have turned students away. According to Mazzeo, not only did students not take advantage of the available higher mathematics courses at the high school level but fewer actually attended college after graduation compared to when the mandatory curriculum was not in place.

Additional support. Although many educators understand the benefits of placing tougher academic demands on students, they also understand the need of providing lower achievers with additional support for them to meet those demands (Jonas et al., 2012). Many projects have been implemented all over the country to help students achieve and adjust to tougher requirements. For example, in Virginia, additional training and resources have been given to teachers to improve Algebra I instruction (Viadero, 2009). Another popular strategy employed by many school systems across the country is to help students rise to expectations by giving them extra periods of algebra and reading (Cortes et al., 2013; Viadero, 2009). In Clark County, Nevada, in addition to requiring students to take Algebra I and Algebra II, electives aimed at helping students accomplish the tougher requirements posed by the CCSS are offered to work in conjunction with the algebra courses (Robelen, 2013). Other interventions that have been implemented across the nation are small group tutoring programs focused on specific areas of study (U.S. Department of Education, 2013).

To prepared students for Algebra I in Grade 9 or earlier, most states following the CCSS have introduced many of the prerequisite skills in the primary grades (Viadero, 2009). Some authors advocate that closing the gap require an increase in the middle grades and not to wait until students reach high school to start the path to college (Huerta et al., 2013; Radcliffe & Bos, 2013). A report prepared for the National Center for Education Statistics recommends aligning the national curriculum by introducing more challenging topics in the earlier grades (Hughes, Daro, Holtzman, & Middleton, 2013).

Student Motivation and Achievement

Ninth-grade students often lack the maturity to understand the importance of learning algebra (Emmett & McGee, 2012/2013). This narrow vision of freshman students often translates into a lack of motivation. Student motivation is a necessary ingredient for student achievement in any subject and probably more critical in algebra than in any other subject. To be successful in mathematics, students must be willing to think critically in order to grasp the concepts and meet the challenges of the subject (Roegner, 2013). Unfortunately, academics motivation seems to decrease as students enter high school (Bembenutty, 2011; Emmett & McGee, 2012/2013; Froiland, Oros, Smith, & Hirchert, 2012). Froiland et al. (2012) agreed and further contended that mathematics motivation seems to be the most affected.

Students who do well in algebra are usually intrinsically motivated to learn the subject; these students understand the value of learning algebra and feel confident about their abilities to attain the required knowledge to be successful (Froiland et al., 2012). Researchers have identified self-efficacy and self-regulation as two important components of intrinsic motivation and of student academic development (Bembenutty, 2011; Fan et al., 2009). Fan et al. (2009), found that students who believed they had the ability to succeed academically were more proactive about learning and more engaged in academic activities. Moreover, Bembenutty (2011), who strongly advocated for the value of doing meaningful homework for academic success, found that students who have a strong self-efficacy belief were more likely to do homework.

Cultural Identity and Achievement

The academic gap among students from some minority groups, such as African American, Hispanic, and Caucasian students, hints to the possibility of a connection between one's culture and achievement. Another good reason to explore this avenue is that some researchers have found that social relations influence student motivation (Fan et al., 2009). Other researchers believe that although many factors affect motivation, culture plays a role in student academic performance (Elliott & Tudge, 2012).

An academic achievement gap between minority students and students from the majority culture is not a problem unique to the United States. For example, in New Zealand, efforts to elevate the academic performance of students belonging to indigenous groups have been documented (Graham, Meyer, McKenzie, McClure, & Weir, 2010). Likewise, in Israel, Ethiopian Jews have been identified as lagging academically behind other Jewish students (Mulat & Arcavi, 2009). As in the United States, in both New Zealand and Israel, the underachievers belong to minority groups that are economically disadvantaged (Graham et al., 2010; Mulat & Arcavi, 2009).

What may be perceived as a lack of motivation may be a symptom of lack of economic resources such as inadequate nutrition or poor living conditions (Jasis, 2013). "Being poor in a rich country can lead to ill-placed shame, pervasive despair, and anger" (Jasis, 2013, p. 115). In addition to economic conditions, Mulat and Arcavi (2009) also found that other factors are related to low achievement among minority students such as having to learn a new language and culture, starting school already behind, and feelings of isolation due to being different. Another explanation for the poor intrinsic motivation of low-income students can be that different socioeconomic groups tend to deal with parenting in different ways (Elliott & Tudge, 2012). For example, Elliott and Tudge (2012) stated that "middle-class families . . . encourage autonomy and self-direction in their children [;] . . . working-class families are more interested in fostering obedience and rule-following" (p.171). In this context, middle-class students would be more intrinsically motivated than poor children would, since some of the major components of intrinsic motivation are self-regulation and self-efficacy. In addition to the effects of socioeconomic status on student motivation, researchers have found that parents' expectations also affect student motivation (Graham, Meyer, McKenzie, McClure, & Weir, 2010; Mulat & Arcavi, 2009).

Families and Motivation

In New Zealand, researchers found that parent expectations played a big role in student motivation and achievement (Graham et al., 2010). Parental support and encouragement was identified as an important element contributing to the mathematics success of some Ethiopian students in Israel (Mulat & Arcavi, 2009). Although parents of the motivated Ethiopian students lacked academic skills or command of the Hebrew language, they still encouraged their children to study on their own (Mulat & Arcavi, 2009). Similarly, many Hispanic parents supported and encouraged their children to learn (Martinez & Ulanoff, 2013). Parental support seems to be vital for student success, even when students are supported by mentors, tutors, or teachers (Mulat & Arcavi, 2009; Niehaus, Moritz Rudasill, & Adelson, 2012). Intrinsically motivated children most likely have parents who have encouraged them to learn and who have supported their efforts (Martinez & Ulanoff, 2013; Mulat & Arcavi, 2009; Niehaus et al., 2012).

In addition to been motivated to learn, to develop algebraic thinking students must understand other mathematical basic concepts (Dixon & Tobias, 2013). Several researchers have identified performing operations with rational numbers as a prerequisite to learning algebra (Brown & Quinn, 2007; Lee & Hackenberg, 2014). Although encouraging parents can contribute to student success, it is essential that students have the prerequisite skills needed to develop algebraic thinking.

Prerequisite Skills: Operations With Rational Numbers

Several researchers have identified the ability to perform operations with rational numbers as essential to develop algebraic thinking (Booth & Newton, 2012; Brown & Quinn, 2007; Lee & Hackenberg, 2014). They determined that students need to understand the structure of operations with rational numbers to understand the structure of algebraic operations (Booth & Newton, 2012). Merlin (2013) stated that even when students can perform basic algebraic operations without fully understanding the structure of rational numbers, as they progress in the algebra class, they would eventually need to perform operations with fractions to solve more complex algebraic problems. Merlin pointed out that student misconceptions about rational numbers may interfere with performance of more advanced algebraic operations such as simplifying rational expressions. According to Cortes et al. (2013), "pushing students into course work for which they are ill prepared actually harms their subsequent academic achievement" (p. 71).

Yearley and Bruce (2014) stated, "a Canadian college mathematics achievement project identified proficiency with fractions as an ongoing area of need for post-secondary students" (Background section, para. 1). As more and more researchers acknowledge that students' lack of understanding of rational operations is a persistent problem in many academic settings, researchers are taking a closer look at the pedagogy involved in the teaching of rational numbers. Several have subscribed to the idea that operations with rational numbers are a complex topic. They believe such operations are not only difficult for students to understand, but that educators find them equally difficult to teach (Booth & Newton, 2012; Yearley & Bruce, 2014). Heitin (2014) urged the creation of more professional development programs geared to improve the teaching of rational number operations. One such program in teaching fractions was recently implemented in Canada, because, according to Yearly and Bruce (2014), "teachers lack comfort with the content area" (p. 35).

Booth et al. (2014), claimed that many important concepts are related to operations with fractions that should not be neglected. These include magnitude, equivalence, and proportionality. Yearly and Bruce (2014) also emphasized the idea that many concepts are related to operations with fractions that need to be addressed to promote understanding. One such concept is partitioning. Peppers, Wan, and Phillips (2014) promoted the reviewing of partitioning, equivalence, and proportionality with students who are struggling with the fraction operation. Several authors emphasized the use of number lines when teaching fractions (Heitin, 2014). The use of number lines to teach students about fractions, and the emphasis on such concepts as magnitude, partitioning, equivalence, and proportionality have become part of the CCSS (National Center for Education Statistics, 2013).

The Common Core State Standards and Rational Numbers

One of the major developments affecting American education during the early part of the 21st century has been the creation of the CCSS. For the first time in its history as a nation, most of the leaders of different states and territories have agreed to promote the same educational standards (Common Core State Standards Initiative, 2017a). In a country like the United States, where Internet access is easily available, parents can visit the CCSS Initiative website to see what their children should be learning. The website presents a clear sequence of the standards from kindergarten to Grade 12. An examination of the Mathematics CCSS document on the website points to the importance of the understanding of fractions in the mathematics curriculum.

Students following the CCSS curriculum are introduced to fractions starting in Grade 3 and continue to develop an understanding of fractions and their applications in Grades 4 through 6 (Common Core State Standards Initiative, 2017b, 2017c). By the time students reach Grade 7, according to the CCSS curriculum, they should be able to solve real-life problems by applying a conceptual understanding of rational numbers with an ability to perform fractional operations. Seventh-grade students continue exploring fractions as they study ratios and proportions; and in eighth grade, they continue using ratios and proportions in relation to linear functions (Common Core State Standards Initiative, 2017b, 2017c).

In high school, the understanding of fractions continues to be vital for student success in every mathematics course. For example, ratios are essential to the understanding of functions in Advanced Algebra and in Trigonometry; proportionality is a major concept in Geometry; and determining equivalence among fractions, decimals, and percentages is a critical skill for the Statistics and Probability course. The importance of understanding fractions in the study of advanced mathematics courses, as conveyed by the CCSS, is summarized as follows:

> The Common Core State Standards for mathematics include increased emphasis on the teaching of fractions and the need for Algebra-readiness. Not only are these math concepts important to a student's understanding when it comes to higher level learning, but they also influence many career and technical education programs (Heitin, 2014, p. 3).

Understanding Rational Numbers

The designers of the CCSS are proposing, in addition to creating a cohesive set of standards to be implemented across the nation, a change of paradigm for the instruction of mathematics. They are suggesting a more rigorous approach to the curriculum, with the expectation that students will be able to demonstrate an understanding of concepts by solving application problems (Common Core State Standards Initiative, 2017b). This change in paradigm does not mean that the teaching of procedures should be abandoned, but that the procedures should be accompanied by the promotion of student understanding (Common Core State Standards Initiative, 2017b). Prior to the CCSS, researchers claimed that a lack of emphasis on conceptual understanding and an overabundance of emphasis in teaching procedural skills existed (Norton & Boyce, 2013). The CCSS is a validation of the ideas of these earlier researchers who pointed out the complexity of fractions and the need to give more emphasis to conceptual understanding (Charalambous & Pitta-Pantazi, 2007).

Since the formulation of the CCSS, the literature promoting the understanding of fractions and their applications has grown exponentially. For example, the National Council of Teachers of Mathematics has published a large number of books and other educational materials addressing the instruction of rational numbers at different grade levels. For example, one of the books of the *Putting Essential Understanding Series* is dedicated to the exploration of fractional operations in Grades 3 through 5 (Chval, Lannin, & Jones, 2013). This book emphasized the use of drawings to solve real-life problems. Other researchers also promoted the idea of using drawings in conjunction with other strategies.

Dixon and Tobias (2013) wrote about having students decipher context problems by drawing a visual representation of the actual circumstances to promote conceptualization of the situation. Pitsolantis and Osana (2013) also supported the use of drawings by students to represent real-life situations. They believe that other benefits also relate to this approach. According to Pitsolantis and Osana, instructors can determine the kind of misconceptions that students are having by analyzing their representations of the context problem. Analyzing misconceptions can be a powerful tool for redirecting student thinking and arriving at a correct solution (Pitsolantis & Osana).

In addition to the use of context problems and visual representations, many researchers also urged for the use of manipulatives (Dixon & Tobias, 2013; Peppers et al., 2014). Small (2014) promoted a variety of approaches to teach the various concepts related to rational numbers in primary and middle grades recommending the use of skillfully crafted questions, or guided inquiry, that promote critical thinking. These oral discussions, besides promoting understanding, according to Small, also allow the teacher to determine whether the student has gained the desired understanding.

Interventions

The awareness of educators about the importance of operations with rational numbers has led to the development of many new interventions to address the CCSS. These interventions usually involve a multiplicity of strategies. Some examples are small group instruction, the use of manipulatives, the use of computer aided instruction, and guided inquiry.

The Institute of Educational Sciences reported on a study that "examined the effects of *Fraction Challenge*, a supplemental small group tutoring math program [that] focuses on improving understanding of fractions" (U.S. Department of Education, 2013, p. 1). *Fraction Challenge* is a computer program design to practice fractional operations (U.S. Department of Education, 2013). Peppers et al. (2014) also employed computers in their intervention. These researchers used both virtual manipulatives and physical objects in the remediation of fractions. Champion and Wheeler (2014) also capitalized on manipulatives to implement their intervention. The application of manipulatives in the mathematics classroom, though not new, has regained popularity with the introduction of the CCSS.

In addition to the use of manipulatives and computer aided instruction to help students understand rational numbers and its operation, educators are promoting other pedagogical strategies. For example, Small (2014) proposed the use the guided inquiry along with the use of manipulatives to guide students to solve problems involving fractions. Dixon and Tobias (2013) also promote guided inquiry, but they combine this strategy with the use of graphic representations.

Summary

One of the major educational objectives of the Council of Chief State School Officers (2010) is that all American students graduate from high school ready for college and careers. The desire to accomplish these objectives has fueled the trend toward a more rigorous curriculum and a demand for tougher graduation requirements (Mazzeo, Allensworth, Nomi, Montgomery, & Lee, 2010). This movement has also stimulated a growing concern about the ability of some students to rise to the new demands (Fan & Lissetz, 2010). This concern is founded on government data exposing an achievement gap between minority students and students from the main culture (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010). Tougher requirements could have the potential of increasing the gap (Fan & Lissetz, 2010).

In response to the trend and to the achievement gap, educational leaders have tried many initiatives to help minority students meet the new demands. Some of these initiatives include better teacher training, extra reading and mathematics classes for students, and tutoring after school hours. These initiatives have shown and continue to show some potential for success but more is needed to help close the achievement gap. Researchers have been studying the impact of the initiatives implemented in recent years. Even though these initiatives seem to have had a positive impact on student achievement, none of the initiatives have been shown to be the absolute solution to the problem. The complex problem of closing the gap needs to be solved with a combination of approaches.

Researchers have uncovered a variety of issues that impede minority student progress such as cultural differences, economic conditions, previous preparation, perceived lack of motivation, and lack of English language acquisition. Economic conditions have a profound effect on student performance, but improving such conditions is beyond the scope of educators. Academics have, therefore, focused on those aspects educators can influence.

Recently, research related to understanding the importance of rational operations in algebraic operations has been emerging. This connection of rational operations with algebraic understanding offers a new avenue of exploration at the high school level as most of the inquiries have been done at the elementary and middle grade levels. Interventions to help students acquire a deep understanding of rational numbers have proven to be successful with students who are not in high school. To determine if this approach could have an impact on students learning basic algebraic operations should be explored at the high school level.

Research Questions

The following research question and sub question were used to drive the study: What were the outcomes of a small group intervention focusing on operations with rational numbers on student performance on the Algebra I EOCE at the target high school? The following sub question was developed to answer the research question: Did the intervention had an impact on students' learning gains in the Algebra I EOCE? To try to answer the research question the following null hypothesis was formulated: The mean learning gains in the 2016 Fall Algebra I EOCE for the participants was the same as the mean learning gains for the population. The corresponding alternative hypothesis was that the mean learning gains in the 2016 Fall Algebra I EOCE for the participants was not the same as the mean learning gains for the population. If the analysis of the data resulted in the rejection of the null hypothesis, the corresponding alternative hypothesis would be accepted.

Chapter 3: Methodology

Participants

The general population of concern for this study was 10th and 11th grade high school students who needed to pass the mathematics exit examination to receive their high school diplomas at the target school. The students in the target population had failed the Algebra I EOCE at least once. At the beginning of the 2016-2017 school year, 581 students were in the target population.

Three classes were selected for the study: two Intensive Mathematics classes and one Liberal Arts Mathematics 2 class. Members of the target population enrolled in these classes were invited to be part of the study. Sixteen sophomores and four juniors who had the support of their parents and mathematics teachers volunteered to participate in the research. Eighty-five percent of those who took part in the research were Hispanic and 15% were African American. Four of the Hispanic students, for whom English was their second language, had been in the United States fewer than 2 years. Among the participants, one student was eligible for the exceptional student education program. The student was enrolled in regular classes and was doing better than average in all of them. Fifty-five percent of the participants were female and 45% male. All 10th-grade participants had failed the Algebra I EOCE when they took it for the first time in spring 2016. The participants who were in 11th grade had taken and failed the test for the first time in the spring of 2015. These juniors had taken and failed the test several more times after the spring of 2015.

Per Florida statutes, four credits in mathematics are one of the requirements for a high school diploma (Florida Legislature, 2017). To comply with the mathematics course requirements, those enrolled in high school must take Algebra I, Geometry, and two other mathematics courses. Most freshmen at the target school take Algebra I in Grade 9 and Geometry in their sophomore year. All students in the target population had already taken Algebra I. When the study began, the sophomores were enrolled in Geometry and Intensive Mathematics, and the juniors were enrolled in Liberal Arts Mathematics 2. The Intensive Mathematics course is considered an elective and does not fulfill the four credit requirements in mathematics for graduation. The Liberal Arts Mathematics 2 course is, however, a regular mathematics course that students can use to meet the four credit requirements in mathematics for graduation. Both courses were designed to help students acquire the necessary knowledge to pass the Algebra I EOCE.

Participants were at least 1 year behind in mathematics since they had not been able to pass Algebra I EOCE, a ninth-grade test. That these students become proficient in solving basic algebraic problems was of utmost importance, not only to pass the Algebra I EOCE, but also to be able to face the mathematical challenges that are part of the high school curriculum. Those students who did not perform well in the Algebra I EOCE will continue to be placed in low level mathematics classes in their junior and senior years. Although students could fulfill the four credit mathematics requirement for graduation with some low-level courses, those who had not taken the higher-level courses could be denied admission to some colleges. In addition, for students to be successful in any high school mathematics course, they would need to be proficient in solving arithmetic problems as well as basic algebraic equations.

Instrument

The Algebra I EOCE was the instrument used to determine the outcome of the project. Students in the target population had taken and failed the Algebra I EOCE one or more times. In September 2016, students in the target population were given the Algebra I EOCE again. Prior to the administration of the test, those students in the target population who were participating in the study received small group instruction focused on operations with rational numbers. Students' previous scores were subtracted from the students' 2016 Fall Algebra I EOCE scores to determine learning gains. I compared the mean learning gains of the participants to the mean learning gains of the whole population using a *t* test.

Procedures

For several years, the school had been employing interventionists to help students study for the Algebra I EOCE, the Algebra II EOCE, and the PERT. An interventionist is usually a Florida state certified instructor hired by school representatives to help students study for a specific test. The researcher who conducted this study was a mathematics teacher at the target school. For the implementation of this project, the researcher took the role of interventionist. The researcher visited the targeted classes to acquaint the students with the project. The practitioner identified herself as one of the school's regular teachers and told the students that she was going to be the interventionist for the project. She explained why she was conducting the study and the potential benefits for the participants. Students were told that participation was voluntary and that there will be not consequences for not participating. Students were also told that the instructor was a native Spanish speaker with the ability to answer any pertinent questions about the project in either English or Spanish.

The researcher met with the students during the targeted classes for about 45 minutes two to three times a week. Students in 10th grade received small group instruction in a separate room. The juniors engaged in small group instruction in a separate area of their mathematics classroom. The teachers assigned to teach the targeted classes employed a variety of teaching strategies. These teachers were supportive of the researcher's project and had agreed to allow the researcher to work with small groups of participants during the selected periods. The classes met for 1 hour and 30 minutes every other day; thus, the researcher worked with small groups during a portion of the class period for several weeks.

Because the main purpose of the Intensive Mathematics class and the Liberal Arts Mathematics 2 class was to prepare students to pass the Algebra I EOCE, students who were part of the intervention were working toward the same objectives as the other students not participating in the project. The instructors of targeted classes made the proper accommodation to ensure that students who participated in the intervention received fair grades for their efforts. This type of arrangement was frequently provided at the target school since the use of interventionists conducting small group instruction with different mathematics students for several reasons was not unusual. For teachers at the school to make accommodations in student grades, for those who took part in a special instructional intervention, was common practice.

What distinguished the intervention for this research from other interventions was the focus of the study. The sessions consisted of solving context-appropriate problems involving rational expressions. Students were encouraged to make visual representations to solve problems. Manipulatives were also used when appropriate, and oral discussions were encouraged. The researcher used guided inquiry to check for understanding and to promote internalization of the concepts, as well as to develop higher level thinking.

In the county in which the target school was located, the school year started on August 22, 2016. The Algebra I EOCE was scheduled for the middle of September of the same year. Due to the short period available between the beginning of the school year and the administration of the Algebra I EOCE, implemented in the fall of 2016, the maximum number of intervention sessions able to be scheduled was six. Participants attended between three and six interventions. Beginning the first week of school, the interventions lasted for a little over 3 weeks. Although students were given the information about the research and the parent consent form the first day of class, not all students returned the forms in a timely manner. Some students started the intervention immediately; others began a week later. In addition, school sanctioned activities and participant absenteeism also prevented some students from attending all interventions.

Data analysis. After results of the 2016 Fall Algebra I EOCE became available, the learning gains of the population were calculated. Before performing any statistical test, the population and the sample had to be redefined. When the project began, the population consisted of 581 students enrolled in the 10th and 11th grades who needed to retake the Algebra I EOCE after failing the examination one or more times. By the time the 2016 Fall Algebra I EOCE was given, 23 students from the target population had withdrawn from the school, passed the test or its equivalent, or transferred to another school. In addition, 22 of the students in the target population who took the test received no score on the test. Students would not get a score on an EOCE if they either did not answer enough questions or if their test had been invalidated (FLDOE, 2015). Thus, the target population was reduced from 581 to 528. The sample population was the 20 students who volunteered and had signed parental consent to participate in the study. None of the students in the sample population left the school. They all took the test, but one of the students was given a no score on the test. Consequently, the sample was reduced from 20 to 19.

The null hypothesis to be tested was that the mean learning gains in the 2016 Fall Algebra I EOCE for the participants was the same as the mean learning gains for the population. The alternative hypothesis was that the mean learning gains in the 2016 Fall Algebra I EOCE for the participants was not the same as the mean learning gains for the population. The researcher chose to use a *t* test at a 95% significance level to determine if the null hypothesis should be rejected. According to Bluman (2014), a *t* test could be used to determine if the means of two distributions were similar (Bluman, 2014). Both the population parameter and the sample statistics were calculated using the data generated by the state of Florida and desegregated by the school testing chairperson.

Chapter 4: Results

Introduction

The purpose of this study was to determine the outcome of small group intervention focusing on operation with rational numbers on high school students' performance on the Algebra I EOCE. This study was conducted in a large inner-city school in south Florida. The graduation rate was a major concern in this community. When the study began, 581 sophomores and juniors had failed the Algebra I EOCE, an exit examination in the state of Florida. This group was the target population. Twenty students from the target population volunteered to participate in the study. Those who volunteered became the sample population.

The premise of the study was that by providing small group instruction focusing on operations with rational numbers, student performance in the Algebra I EOCE would improve. The focus of the small group instruction, which was promoting understanding of operations with rational numbers, was one of the key elements of the implementation. Students were encouraged to make visual illustrations and use manipulatives to solve real-life problems. To promote learning, the interventionist used various teaching strategies, such as guided inquiry, in the development of higher order thinking skills.

Students from three different classes were invited to participate in the project. Those who participated volunteered after receiving signed parental consent. This sample selection was a combination of convenience sampling and self-selected sampling. Twenty students participated in the project: 16 sophomores and four juniors. The small group instruction took place for a portion of the mathematics class. A total of six sessions that lasted for 45 minutes were provided for each group of students. Each participant attended at least three sessions before retaking the test. The students in the target population took the 2016 Fall Algebra I EOCE in mid-September, 2016.

Data used to determine the efficacy of the study were the most recent Algebra I EOCE scores available for each student in the population when the project began, as well as the scores of the 2016 Fall Algebra I EOCE. The difference between the two scores was used to calculate the learning gains of students in the target population. Students' learning gains in the 2016 Fall Algebra I EOCE were the measure used to determine the outcome of the study. Learning gains were calculated for a population of 528 with a sample size of 19.

Research Questions

What were the outcomes of a small group intervention focusing on operations with rational numbers on student performance on the Algebra I EOCE examination at the targeted high school? To indicate what type of outcome was going to be measured, the following sub question was formulated: Did the intervention have an impact in students' learning gains in the Algebra I EOCE? The sub question led to the formulation of the null hypothesis to be tested: The mean learning gains in the 2016 Fall Algebra I EOCE for participants was the same as the mean learning gains for the population. The alternative hypothesis was: The mean learning gains in the 2016 Fall Algebra I EOCE for the participants was not the same for the participants as the mean learning gains of the population.

A *t* test was used to determine whether to accept or reject the null hypothesis. The mean learning gains and the standard deviation the 2016 Fall Algebra I EOCE were calculated (see table I). The results were as follow: (M=2.36, SD=32.3) for the population and (M=−1.16, SD=19.63) for the participants. Using eighteen degrees of freedom and α=.95, the results were *t* (18) =2.10, the *p*=0.78. Since the *p* value calculated was within the limits of the interval, no evidence existed to reject the null hypothesis. The conclusion from the previous analysis suggested that with a 95% certainty that the null hypothesis should not be rejected. By accepting the null hypothesis, it was accepted that the mean learning gains in the 2016 Fall Algebra I EOCE for the participants was the same as the mean learning gains for the population.

Table 1

Change in End-of-Course Examination Scores

	Mean Learning Gains	Standard Deviation
Population	2.36	32.3
Participants	-1.16	19.63

Note. Data represent performance as reflected by the 2016 Algebra I EOCE implemented in the fall of 2016.

Conclusion

To determine if the small group interventions focusing on operations with rational numbers implemented for this research project had an impact on student performance on the 2016 Fall Algebra I EOCE, the learning gains and the standard deviations were calculated for both the population and the participants. The null hypothesis was that the mean learning gains in the 2016 Fall Algebra I EOCE for the participants was the same as the mean learning gains for the population. The alternative hypothesis was that the mean learning gains in the 2016 Fall Algebra I EOCE for the participants was not the same as the mean learning gains for the population. A *t* test was used to determine whether to reject the null hypothesis and accept the alternative hypothesis. Based on the results of the *t* test with a 95% certainty, the null hypothesis could not be rejected. Accepting the null hypothesis implied that the interventions had no effect in the participants learning gains in the 2016 Fall Algebra I EOCE.

Chapter 5: Discussion

Introduction

During their 4 years of high school, public school students are required to take many assessments to demonstrate achievement of standards set by the FLDOE. In addition to teacher-made assessments, students also take district-mandated assessments, midyear assessments, college placement tests, and EOCE for Algebra I, Biology, Geometry, Algebra II, Civics, and U.S. History. Students also take Florida Standards Assessments for English Language Arts that includes a writing component as well as many other additional tests. The most important of all these tests are the Florida exit examinations, the Algebra I EOCE, and the Florida Standards Assessments for English Language Arts. Passing is not required for the other state examinations.

This research study was designed to address one of the most important challenges facing students: achieving the Algebra I EOCE graduation requirement. The stakeholders at the research location had already tried many strategies to increase student achievement on the Algebra I EOCE for students who were taking the test for the first time and who were retaking the test. For the past few years, a sizable part of the budget had been invested in raising students' test scores on the Algebra I EOCE. Student resources included additional Algebra I EOCE review classes, tutors, small group instruction, tablets, and at-home computer practice sessions. In addition, every mathematics teacher had received intensive training in the latest pedagogical strategies to assist them in helping students achieve in this area. Moreover, a mathematics coach provided information on the latest teaching strategies.

Because so much had already been done to increase student achievement in the Algebra I EOCE, the challenge for the researcher of this study was to discover an area that had been overlooked. After extensive research of the literature, the researcher identified lack of student understanding of operations with rational numbers as a possible cause for poor performance on the Algebra I EOCE (Booth & Newton, 2012). The researcher also identified the use of small group instruction as an educational strategy with the potential to increase student understanding of operation with fractions (Fuchs et al., 2013).

Although teachers and interventionists at the school had already been using small group instruction, such instruction was not focused on just one specific topic. In addition, educators had not developed data to evaluate the practice of small group instruction. Thus, the practitioner had identified several elements that needed further investigation and documentation. After identifying the desired outcomes and selecting the area of investigation, the rationale for the study was chosen.

Analysis of the Study

The purpose of the study was to determine the outcome of small group intervention focusing on operations with rational numbers on high school students. Sophomores and juniors from three different classes were invited to participate in the study. Twenty students, with their parents' permission, volunteered to participate. Students from each class were offered six sessions of small group instruction. Participants' attendance ranged from three to six sessions. The 45-minute sessions were held during a portion of the mathematics class.

During the sessions, the students were given real-life related problems involving fractions to solve within their small groups. The researcher used guided inquiry to promote problem solving and critical thinking. Students were encouraged to draw pictures and to use manipulatives to help visualize the given situations. Collaboration within the groups was encouraged by the teacher. The FLDOE scheduled the Algebra I EOCE retake the test, implemented in the fall of 2016, for the second half of September. Moreover, the study started at the beginning of the school year and ended in the middle of September.

When the scores became available, the new scores were compared to the previous scores for all students in the target population to determine learning gains. The target population was defined to be all 10th and 11th grade students in the target school who had previously failed the Algebra I EOCE and who had a new score for the Algebra I EOCE that was implemented in the fall of 2016. The final count for the population was 528, and the final count for the sample was 19.

Review of the literature uncovered several small group intervention studies in which the number of sessions ranged from 21 to 50 (Buckingham, Beaman-Wheldall, & Wheldall, 2014; Doabler et al., 2016; Jitendra et al., 2013). The authors of a study examining the efficacy of small group interventions focus on reading for elementary students reported, that after 14 weeks of implementation, students have shown improvement in at least one of the five components being measured (Buckingham et al.). In the previous study, according to Buckingham et al. (2014), it took at least 14 implementation sessions before they could detect the benefits of their work (Buckingham et al.). Researchers of a replication study that promoted mathematics understanding among kindergarten students using small group interventions reported, that after fiftylessons, the students who received the intervention outperformed those who did not receive it (Doabler, et al., 2016). Another group of researchers, who implemented interventions that involved small group tutoring geared to promote the development of word problem solving skills, reported success after twenty-one interventions (Jitendra, et al., 2013). All the studies previously mentioned included a substantially larger number of interventions than this research project. Although establishing that a larger number of sessions may have produced different results, more sessions were not possible.

Analysis and Conclusions

There is no evidence that the small group intervention focusing on operation with rational numbers had any impact on students' performance in the 2016 Fall Algebra I EOCE. In the 2016 Fall Algebra I EOCE, no significant difference was found between the participants' and the target population's learning gains. Other results that also became evident when the 2016 Fall Algebra I EOC data was analyzed were the lack of success of all the other initiatives implemented by the school. Large amounts of resources had been designated by the school administration to help students pass the Algebra I EOCE, yet in the Algebra I EOCE implemented in the fall of 2016, only 8.5% of the population passed the test. Not only did over 90% of students in the population fail, but also over half the students in the population either had no gains or had regressed.

Menard and Wilson (2014) believed that students in low socioeconomic environments are more likely to lose academic knowledge during the summer vacation. A decline of students' academic performance after several weeks of summer vacation, often referred to as summer regression, is not unusual (Menard & Wilson, 2014). Zvoch and Stevens (2011) also wrote about the negative effects of summer vacation on student academic retention, especially for those students who are already academically behind. "On average, students lose approximately 1 month of grade-equivalent skills over the summer" (Zvoch & Stevens, 2011, p. 649). A study conducted by Menard and Wilson (2014), in which students were tested in September, determined that students substantially declined in academic performance.

Beside the possibility that students may have regressed academically due to the gap in instruction caused by the summer vacation, the possibility also existed that the stress of retaking the test so early in the year may have been one of the causes of such a poor student performance in the Algebra I EOCE which was implemented in the fall of 2016 for the study population. Minarechova (2012) contended that the stress caused by having to take a test could affect student ability to perform well academically and that stress could be even more significant for underprivileged children taking high-stakes tests. Segool, Carlson, Goforth, von der Embse, and Barterian (2013) also supported this idea claiming that "students perceive high-stakes testing situations as more stressful and anxiety-provoking than typical testing situations that occur as part of the curriculum" (p. 495).

Nichols, Glass, and Berliner (2012) also found "that test related pressure is significantly and positively correlated with state poverty level" (p. 24). Thus, given that most students in the target population were both economically disadvantaged and academically disadvantaged, as proven by failures in previous Algebra I end-of-course examinations, test performance might have been significantly affected by test anxiety. According to Segool et al. (2013), the effects of text anxiety could lead to the inability of a student to perform well on assessments even when the student is knowledgeable in the content being tested.

Implications of Findings

The most significant finding of this study was the fact that over half of the target population either made no gains or regressed on the Algebra I EOCE administered during the fall of 2016. The results of the study proved no more successful than that of the many other initiatives already in place at the targeted school. These data indicated that underlining issues affecting students' test performance had not yet been uncovered. Furthermore, the many resources that the schools' stakeholders had allocated to address this issue, just like this project, had failed to significantly increase student achievement in this area.

Limitations

Among the limitations of the study, four were of major concern. The first was the limited number of participants who volunteered to join the project. The second was the limited number of intervention sessions the researcher could provide for students prior to taking the Algebra I EOCE administered during the fall of 2016. The third was the participants' lack of English reading comprehension, and the fourth was the lack of motivation of those who participated in the study.

Although over 600 students were in the target population, only those students assigned to the three chosen classes could be part of the study. Of those in the targeted classes, less than 20% obtained parental approval and volunteered to participate in the study. This limited number of participants produced a sample too small to allowed the researcher to explore the possibility of conducting other statistical tests.

Another major limitation was the number of intervention sessions available to participants. Due to the scheduling at the beginning of the school year by the school board overseeing the target school and the scheduling of the Algebra I EOCE implemented in fall 2016 by FLDOE, the maximum number of interventions that could be offered was six. While a recommended number of tutoring sessions or interventions was not found in the researched literature, the number of sessions was substantially larger where interventions were used. For example, a study to determine the effect of small group tutoring of third-grade students who were below grade level in mathematics offered 21 tutoring sessions (Jitendra et al., 2013). A replication study investigating the efficacy of mathematics interventions with kindergarten students included 50 lessons (Doabler et al., 2016). Researchers conducting an evaluation study in reading involving small group interventions at the elementary level, reported that at least 14 weeks was needed to be able to detect significant levels of student progress (Buckingham et al., 2014).

The ability of the participant to comprehend word problems on the Algebra I EOCE could have been a major obstacle for some participants. Understanding the language and being able to clearly decode the questions was a necessary skill for success when solving word problems (Jitendra et al., 2013). The English language proficiency of some participants and the lack of reading comprehension skills of others could have affected their performance on the Algebra I EOCE.

Another factor that could have impacted the results was the lack of student motivation put forth to achieve maximum effort in passing the test. Students knew that if they did not pass the Algebra I EOCE implemented in the fall of 2016, they would still have many more opportunities to take the test in the future before the end of their senior year. Students in the study were already academically behind and were facing pressure to pass their present year academic challenges, which included several major examinations. Some participants may have been putting more effort into trying to pass some of the tests and classes, to be promoted to the next grade level, knowing that they would have more time to work on the Algebra I EOCE.

Recommendations for Future Research

For this study, due to the time restrictions, the number of intervention sessions offered to the participants was limited to six. A larger number would not have been possible since the 2016 Fall Algebra I EOCE administration took place just a few weeks after the beginning of school. Perhaps the outcomes of this project would have been more successful if the number of intervention sessions had been substantially larger.

Besides increasing the number of sessions, another change that could have been beneficial may have been to start the interventions in an earlier grade. Helping increase student understanding of operations with rational numbers prior to the beginning of an algebra course may avoid pupil misconnections about algebraic operations. Future research should lead towards uncovering how the lack of understanding about operations with rational numbers affects student ability to learn algebra. In addition, studies should also focus on what skills are vital to developing algebraic thinking prior to taking that first algebra course.

Summary

This investigation attempted to find a solution for an issue of major concern for the stakeholders at the school where the project was implemented. Students inability to pass the Algebra I EOCE, an exit exam required for graduation, is one of the main obstacles to increasing the graduation rate at the school. Many resources have been designated to find solutions to the problem, but all of them have been unsuccessful.

Examination of the literature revealed some strategies that have worked at other schools, such as training teachers, providing additional support classes in reading and mathematics, and providing small group instruction during and after school. All the previous strategies have been tried already with no success. In additional to those strategies, the school administration provided students with tables and computer programs aimed at helping students practice for the Algebra I EOCE. Again, student achievement in the test did not improve.

Additional analysis of the literature revealed a few more strategies that had not been tried, such as, promoting understanding of operations with rational numbers in order to develop algebraic thinking. Other strategies found in the literature, such as the use of manipulatives, visual, and guided inquiry, were also incorporated in this research. Based on the literature finding, an action research project was designed that included small group instruction combined with the other elements found in the literature that had not yet been tried at the target location. The plan was to offer small group instruction focusing on operations with rational numbers to 10th and 11th grade students who had failed the Algebra I EOCE at least once.

The plan was implemented. A small group of students volunteered to participate in the study. These students were provided with six sessions of small group instruction focusing on operations with rational numbers before retaking the test. As part of the instruction, they were given real-life related problems to solve. They were encouraged to use manipulatives and to make graphic representations of the problems. The researcher used guided inquiry to promote critical thinking. After receiving between three and six intervention the students in the study took the Algebra I EOCE again. The results of the 2016 Fall Algebra I EOCE appear in Table 2.

Table 2

Passing Rate of Participants

Population	*N*	Passed
Sample	19	0.052
Target	528	0.085

Note. Data represent performance as reflected by the Algebra I EOCE implemented in the fall of 2016.

The impact of small group intervention focusing on operations with ration numbers on students' performance in the Florida Algebra I End-of-Course Examination was not different from the impact of the other strategies implemented by the school. In the 2016 Fall Algebra I EOCE, only 8.5% of those 10th and 11th graders retaken the test passed. Based on this results, it is evident that there is still a need to find strategies that will impact student performance in the Algebra I EOCE. This investigation was not able to find a solution to the problem, but it has contributed to the existing research. The information presented here may be of value to other researchers trying to find the solution.

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