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The Effects of Inquiry-Based Mathematics Instruction For English Language Learners

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The Effects of Inquiry-Based Mathematics Instruction

For English Language Learners

By

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Abstract

This article reviews the effects of hands-on, inquiry based learning on the mathematics achievement of English language learners (ELLs). There were eighteen third grade participants of Mexican descent in this study. Their English language proficiency ability ranged from a level two to six. The study began with data collection from three weeks of regular instruction before doing three weeks of hands-on, inquiry based mathematics instruction. Both data periods began and ended with a pretest and posttest assessment to determine the achievement, measured by points of growth, during that specific type of instruction. The researcher found inquiry-based instruction did not improve mathematics achievement of ELLs; however, it would be of interest to study the impact of inquiry-based instruction in the regular education classroom over an extended period of time.

Keywords: inquiry, hands-on, mathematics, English language learners

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CHAPTER ONE

Introduction

The School District of Sun Valleyǿs mission is ñto educate and graduate students by providing equal access to quality education with high academic standards that develops socially responsible citizens with the skills, attitudes and behaviors necessary for lifelong learning, higher education and employment (School District of Sun Valley, 2012).ò In order to provide equal access to quality education, one must look at the services provided equitably. This researcher defines ñequityò as the right to receive information in a manner that makes sense to the learner and the right to be provided the proper tools to investigate and learn in a way that is meaningful to the specific learner. Therefore, in the context of the research classroom, the students participate in the workshop model of learning for reading, writing, and mathematics; in addition, students learn science through inquiry-based, hands-on materials through the use of the Full Option Science System (FOSS) science curriculum that the district adopted beginning with the 2012-2013 school year. According to Mido Chang (2008) forty percent of Hispanic English language learners (ELLs) need some amount of additional assistance to succeed in mathematics. Therefore, this researcherǿs goal is to find out if hands-on, inquiry-based instruction with specific content and language objectives improves ELLsô performance in mathematics.

The researcher was in her seventh year of being a bilingual educator; however this year was her first year at the suburban elementary school described below. The teachers in this district have been teaching using the readersô and writersô workshop model for approximately the past five years; math workshop was added to the teachersô repertoire of teaching methods this school year. Therefore, the model of teaching used for mathematics was new this school year, which allows the researcher more leniencies with her method of instruction. The 25 third graders in the class came to the researcher at various skills levels, ranging from students far below grade level to students slightly above grade level. Knowing this, the researcher knew change in instruction was necessary and chose to implement the use of hands-on, inquiry based instruction with both content and language objectives as the focus of this mathematics research.

Description of the School

Maple Creek Elementary School was situated on the south east side of this suburban community, and serviced approximately 460 students in kindergarten through fifth grade. The School District of Sun Valley was considered the most culturally diverse school district in Sun Valley County, with a 2012-2013 demographic of 29.9% students being minority students. In Sun Valley, 36.9% of students met the federal guidelines to receive either free or reduced lunch fees. Only 14.4% of the student population qualified for special education services *(WINSS, 2013)*. While there were at least 39 different languages spoken by the students in Sun Valley, there was currently only bilingual programming in Spanish at four of the elementary schoolsô Maple Creek Elementary School was one of those schools; Weeping Willow Elementary School, Towering Pines Elementary School, and Mighty Oak Elementary School were the other three bilingual schools in the School District of Sun Valley. Towering Pines began its two-way dual language programming for kindergarten this year, after the closing of Redwood Forest Elementary School. English as a second language (ESL) services were provided following state policies. Two-thirds of Maple Creek Elementary Schoolõs 18 classrooms were devoted to regular education for native speakers of English and students whose parents opt-out of bilingual programming; the other third of the classrooms were dual language one-way bilingual classrooms taught by teachers who were bilingual in Spanish. In this section the researcher presented information on the school, while the next section focuses on the staff information.

Staffing Information

The School District of Sun Valley employed approximately 850 teachers, 300 instructional aides, 70 support staff, 100 custodial or maintenance, and 60 district and school administrators, as seen in Figure 1.

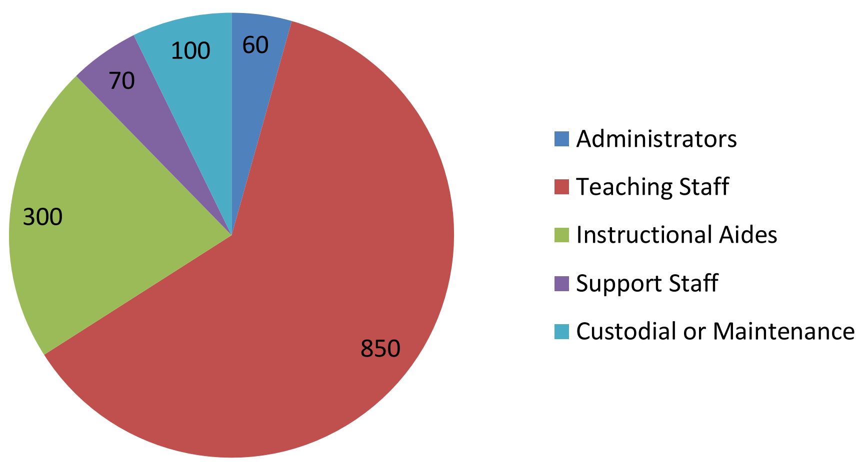

Figure 1. *The distribution of employee positions throughout the School District (Wisconsin's Information Network for Successful Schools (WINSS, 2012)*

Over 60% (256) of the Sun Valley teaching staff had a Masterôs Degree or beyond. The ratio of professional educators to administrators was approximately 14:1. Thus, each administrator was responsible for an equivalent of approximately 14 teachers, 5 instructional aides, 1 support staff member, and 1.5 custodial or maintenance staff. When comparing staff to student ratios, each administrator was responsible for approximately 321 students. The ratio of students to teachers was approximately 15:1; and the ratio of students to instructional aides, support staff, and other staff is approximately 33:1.

The past school year, at Maple Creek, 27 (98.2%) of teachers were fully-licensed; however, there was one part-time teacher (1.8%) who held an emergency license *(WINSS, 2012)*.

At Maple Creek there were approximately 460 students. Therefore, each of the 18 classroom teachers was responsible for approximately 25 students; this was a student to ratio of 25:1, which was much higher than the districtøs reported ratio. With the information about staffing in mind, the researcher shares information about the decision-making processes.

Decision-Making Processes

In the School District of Sun Valley, program directors and coordinators made decisions in a top-down fashion. The administrators at central office research programs and initiatives; then, if the district administrators find it worthwhile, they mandate its implementation in the schools. Generally, administration provides teachers with a template or guidelines for administration of these programs and initiatives, such as mandated minutes of instruction for the newly adopted curriculum. After implementation, administrators ask for feedback to edit the model to make it work for the district. The feedback teachers give to administration are reviewed by the program directors and coordinators, and changes are made to the programming model in order to accommodate studentsô needs. At the building level, Maple Creek developed four task forces to address the areas off need in the schoolô technology, parent and community involvement, *Positive Behavioral Interventions and Support (*PBIS), and student engagement. Staff members met bi-weekly for staff meetings as a whole staff and the other weeks teachers met in professional learning communities (PLCs) around either language arts or mathematics, depending on the subject they specialized in for the mainstream classroom teachers. The researcher presented information about the decision-making processes, now the next section focuses on the districtøs programming models.

Programming Model

In the School District of Sun Valley, there were four elementary schools that offered programming in Spanish. Weeping Willow and Towering Pines had a two-way dual language model where students from various backgrounds learn both English and Spanish beginning in Kindergarten; Weeping Willow offered the two-way dual language model through fourth grade and expanded to fifth grade the next school year. Mighty Oak and Maple Creek followed the one-way dual language model with students who speak Spanish as their first language, which was commonly referred to as the maintenance bilingual model. Both dual language programs followed the same guidelines in terms of language distribution. In kindergarten and first grade, students received 90% of their instruction in Spanish from the bilingual teacher and 10% of their instruction in English from the English as a Second Language (ESL) teacher. In second and third grade, students received 70% of their instruction in Spanish and 30% of their instruction in English. At this level, the bilingual classroom teacher instructed students in science and social studies in English for 45 minutes daily; these subjects were not taught sequentially. In addition, students received an additional 180 minutes per week of English literacy instruction with the ESL teacher and bilingual teacher used a model of co-teaching. At the fourth and fifth grade levels, the bilingual teacher was responsible for students receiving 50% of their instruction in English and 50% of their instruction in Spanish. Each school also had an English-only program option, ranging from one to three classrooms per grade level. While the school wide programming model was important to the education of the researcherǿs students, the English as a Second Language (ESL) policies and procedures directly affected the studentsô English assessment and instruction.

Policies and Procedures for English as a Second Language (ESL)

The School District of Sun Valley identified English language learners (ELLs) through a home language survey given to parents at registration. If a language other than English was spoken at home, then students would be given the Assessing Comprehension and Communication in English State-to-State (ACCESS) test to assess their English language proficiency level. Language proficiency levels began at a level one and continued through to a level six (WIDA Consortium, 2007). Appropriate accommodations were made for ELLs at all levels, however the level of rigor in regard to testing changed based on the studentsô English proficiency levels. A student classified with an English proficiency level of one or two who had been studying in the United States was exempt from the state achievement test. However, levels three through six, and all students who had been studying in the United States for three or more years, were required to take all assessments. Only students at a level six no longer needed accommodations. Results for these assessments and the subsequent programming options were provided to parents in English and their home language when possible.

All students in the School District of Sun Valley had a right to equal instructional opportunities, including supportive services to achieve a level of instruction that allows them to become proficient or advanced learners in all content areas. One such supportive service was that of English as a Second Language (ESL). Students in levels one through five received ESL services; students with an English language proficiency composite score of six were exited from the program. An exception was made when a student with a level five language proficiency score demonstrated near proficient abilities in all content areas, understood and spoke English well in both academic and conversational contexts, and only had required occasional support from the ESL teacher. In addition to these criteria, to be exited from the ESL program at a level five, both the parents and the teacher must agree to the studentøs dismissal from the ESL program and there needed to be two additional pieces of evidence which supported the studentøs dismissal from ESL that were kept in the studentøs file. Any students exited from ESL program were monitored for the following two years to ensure their continued academic success. The consideration of the policies and procedures for the ESL program was especially important when considering the student population for this researcherøs research.

Student Population

The researcher worked with students of Hispanic ethnicity. This was a third grade classroom of English language learners (ELLs). There were 25 students and 100% of the population for the research came from Spanish speaking, Hispanic families who had backgrounds from either Puerto Rico or Mexico. However, only 18 of the students received permission from their parents to participate in the research; there were 8 females and 10 males, all of whom were of Mexican descent. There were no students who received special education services. Many students began school here in first grade, a few started in second grade, and approximately one third of the class came from Redwood Forest when it closed. This section described the population for the research; the next section will address their language and academic data more in depth.

Student Language and Academic Data

The abilities of students varied greatly according to the ACCESS test and the Measures of Academic Progress (MAP) test created by the Northwest Evaluation Association (2012). The ACCESS test was used to measure studentsô yearly gains in English language proficiency. This test measured student gains in listening, speaking, reading and writing; the ACCESS test also provided a composite score (WIDA Consortium, 2007). In Sun Valley, this test was given in two group sessions; one session was for the combined assessment of listening and reading and the other group session was for the writing portion of the assessment. Speaking was assessed individually at a separate time that usually follows the group testing sessions. The studentsô composite proficiency levels ranged from level 1 to a level 4 on the ACCESS test (Table 1).

Table 1

ACCESS test scores from the fall of 2012

	Level 1 Entering	Level 2 Beginning	Level 3 Developing	Level 4 Expanding	Level 5 Bridging	Level 6 Fully English Proficient
Number of Students	0	1	6	8	2	1

The MAP test was an adaptive test for measuring student growth and achievement based on performance, rather than measuring grade level. This test helped teachers pinpoint areas where students needed assistance or where they needed to be challenged (Northwest Evaluation Association, 2012). On the MAP test, students in the sample for this research had reading Rasch Unit (RIT) scores range from 161 to 209; and, in mathematics, the studentsôRIT scores ranged from 180 to 210 (Table 2).

Table 2

MAP test scores in math and reading from May 2013

	RIT range				
	161-170	171-180	181-190	191-200	201-210
Reading	3	4	7	3	1
Mathematics	0	1	7	7	3

This information provided baseline data for this research project, which was supported by the best practice research found in the next section.

Summary of Best Practice Research

Hands-on activities help students to make concepts concrete. One way to make concepts concrete is to demonstrate a strategy for students using realia (Furner, Yahya, & Duffy, 2005). Realia are real objects from our daily lives that can be used within a specific context to teach a concept. Another way for students to conceptualize mathematics is through the use of manipulatives, which can be purchased commercially or handmade by the students or the teacher (Anhalt, Farias, Farias, Olivas & Ulliman, 2009; Furner, et. al, 2005). Another activity that helps make mathematics tangible for students is the use of Total Physical Response (TPR). This is a strategy generally used with ESL students, but can be used in mathematics to make terms and concepts more distinct in their mind (Furner, et. al, 2005). When using TPR, the teachers model and explain a concept, while making motions; then, the students make these motions as well in order to associate the movements with the concept they just learned. While hands-on activities are one best practice for working with students learning mathematics, inquiry-based instruction is equally important in mathematics instruction.

Inquiry-based instruction is the use of studentsô questions, or inquiries, as their road map to learning; in the context of inquiry-based learning, the teacher acts as a guide leading students to find the answers to their own problems within a specific framework. Marshall, Horton, Igo, and Switzer (2007) found that in elementary schools science teachers used inquiry-based instruction more than mathematics teachers. They also discovered that women were more likely than men to use inquiry-based instruction when they have the appropriate materials to do so. In order to use inquiry-based instruction in the classroom, teachers must create an atmosphere conducive to creativity and one that avoids asking students to find one ñrightò answer. While inquiry-based instruction had the question form the foundation of learning, content and language objectives through the Sheltered Instruction Observation Protocol (SIOP) model (Echevarria, Vogt, & Short, 2008) were also deemed a necessary part of the researcherǂs lesson planning for this research.

The SIOP model was developed by Echevarria, Vogt, and Short (2008) in order to make sure English language learners (ELLs) were receiving the appropriate instruction to succeed. Two of the aspects of the SIOP lesson included the language objectives and the content objectives. The content objectives were those objectives directly related to district or state standards. The language objectives were those objectives that defined the activity or task the student would complete. These language objectives needed to be differentiated by students based on their language proficiency level provided by the ACCESS test. While keeping the content and language objectives, inquiry-based instruction, and hands-on learning in mind, the project overview below describes the researcherǂs intended course of action in regard to the implementation of these best practices.

Project Overview

Through action research the researcher sought to answer the following question: Will hands- on, inquiry based instruction with specific content and language objectives improve ELLs' performance in mathematics? The researcherǂs hypothesis was that studentsô achievement in mathematics would increase through the use of hands-on, inquiry-based instruction following the SIOP use of content objectives as a guide to instruction. In order to test this hypothesis, the researcher intended to provide small group instruction to the students at the appropriate language proficiency level. Students were grouped according to academic ability with common content objectives.

Instruction was conducted in three week cycles consisting of approximately two fifteen day periods based on the content objective being taught. Research consisted of two cycles, for a total of six weeks of research. During this time, the researcher provided instruction in two areas of mathematics. The areas of mathematics covered examined all four of the Common Core State Standards for fractions in third grade. This researcher continued with regular instruction which followed the math workshop format. Students first received instruction during a whole group mini-lesson, then proceeded to application time, and concluded with a whole group share time. The data recorded came from students pre-assessment and post-assessment scores; the teacher assessed the students at the beginning and end of each fifteen day period. Students were regrouped approximately eight days into each fifteen day period based on a midway, formative assessment to make sure that students are always with the appropriate academic level group.

During the first fifteen days students received their regular instruction with no language objective or hands-on, inquiry-based instruction. The first fifteen days focused on the understanding of fractions being part of a whole and the ability to represent this on a fraction line. For the following fifteen days, students were taught using a language objective appropriate to their proficiency level along with the use of hands-on, inquiry-based instruction. The second fifteen days focused on equivalent fractions and was taught using recipes and measuring cups to create simple recipes.

Conclusion

In conclusion, research in the area of hands-on, inquiry-based instruction in mathematics using content and language objectives is necessary for the success of English language learners

(ELLs) in the bilingual classroom. As the third grade teacher bridging the students from mathematics in Spanish in second grade to mathematics in English in fourth grade, it was essential for the researcher to find a method of instruction that made mathematics both comprehensible and engaging for students. Throughout this chapter the researcher provided a description of the school, staff, and the decision-making processes, discussed the programming model, policies and procedures in place for working with ELLs in the School District, introduced the student population with their corresponding academic data, and concluded with a summary of the best practices and a project overview. The researcher hypothesized that with engaged students receiving input that was comprehensible to them, their mathematics skill level would increase. Therefore it was the intent of the researcher to use hands-on, inquiry-based instruction in mathematics with appropriately identified content goals to meet the districtôs mission by providing the ELLs in this classroom with equitable instruction to help them succeed. Chapter two will address previous research done with professional development that encouraged best practices in instruction, working with English language learners, mathematics programming, and inquiry-based learning,

CHAPTER TWO

Introduction

Programming and instructional decisions in the classroom affect the learning of English language learners (ELLs). When deciding on which reform-oriented practices to implement, teachers must be involved in the selection decision-making process and they need training in the effective instructional strategies that work with ELLs as well. A major component of the professional development provided to teachers is learning how to create and implement authentic assessments and instruction, along with learning strategies to support problem-solving abilities. One strategy that works is inquiry-based instruction; however, teachers need ample time for collaboration to discuss and remedy any digressions from the model. One of the best ways to reach out to ELLs is in small groups or with teacher-direct independent activities. These activities provide one scaffold to ensure that ELLs are not falling behind their English-speaking peers. This chapter will review research related to the effects of inquiry-based instruction and professional development related to the teaching of ELLs. The first section will address professional development and programming decisions, the second section will examine studies that focus on instruction to ELLs, the third section will focus on mathematics instructional practices, and the final section reviews research about inquiry-based methods of instruction

Programming Decisions and Professional Development

Staff and administration must support teachers with extensive professional development and collaboration opportunities in order for new initiatives to be successful. The following articles review teachers perceptions compared with their actual practices, problem-solving through authentic instruction and assessment, and conclude with a model for classroom-based professional development.

In the article *Urban third grade teachers' practices and perceptions in science instruction with English language learners*, Scott Lewis, Jaime Maerten-Rivera, Karen Adamson, and Okhee Lee (2011) studied the impact of instructional practices with English Language Learners (ELLs) in relation to the four key domains of science instruction. ñThe four key domains that were under scrutiny include: knowledge of science content, practices that support scientific understanding, practices to support scientific inquiry, and teaching practices to support English language development (ELD) during science instruction.ò (Lewis, et al. 2011). The researchers collected the data through surveys of teachersô self-perceived practices in science instruction, as well as classroom observations done by two members of the research team that were specifically trained for this purpose. Lewis, et al report their findings after the first year of professional development interventions.

This study included 38 teacher participants who completed the full course of the intervention. Only six of those teachers spoke a language other than English as their native language, 33 of the teachers had training in English for Speakers of Other Languages, and only five were Caucasian The teachers were selected from an urban school district with a large English language learner population, high population of students receiving free or reduced lunch, and a grade of C or D according to the stateôs accountability plan.

For this study, teachers were provided with science curriculum units and student books that provided the teachers with many possible student support and suggestions for hands-on activities that incorporate the various functions of language. The expected instruction provided for the gradual release of responsibility from the teacher to the students as well as an increased expectation in regard to the use of English from third to fifth grade During the first year, teachers attended a workshop that explaining the units and other resources, explained how to incorporate English development into their instruction, and clarified the expectations for implementation. Teachers completed a questionnaire in both the fall and spring of that school year and were observed during both of these time frames as well.

The results of this analysis were based on 76 classroom observations and 38 questionnaire responses. Teachers often inaccurately perceived their own practices when the researchers compared their self-perception surveys to their classroom observation of observed practices. This discrepancy could be attributed to several factors that include one observation compared to the questionnaire asking about a month of instruction, teachers own expectations compared to standards-based expectations, or an overly stringent observation protocol used by the observers. This study by Lewis, et al was correlational and therefore the results cannot be used to determine any causal relationships. Teachersô mismatch between practices and perceptions lead to the discussion of possible professional development to address these issues in the forthcoming article.

As written in *The impact of sustained, standards-based professional learning on second and third grade teachers' content and pedagogical knowledge in integrated mathematics*, Lora Bailey studied the effects of teachersô professional development in mathematics content and strategy knowledge on their studentsô learning. Data was collected throughout a 3-year longitudinal (quasi-experimental) study through the use of surveys completed by the teachers about their perceived performance in the classroom; these surveys were completed at each stage throughout the professional development.

This study included thirteen teachers and approximately 260 students who were impacted by their teaching. The teachers who participated in this professional learning opportunity came from a population of thirty educators from nine different schools. The nine schools were chosen based on the United States Department of Agriculture (USDA) poverty guidelines of at least 80% and at least 35% of the student population needed to be achieving below basic proficiency on state assessments. Once the teachers qualified for the study based on their schools qualifications, the participants were randomly selected from the population. The thirteen who were reported on were those whom completed the full three-year commitment to the professional development workshop program

For this research, Bailey began by finding schools that met the criteria, locating the studentsô test scores, and collaborating with the school district staff. Then, teachers needed to agree to participate for a five-year period to include a summer learning institute, focus sessions, submitting samples of the homework and assessments given to students, and prove their use of standards-based strategies into the curriculum. The workshops included those related to the improvement of teachersô content knowledge, cognition of the National Council of Teachers of Mathematics (NCTM) standards and principles, development of authentic assessments, and standard-specific acquisition of strategies. Several of the topics included: number operations, probability and data analysis, measurement, and geometry. These sessions focused on teachers finding meaningful ways to implement this knowledge of the standards to create authentic assignments and assessments for students. Bailey looked at teachersô perceived ability to prepare and use standards-based curriculum, including assessments, homework, and instruction and their ability to select and use appropriate materials; the researcher compared the pre- and post-test results.

Authentic assessment and instruction based on the standards was necessary in order to see an impact on studentsô learning. The researcher of this research found teachers must receive professional development that supports studentsô problem solving abilities, acquire training to create authentic learning opportunities, and keep current in best practices in mathematics. Although teachersô perceived ability to prepare and use standards-based curriculum, including assessments, homework, and instruction improved significantly based on a comparison of pre- and post-test results, teachers reported no significant change in their ability to select and use appropriate resources for instruction after receiving the professional development provided during the longitudinal study Bailey also found that the observations, live or video, and discussion surrounding the best practices of other teachers were also effective tools to increase content and pedagogy. While the use of authentic instruction and assessments is important, teachers must remember that their discourse about students, the classroom environment, and their opinions about the students also affect student performance in the classroom.

In the paper titled *Professional development as discourse change: teaching mathematics to English Learners*, Miwa Takeuchi and Indigo Esmonde reminded us that in our globalized society, English was often a studentôs second language, which left English language learners (ELLs) limited opportunities to interact in content in English. This affected teachers due to the lack of professional development available for working with ELLs. Takeuchi and Esmonde felt that learning should be in social and historical contexts due to the fact that knowledge comes from outward in and that teachersô discourse and classroom, social organization have a reciprocal relationship. Traditionally, there have been three views on how to address math for ELLs: 1) a focus on math vocabulary, 2) the development of multiple, specialized meanings for words, or 3) use their first language as a resource, rather than a deficit. For this study, Takeuchi and Esmonde provided teachers with a method of classroom embedded professional development to facilitate reflection on student work and problem solving and then answer the question of how teacher discourse on teaching ELLs changed over the course of professional development.

The sample came from the staff at an urban multilingual public elementary school in Canada; there were over 30 languages represented by the 450 students in the school. Over half of the students spoke a language other than English at home and approximately one-fourth of the students were not born in Canada. Elementary teachers instructed in English only until the upper grades when students began learning French. From the staff, six teachers, four interns, one administrator, one librarian, one community member, and the math coach from the school board participated in the project. The project itself was implemented by one of the researchers in collaboration with anther math coach

Takeuchi and Esmonde called their study the Radical Math Project. The teachers connected discourse to the social organization of the classroom by creating inquiry-based projects. First teachers developed inquiry questions about equitable teaching, then designed a research plan, and finally implemented the plan before a final reflection and presentation. The teachers participated in monthly professional development sessions from October 2008 to May 2009; halfway through teachers divided into subgroups focusing on a jointly created inquiry question. Outside of these monthly meetings, subgroups met regularly to plan and implement research. At each monthly session, the researchers collected agendas, teachersô work, and student artifacts to compare with field notes and meeting notes that showed discussion on what had been said and progress made which were public to all participants. At the final session, each teacherös final presentation was recorded and transcribed.

The information provided was a case study chosen because of the classroom teacher pairing with an English as a second language (ESL) teacher who chose to focus on how to address linguistic diversity in their math lessons because they wanted to improve their teaching for all students by better reaching their ELLs. During the first meeting, the researchers provided information on mathematics instruction for ELLs and on the diversity of Canada, which led to the focus on diversity in Canada as the topic of inquiry. When Takeuchi and Esmonde did their two classroom observations, they worked with students, collected some of their work as samples, and wrote field notes focused on what students were doing and saying. The data recorded focused on teachersô talk about ELLs or immigrants and how it changed before, during, and after implementation of the in-class professional development and research. To make the analysis of data streamlined, the researchers created a code to identify prevalent themes in their findings.

Takeuchi and Esmonde found students were engaged in and willing to do tasks related to their languages and that then the students made personal connections with numeric representations. During this period, one student noticed the numbers she knew were not accurate compared with those provided by the official data. This showed the researchers that ELLs have a heightened knowledge of speakers of other languages, in comparison to English only peers. The ESL teacher pointed out that school data and actual information varied because some parents hid their home language so not to be punished by the school for not using English at home. At the beginning all of the teachersô talk focused on ELL barriers and how to simplify the language for them. During the implementation of the classroom-based professional development, vocabulary and word density were still significantly important but gradually faded to highlight other aspects of math instruction. By the final meeting, teachersô discussion had no focus on barriers, but rather what they had learned about the linguistic diversity of the community.

These three articles explained practices that were achieved through extensive professional development for teachers. Teachers need to be trained in the content areas they are expected to teach. These ideas are relevant to the researcherôs research in that teachers need professional development for working with ELLs, especially when implementing new programming. While these researchers presented information that supports teachers implementing new initiatives, the programming decisions and subsequent support by administration, the next articles show how these aspects influence the quality of the instructional decisions made about working with English language learners within the classroom.

Instructional Decisions in the ELL Classroom

Teachers manage what to do in the classroom; however, their beliefs and their practices sometimes differ. This section will focus on these discrepancies and how important it is to match beliefs and practices, especially when working with language minority students.

In the article *Investigating proficiency in the language of instruction as a means of improving mathematical proficiency in a multilingual classroom*, Anthony Essien (2010) found that low English language proficiency (ELP) led to poor mathematics performance. The researcher defined mathematic proficiency as the interaction with and between the five strands of procedural fluency, strategic competence, conceptual understanding, adaptive reasoning, and productive disposition. Essien defined English language proficiency as an individualôs knowledge of the English language and the userôs subsequent ability to control its usage. For the purpose of this article, math is only the numbers and symbols; concurrently, the language of mathematics is used to interpret the symbols, express ideas, and to record, and justify math knowledge. In order to accomplish this, Essien found that the students needed to develop an appropriate socio-cultural meaning within the math community of the classroom. The study focused on the language of instruction and its impact on mathematical proficiency.

The sample came from 1900 students from a black township school, in an impoverished town on the East Rand in South Africa. In this town, the first languages of the students included Zulu, both Northern and Southern Sotho, Tswana, and Tsonga. From these 1900 students, the researcher chose to work with two math classes taught by the same teacher, giving him data for 93 ninth graders. There were 45 students in the experimental group, almost all of whom spoke either Northern Sotho or Southern Sotho. All students were assumed proficient in their first language for the purposes of this study.

Essien conducted a quasi-experimental, nonequivalent comparison group design, where the learners were randomly assigned based on the class they were placed in for ninth grade math. Data was collected over a four week period beginning with a pretest prior to the implementation and a posttest, from the ASTRALAB software (Steck-Vaughn/EDL,1998), following the four week period of implementation.

The implementation period that came after the pretest consisted of the experimental group receiving instruction using the ASTRALAB software. The ASTRALAB English literacy software was to help build vocabulary, spelling, reading fluency, and comprehension ASTRALAB was designed by lesson and was originally intended to be used independently, but the school chose to adapt the software for whole group lessons on a projector. Students received a total of 22.5 hours of instruction from over 30 sessions of ASTALAB. Each session began with whole group instruction using the lessons, an individual session to complete the comprehension exercises, and then followed by whole group vocabulary review and word games intended to improve ELP. The posttest session of the experimental group was videotaped, in order to compare it to the class observations during the implementation to the results. The posttest was a 35 question instrument with questions selected and modified to meet standards from Third International Mathematics and Science Study.

Essien found that once a student has reached linguistic competence in English, positive cognitive results occurred. He noted that the greater the studentøs bilingual proficiency, the greater the academic gains made by the students; however, this was only possible if their first language was adequately developed. Essien found in his study that students who were proficiently bilingual outperformed their native peers who only spoke English, and/or those who had not yet become proficiently bilingual.

Essien used class observations as a qualitative measure as well as pretest and posttest data as the quantitative measure of the study. At the beginning of the study, the pretest data showed there was an even distribution of learners by ability, with no significant difference in scores between the two classes. The control group showed no significant difference in their scores between the pretest and the posttest; however, the experimental group showed a significant improvement of 28.2% over their pretest scores. The results showed no significant improvement in any specific domains of math and found no difference in interactive patterns of classroom speech after the implementation of the ASTRALAB lessons. Also, the data showed an improved ELP level led to improved math performance, but it did not change the quality of class communication. While the studentsô proficient bilingualism can lead to academic gains, teachers must be aware of the methods that best affect the learning of ELLs.

Teacher instructional practices and language minority students by Mido Chang (2008) reviewed the impact of teachersô instructional practices with English Language Learners (ELLs) on their early achievement in mathematics. The researcher collected the data using the Early Childhood Longitudinal Study Kindergarten Cohort database (ECLS-K; National Center for Education Statistics [NCES], 2006). Chang looked to compare the mathematical performance of language minority students compared to English speaking students, their performance by social class and ethnic group, and then reviewed the frequency of teacher grouping strategies that proved to be culturally relevant.

This study included 47,101 observations of 11,776 kindergarteners through fifth graders separated into four ethnic groups (Caucasian, African American, Hispanic, and Asian), through the use of a multistage probability sample design. The study was meant to examine the average growth trajectory of students of different ethnic backgrounds. The ELLs used in the study were those who spoke a language other than English at home and were having difficulty acquiring English.

For this sample, the studentsô socioeconomic status was controlled. The variable was the frequency of teaching methods received by each group of students: whole group instruction, small group guided instruction, and either teacher or student selected independent activity. Data was collected at four distinct times during the research process: baseline data and data from three follow-up sessions. Chang gathered this data from the Early Childhood Longitudinal Study (ECLS-K, 2006) data. First, Chang examined growth patterns and the gap in achievement using a baseline model. This was the first step in the study and included a time variable to control for variance in achievement and language status. Then, the researcher studied the gap in performance between English-speaking students and ELLS with regard for socioeconomic status

(SES). Next, Chang focused on the effects of socioeconomic status on studentsô achievement. The socioeconomic status of families changed, so the researcher had a time-varying covariate to represent the SES of the families in the study. Finally, the researcher looked at the grouping practices of teachers to determine how each of these instructional methods affects student learning in each of the ethnic backgrounds.

Both dual-language students and English language learners scored lower than their English-only counterparts. The high socioeconomic status of English-only students yielded high scores; although this status was not indicative of achievement in the other ethnic groups. During whole group instruction, Caucasian and African-American English-only students excelled, but Hispanic studentsô achievement decreased. During the use of small group instructions, scores rose slightly for Hispanic and African-American students, however only the Caucasian studentsô growth was significant; Asian ELLs did not benefit from this type of instruction. Hispanic studentsô scores rose through the use of teacher-directed independent activities; African-American studentsô academic achievement diminished when they participated in self-selected independent activities. Asian students who began their schooling with language barriers were unable to achieve the level of attainment of their English-speaking Asian counterparts. Although there was not a significant difference between ethnic groups, poverty appeared to directly and indirectly affect studentsô academic achievement, especially during their early schooling. Small group instruction is one way to reach ELLs; accordingly this may lead to improved math achievement and improved behaviors and practices.

As written in *Approaches to learning and Hispanic children's math scores: The moderating role of English proficiency*, Erin Bumgarner, Anne Martin, and Jeanne Brooks-Gunn (2013) based their study on the fact that Hispanic immigrant students lag behind their native-

Hispanic peers in academic outcomes. The researchers grounded their research on the approaches to learning which include the behaviors and characteristics of self-control, persistence, attentiveness, independence, and responsibility. A lack of English language proficiency has been known to cause a barrier to typical classroom materials and language is a means to experience activities, build relationships, and to integrate and engage in the math community. This language problem only exacerbates as studentsô progress through their academic years because of the lack of English that their parentsô speak. Therefore, the researchers chose to study whether or not approaches to learning had a positive association with studentsô math achievement of first and second generation Hispanic students and what effect their English language proficiency may have on this association.

The sample came from 21,409 students entering kindergarten in the fall of 2008; the students came from 1,280 schools across the country. There were 3,826 Hispanic students, but only 1,374 of these students were first or second generation Hispanic students. The researchers then excluded another 72 students with individual education plans (IEPs) and nine students who did not receive cognitive assessments for some other reason. This exclusion left 1,293 students, then 305 were missing data for one or more of the points so they were excluded leaving a total of 988 students in the study. For the purposes of this study, first generation refers to the students who were born in a foreign country to foreign-born parents and second generation refers to students who were born in the United States to foreign-born parents

For this model, Bumgarner, Martin, and Brooks-Gunn looked at the approaches to learning, English language proficiency and math achievement data from those 988 students at various points between the beginning of kindergarten and the end of third grade: fall 1998, spring 1999, fall 1999, spring 2000, and spring 2002. The study was a multistage probability sample design with each county or vicinity counted as a primary sampling unit; schools or programs were secondary units and individuals were the third and final stage units.

The math test covered measurement, geometry and spatial sense, number properties and operations, data analysis, statistics and probability and patterns, algebra, and functions. Students who were not proficient in English were allowed to take the math test in Spanish. The researchers used the Oral Language Development Scale (Duncan & DeAvila, 2007) to assess ELP in kindergarten to measure speaking and listening; those students who scored a 37 or greater were. Students who were not considered proficient were only tested until end of first grade, because most students were considered proficient by then. Students who were not screened were also considered proficient. Teachers reported approaches to learning scores in kindergarten and first grade using a Likert-type scale of 1-4 with same questions in both grades; in third grade, the researchers added additional item about following classroom rules.

Scores on all three data sets were mean-centered to facilitate their interpretation in relation to one another. Control variables included sex, age, health, whether they were the product of a premature birth, the mothersô age at birth, whether mother worked, if the parents were married, the number of siblings when they entered kindergarten, the parentsô socio-economic status (SES), geographic characteristics of their vicinity, and whether they attended preschool. Teachers provided the approaches to learning data based on negative behaviors, using a Likert type scale. All data were controlled for previous achievement score. Each piece of data carried a single weight so the analyses could be used and compared every assessment period.

Bumgarner, Martin, and Brooks-Gunn found that over half of the students were from homes that were of low SES and only two-thirds of the students had parents who were married.

Approximately 40% of the students attended preschool and one-half of the students were from the western United States. Forty-five percent of the students were ELP entering kindergarten, but by the end of first grade eighty-four percent of the students had achieved ELP. The researchers found the relationship between math achievement and approaches to learning was two times stronger in 2002 than it was in spring 2000. Their results showed that a studentôs previous approaches to learning more predictive of math achievement over time; however, these approaches to learning scores and relationships had no bearing for students who were not ELP. In general with the student population used for this study, ELP had little effect on the relationship between approaches to learning and math achievement, but students who were at a higher ELP generally had significantly higher math scores.

These three articles focused on the instructional options and designs that offer the best support for English language learners (ELLs) while learning content and language simultaneously. These studies took us all around the world to find the best practices with ELLs. Beginning with a study of whether or not English proficient affected mathematics achievement, then the use of small groups as a more effective means of working with ELLs than whole group or independent work, and concluding with the relationship between language, achievement and behaviors. These studies drove the hypothesis for this researcher; therefore the next section will address instructional options specific to mathematics instruction.

Instructional Programming in the Mathematics Classroom

Most teachers recognize how to approach mathematics instruction with English language learners (ELLs); yet sometimes they lack the appropriate materials or practices to implement these practices. This section will focus on how important it is to take advantage of studentsô math skills and interest in the early years before presenting technology based programs for instruction and intervention in future years.

Early math interest and the development of math skills, written by Paige Fisher, Greta Doctoroff, Jennifer Dobbs-Oates, and David Arnold (2012) considered the acquisition process of mathematics specifically in regard to the reciprocal relationship between interest and achievement. The study was conducted in order to prove mathematic interest positively affects mathematic skills, especially amongst students of low socio-economic status (SES). The researchers of the research also predicted that the inverse would be true. Finally the study expected mathematic skills and ability would positively affect studentsô interest in mathematics.

This investigation included 118 students, of which slightly over half were female students. The students were of various ethnic backgrounds and between the ages of three and six years old. The largest percentage of students came from African American or Puerto Rican families; approximately 80% of the students in this sample spoke English as their first language, which eliminated language interference as a possible limitation to this study. These students were of low socio-economic status (SES) status; their families qualified for Head Start, which means their household income falls below the federal guidelines for poverty. The students were enrolled in either the full-day or half-day Head Start program. Students from both half-day and full-day programs were selected in this sample.

The researchers assessed the students with pre- and post-assessments. The assessments were given at the beginning and end of the school year. For this sample, students were assessed with a pre and post assessment near the beginning of the school year, and again near the end of the school year, respectively. The researchers were studying the effect of academic interest in learning and determining whether there was a reciprocal relationship between interest, skills and achievement. The researchers predicted that early math ability would affect later math interest and that early interest would affect subsequent math achievement. The approximate time between the pretest and posttest sessions in any of the classrooms was five months. In order to properly triangulate data, students were assessed using various measures, which includes: the Test of Early Mathematical Abilities (2nd ed.: TEMA-2) which focused primarily on studentsô numeracy skills, the Early Screening Inventoryï Revised (ESI-R) to assess studentsô oral expression abilities, videotapes of studentsô play with a math activity to determine the level of student enjoyment, calculations of the amount of on-task playtime with the stimulus cards, observations that were coded for the perceived enjoyment of students, goal-directed play, and the teacherõs report about their observations with regard to the studentsô interest in math activities. The researchers used a large variety of assessment measures ensure that all aspects of the learning environment were included in the study. The results were all converted to numerical representations for which the researchers subsequently obtained means, standard deviations, and intercorrelations for the various measures.

Interest and achievement had a reciprocal relationship, as the researchers predicted. Low socio-economic status also affected the scores as was noted in the scores on the TEMA-2. TEMA-2 and ESI-R scores coincided with one another; and, assessments showed that students in all age groups played for an average of 2.5 minutes. The researchers found that age does affect the studentsô interest level; however, there was no significant correlation between difference in interest and ability within a specific age range. Initial enjoyment, goal-oriented play, and interest positively affected studentsô later ability in mathematics. The results of this study also indicate no difference in interest between the genders. Not surprisingly, the researchers also found that the higher a studentô s ability, the more interested they were in completing the math tasks. This study showed many significant differences in math interest related to gender occurred after the preschool years. Although studentsô ability may affect studentsô interest in mathematics, there may be strategies and programs to help increase student interest.

In the article *Using an intelligent tutor and math fluency training to improve math performance*, Vincent Aleven, Judy Kay, Ivon Arroyo, James Royer, and Beverly Woolf (2011) designed an experiment to study the effectiveness of combining strategy instruction with computational fluency instruction in raising studentsô math performance. Previous research had been done that showed the effectiveness of the Wayang program in improving studentsô math performance, but these researchers determined that more evidence was necessary before teachers would begin to implement this intervention.

This experiment included 173 seventh and eighth grade students. There were 103 students who received the math fluency training and math tutoring with the Wayang program, whereas the other 70 final participants only received math fluency training. All of the eighth grade students had the same teacher, but came from six different math periods that this teacher taught. All of the seventh grade students had the same math teacher during the experiment, but also could have been in any one of the six classes this teacher taught. Three of these twelve classes were each randomly assigned to one of four possible conditions. The possible conditions include: Wayang and fluency instruction, Wayang and no fluency instruction, no Wayang and fluency instruction, or no Wayang or fluency instruction. It is important to note that these interventions were on top of studentsô regular math instruction.

Researchers began by creating two different tests on the Wayang program including a variety of questions that could be found on the Scholastic Assessment Test (SAT); questions included all levels of difficulty, both multiple choice and short answer questions. Students who received test A for their pretest, received test B as their posttest and vice versa. Students were also required to complete a math fact retrieval task as part of both their pre- and post-test assessment measures. Learners who used the math fluency program were drilled about 15 minutes daily on their facts; whereas students who participated in the Wayang program completed nine different topics with problems of varying difficulty. The difficulty level of the problems in the Wayang program adapted to the studentsô level; students in the Wayang program experimental conditions were asked to request hints from the program when there was something they did not understand. In the case of the pupils who were in the experimental condition that included both the math fluency program and the Wayang program, those students we required to complete the math fluency program training before beginning to work in the Wayang program.

Both test A and test B were similar enough in level of difficulty to not cause significant variance; however, when comparing students across grade levels (seventh or eighth), there was significant variance in the studentsô test scores. In addition, the results of this experiment indicated students who received the math fluency instruction performed more accurately and more quickly than those who did not. In regards to achievement, the group that received both strategy and fluency instruction had a significantly higher level of achievement on the posttest than the other three treatment groups. However, the group that received only the strategy instruction through Wayang answered complex problems more quickly than all other groups; this is due to the fact that the students who received both Wayang and fluency instruction had a portion of their instructional time (15 minutes) dedicated to fluency rather than the full instructional period. Also, fluency training benefited students in both grade levels, regardless of whether or not they received strategy instruction through the Wayang program. As noted above, a combination of strategy and fluency instruction leads to the greatest academic gains; consequently, the next article focuses on effects of an intervention program on mathematics achievement.

In the review *Effects of cognitive strategy instruction on math problem solving of middle school students with learning disabilities,* Marjorie Montague, Craig Enders, and Samantha Dietz (2011) described the effects of the Solve It! mathematics intervention program (Montague, 2003). This program was created specifically with students with learning disabilities (LD); however the researchers of this intervention decided to apply the intervention to all students in these inclusive classroom settings.

This study included results from the 37 teachers who consented to participate in the study, 319 students from the intervention schools, and 460 students from the comparison schools. The majority of students were either Hispanic (>60%) or Black (>20%). These 40 middle schools were selected from the Miami-Dade Public Schools based on their socioeconomic status (SES) and their scores on the standardized state test. Schools were chosen from all ranges of the spectrum in both categories, in order to avoid bias in their results. By the end of the study, fourteen teachers had left the study and two new principals elected to no longer have their school participate in the study. The study was then reduced to 32 total middle schools participatingð only 8 of which were intervention schools.

For this experiment, the researchers provided the intervention teachers with a three day professional development session to learn the details of the Solve It! mathematics intervention and subsequently provided three-days of intensive instruction with follow-up weekly problems aligned with the standardized state test. The teachers in the comparison schools provided their students with typical classroom instruction using only the textbook and the stateǿs pacing guide. The teachers in both the intervention and comparison schools administered CBMs throughout the study which lasted from October through May. The intervention schools were required to give all seven CBMs throughout the year, whereas the comparison schools began giving their students the CBMs at the third session.

All students in the intervention schools increased their scores by more than one standard deviation. The impact of the intervention was uniform across students of all levels; students who started higher, ended higher. The students with LD also increased their scores; however, although they stayed the lowest scoring group amongst the interventions students, they performed higher than the proficient students at the comparison students at the end of the year.

These three articles presented information on the relationship between interest, ability, and achievement, which led to research about two mathematics programs. One program was an independent program used in a whole group context to improve English language proficiency while learning mathematics and the other was a mathematics program aimed at improving math skills through faithful use of the program. Knowledge of these practices led the researcher to explore the instructional practices related to the use of inquiry in the classroom, specifically when integrating subjects in the elementary classroom.

Inquiry-Based Instruction

Teachers have many instructional practices for teaching subjects individually; however, sometimes they lack a vehicle through which they can integrate subjects. This section will focus certain practices that enhance mathematics instruction and the use of inquiry-based instruction in the classroom to integrate content.

Sueanne McKinney, Shannan Chappell, Robert Berry, and Bythella Hickman (2009) related their plan for action to the Principles and Standards for School Mathematics set forth by the National Council of Teachers of Mathematics (NCTM) in the article *An examination of the instructional practices of mathematics teachers in urban schools.* There are six foundational principles that are necessary in a successful mathematics classroom. These include not only curriculum and assessment, but also technology, learning, teaching, and equity. The researchers also mentioned the differences between traditional methods of mathematics instruction compared to alternative methods of mathematics instructions. In their work, the researchers studied the pedagogical and instructional practices that teachers in schools with a high population of students of low socioeconomic status (SES) use and the extent to which these practices are applied in the classroom context.

The sample came from a total of 176 students who participated in a professional development session provided by the NCTM. This study included 99 teachers, between the ages of 20 and 55, who volunteered to complete the Mathematics Instructional Practices and Assessment Instrument. Approximately two thirds of the teachers in the sample were females, with the other third male teachers. Nearly half of the teacher were Caucasian, another approximately 40% were African-American, with the remaining approximately 10% of teachers reporting themselves as either Hispanic or other. These 99 teachers were asked to participate due to their teaching position in a school with a high number of students considered to be of low SES .For the purpose of this study, McKinney et al. defined a high-poverty school as one in which at least 50% of the student population qualifies for either free or reduced lunch.

The participating teachers took the Mathematics Instructional Practices and Assessment Instrument during a NCTM conference as either part of the registration or evaluation period. This instrument surveyed the teachers on the six principles set forth by the NCTM through the identification of 43 recommended practices and the frequency of use with the option for teachers to write in other practices they would recommend. These practices were rated on a 5-point Likert scale, with five being very frequently and a one representing never. In order to validate their results, the researchers concluded the study with a think aloud for the specialist teachers in three of the participant schools. Data was recorded in a table listing each of the 43 identified practices and its corresponding mathematical principle. The data was then gathered into an additional table.

McKinney et al. organized the data into a table by the 43 practices and the corresponding principles that connect to those practices. Then, the researchers continued to add columns that reported the percentage of teachers that used each practice and to what degree based on the scores from their Likert scale responses. After organizing the data into a table, the researchers compiled their results according to the six NCTM principles. In relation to the equity principle, they found that a high percentage of teachers had high expectations and knew how to ask higher level questions and reinforce the studentsô learning, but very few teachers differentiated their instruction. Relative to the curriculum principle, many teachers connect the current instruction to previous learning, but very few teachers strayed from the curriculum to make the instruction unique. An analysis of the practices related to the teaching and learning principles showed the researchers that many teachers have mastered demonstrations, modeling, and lectures; however, teachersô practices lack student-direct, hands-on, concrete, and abstract activities that promote student learning. Practices from the assessment that addressed the assessment principle showed many teachers still rely on tradition methods of assessment, rather than more authentic forms of assessment that demonstrate studentsô learning over time. Finally, the practices that related to the technology principle indicated teachers were more apt to use traditional methods such as facts programs and calculators, as opposed to virtual manipulatives or Internet-based. With knowledge of the principles of mathematics in mind, the researchers will continue with an exploration of how to integrate science content into literacy.

Journeys into inquiry-based elementary science: Literacy practices, questioning, and empirical study, reviewed the work of Elaine Howes, Miyoun Lim, and Jaclyn Campos (2008) as they researched teachersô use of science as a means to develop literacy skills in order to find how to implement literacy instruction with scientific inquiry for pre-service educational programming. The purpose of this study was to find how teachers define inquiry and place it into practice and the role of literacy in inquiry-based science teaching; however this process was hindered by teachersô lack of knowledge about how science inquiry works and how to implement science in a way that motivates and engages learners. Many teachers were not prepared to teach an integrated curriculum where both science and literacy can be woven together for instruction. In addition, teachers are underprepared to provide literacy education to develop English language learners (ELLs) social and academic English by providing opportunities for students to look to natural world for data to address their own questions. It explored whether students could participate in science inquiry while they learned English. Therefore, the questions of focus for the study were how teachers integrate literacy into what they considered inquiry-based science and how they described their goals and supported their choice in relation to that form of integration.

Howes, Lim, and Campos conducted a long-term, multi-classroom study that was the product of a three year collaboration between an East Coast urban elementary school and researchers from a nearby, private, education graduate school with financial support from the Urban Science Education Center . The students at Monarca School were 82% Latino and 14% African American; most Latinos first language was Spanish. Five to ten science teachers from Monarca School attended each science meeting held throughout the first year of the study; five teachers initially volunteered and three of them were selected based on a diversity of strategies used in the classroom and the fact that science was taught regularly in their classroom. Teacher participation was voluntary and the final product was three collaborative teams formed during the second year of the study. This led to a primary, yet productive relationship between researchers and educators, therefore the researchers took a descriptive stance when describing the study due to the close relationship.

The researchers themselves were the scholars who paired up with a classroom science teacher. Three teacher-research partnerships were formed for the study in classrooms where assistance was needed to enact that teacherȷs idea of inquiry-based science. Placement of the researchers was based on class size, teacher interest in science teaching, and how long the teacher had been teaching. In this relationship, the researcher provided the science content expertise and hands-on support for activities, and then extended to co-planning, co-teaching, and co-researching with the teacher as time went on. Some constraints of this study were high teacher to student ratios, high teacher turnover, irrational politics, and the city-mandated exams.

Howes, Lim, and Campos used ethnographic research methods combined with data from their collaborative teacher-researcher perspectives. This investigation took place during the spring semester of third collaborative year to see overall picture of school; each teacher reported joined during the second year of science meetings. Primary data for the research included classroom observations, in-depth teacher interviews with field notes and interview transcripts for analysis. Participants also went to regular research team meetings to debrief and discuss observed lessons from summaries observations notes and/or partial transcripts. Team meetings were taped and sometimes transcribed to shape perspectives to help distance themselves from teachers with whom they had formed a close relationship, in order to provide accurate data.

During the first stage of this study discussion yielded detailed written descriptions of teachersô strategies and the researchers shared these with teacher to check for accuracy, all of whom agreed with what was written. Each partnership was recorded as an intrinsic case study and were chosen based on researchersô interest in inquiry-based science. The ethnographic part arose when they decided to see how literacy practices could be embedded in this inquiry-based science instruction by providing them a way to connect the three separate cases. The descriptive narratives were used to share teachersô practices and rationales, as wells as instructional strategies, goals for studentsô science learning, and the role of literacy in the classroom. The second stage provided two indicators to elaborate on the results: the role of studentsô questions and the role of empirical study.

Howes, Lim, and Campos organized the data by teacher beginning with the most representative of science teachers in the school. In the absence of real world materials, the first teacher used a non-fiction text unit to do text-based research. The first teacherõs method kept literacy in the school while adding a hint of science. Essentially students were learning about nonfiction text features and the process of researching while learning about animals. Students spent one month studying the features of nonfiction through texts about animals; during the second month students chose and researched a wild animal of choice. During this time students came up with one question and tried to answer it by reading, which led to the teacher creating a common guide of questions for all students to include in their study. Sophisticated questions were left to the designers of the question to answer. After completing their individual research, the students created groups based on a shared characteristic of their animals and continued working in groups; at the end of the third month, the groups shared their findings about their animal group. This teacherĝs goal was for students to be good at the research process to use it in many contexts as well as to share their findings and show how scientists communicate their work.

The second teacher believed that inquiry-based science was a problem-solving, hands-on approach, in which he used direct instruction to teach concepts first. This teacher used whole group instruction to focus on the domains of listening and speaking and to provide background knowledge and the ñcorrect answersò. Students then worked in small groups to complete task challenge while the teacher asked guiding questions; during this time students provided reasoning for their choices and the teacher used this talk as formative assessment information. His philosophy was that a scientist was someone who used a very organized manner to solve problems and that "accountable talk" was a vehicle through which humans begin to understand the world around them. Since the focus was on speaking and listening, reading and writing were only independent choice time activities; however, there were a wide variety of books available for their use during this time. Since the instructor believed that content was secondary to process, problem-solving and the manipulation of material were central to inquiry

The third teacher believed that inquiry-based science was observing, questioning and thinking about science with the active involvement of students. She used a text-based inquiry, self-proclaimed real-world inquiry-based science. Students in this classroom had a natural interest in science and animals due to the year-round classroom aquarium. The learners went to the store to help the teacher buy animals for the aquarium and discussed why or why not animals would be a good fit for their aquarium habitat. The teacher answered questions as they came up, being very attentive to kindergarten students interests. Students in this class formed pairs and chose a topic of interest to study using all levels of books with excellent visual cues to use for knowledge. Students were then to choose an interesting page, describe itsô interest as well as choose a topic to pursue based on this interest. Students were so engaged in this task that they asked the teacher to read the accompanying text and shared information with their peers which led to even more questions and research by the students. In this classroom, English Language Learners (ELLs) were able to learn language at same time as content because of the heavy focus on using the illustrations to find answers. Talk was central to learning and English Language Proficiency (ELP) development in this classroom. It was found that when teachers focused on science as a process, rather than only teaching to the standards, they focused on their beliefs about the efficient and effective use of inquiry in the classroom.

In the article *K-12 science and mathematics teachers' beliefs about and use of inquiry in the classroom*, Jeff Marshall, Robert Horton, Brent Igo, and Deborah Switzer (2009) studied the results of a survey given to teachers about their beliefs and use of inquiry in the science and mathematics classroom. The purpose for this information was to discover the discrepancies between teachersô beliefs with what their actual practice was in order to remedy the lack of inquiry-based instruction in these two academic areas.

This study included 1,222 teachers from one of the largest school districts in the Southeast portion of the United States. In this district there were 4,784 teachers total influencing the lives of approximately 67,000 students. Over half of these teachers held their masterôs degree; only 64% of the teachers responded to the survey.

For this report, teachers took a survey with 58 questions; 43 of the itemsô responses form a part of the results of this study. Items that were included in the survey include: a self-report on the teachersô own inquiry-based practices, a question about teachersô belief of ideal inquiry-based instruction, and teachersô self-efficacy for instruction and the level of support for this type of instruction were measured using a scale of 1-6, similar to the Likert scale. These surveys were administered over a ten-day period during the month of February in five different formats corresponding to level and subject taught. To evaluate the surveys, the researchers conducted a one-way analysis of variance (ANOVA); to balance out the quantity of teachers answering each different survey, they also used the Hochberg procedure during follow-. From this information, the researchers focused on the mean percentage and the standard deviation of teachersô responses to their survey instrument.

The results of this study showed teachers realized they needed to spend more time on inquiry-based instruction. In the district surveyed, the expectations for and the actual implementation of inquiry-based instruction vary drastically. The teachers indicated in the survey that their actual use of inquiry-based instruction is much less (18-20%) than the ideal time they felt could be spent using this strategy. The results also showed that elementary teachers received support in and used inquiry-based instruction more than middle and high school science and mathematics teachers. Science teachers spent more time on inquiry-based instruction than mathematics teachers during the elementary years, whereas this difference dissipated during middle and high school. The researchers also noted the available curriculum affected the amount of inquiry used during the class periods. Teachers with a high self-efficacy score were more likely to teach using inquiry-based methods as well as female instructors were more likely than male to teach using inquiry-based methods.

Studies show small group, inquiry-based instruction is where the teachers of ELLs need to focus the majority of their mathematics instructional time. In addition, when teachersô realized their focus had shifted from where they felt they needed to be, they wanted to take the time to collaborate with peers to find a solution to the discrepancy between beliefs and practices, while focusing on the mathematics principles.

Conclusion

The research reviewed showed that through extensive professional development opportunities, teachers receive the appropriate content and pedagogical knowledge to use new strategies in the classroom. The research continued to demonstrate that although teachers were generally aware of the type of instruction that their students needed; however, teachers lacked the professional development and strategies for effectively working with English language learners within their classroom. More inquiry in the area of instructional programming in mathematics revealed the relationship between interest, skills, and achievement, and how to make these more accessible through the use of specific math programs. Lastly, inquiry-based instruction was presented as a way to integrate literacy into the mathematics and science classrooms, while offering students an understanding of what it means to be mathematicians and scientists. While this chapter reviewed the research related to professional development, instructional decisions for working with English language learners, mathematics instructional programming, and inquiry-based instruction, the next chapter examines the procedures and data of this researcherõs action research study.

CHAPTER THREE

Introduction

During the 2012-2013 school year, Maple Creek Elementary served 450 students in grades kindergarten through fifth grade. Maple Creek had two classrooms in each grade designated as regular education classrooms, and one as a dual language one-way bilingual classroom. Through action research the researcher sought to answer the following question: Will hands- on, inquiry based instructions with specific content objectives improve English Language Learnersô (ELLs') performance in mathematics? The researcherꞆs hypothesis was that studentsô achievement in mathematics will increase through the use of hands-on, inquiry-based instruction following the Sheltered Instruction Observation Protocol (SIOP) (Echevarria, Vogt, & Short, 2008) use of content and language objectives as a guide to instruction. In this chapter, the researcher discusses the student population that participated in the action research, the procedures that were followed during the action research, and concludes with a detailed description of the data collection method.

Description of the Sample

The researcher worked with students of Hispanic ethnicity. This was a third grade classroom of English language learners (ELLs). There were 25 students and 100% of the population for the research came from Spanish speaking, Hispanic families who have backgrounds from either Puerto Rico or Mexico. However, only 18 of the students received permission from their parents to participate in the research; there were 8 females and 10 males, all of whom were of Mexican descent. None of the students received special education services. Many students began school at Maple Creek Elementary School in first grade, a few started in second grade, and approximately one third of the class came from Redwood Forest when it closed. Both of the aforementioned schools are in the same school district. This section described the population for the research; the next section explains their language and academic data more in depth.

Student Language and Assessment Data

The abilities of students varied greatly according to the Assessing Comprehension and Communication in English State-to-State (ACCESS) test (WIDA Consortium, 2007) and the Measures of Academic Progress (MAP) test created by the Northwest Evaluation Association (2012). The ACCESS test was used to measure studentsô yearly gains in English language proficiency. This test measured student gains in listening, speaking, reading and writing; the ACCESS test also provided a composite score (WIDA Consortium, 2007). At Maple Creek Elementary School, this test was given in two group sessions; one session was for the combined assessment of listening and reading and the other group session was for the writing portion of the assessment. Speaking was assessed individually at a separate time that usually follows the group testing sessions. The studentsô composite proficiency levels ranged from level 2 to a level 6, on a 6 point scale on the ACCESS test (Table 1).

Table 1

ACCESS Test Scores from Fall of 2012

	Level 1 Entering	Level 2 Beginning	Level 3 Developing	Level 4 Expanding	Level 5 Bridging	Level 6 Fully English Proficient
Number of Students	0	1	6	8	2	1

The MAP test was an adaptive test for measuring student growth and achievement based on performance, rather than measuring grade level. This test can help teachers pinpoint areas where students need assistance or where they need to be challenged (Northwest Evaluation Association, 2012). On the MAP test, students in the sample for this research had reading Rasch Unit (RIT) scores range from 161-209; and, in mathematics, the studentsô RIT scores ranged from 180-210 (Table 2).

Table 2

MAP Test Scores in Math and Reading from May 2013

	RIT range				
	161-170	171-180	181-190	191-200	201-210
Reading	3	4	7	3	1
Mathematics	0	1	7	7	3

A RIT score is an estimation of a studentôs instructional level and measures student growth in academic achievement. By the end of third grade, students are expected to achieve a RIT score of 199 for reading and 203 for mathematics; therefore, students below the 181-190 RIT range are considered below grade level. This data provided baseline data for this research project, which led to the procedure described below.

Description of the Procedures

In order to test the hypothesis, the researcher provided small group instruction to the students at the appropriate language proficiency level. Students were grouped according to academic ability with the same content objective for all students.

Instruction was conducted in three week cycles consisting of approximately two fifteen day periods based on the content objective being taught. Research consisted of two cycles, for a total of six weeks of research. During this time, the researcher provided instruction in two areas of mathematics. The areas of mathematics covered examined all four of the Common Core State Standards (CCSS) for fractions in third grade (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). This researcher continued with regular instruction which followed the math workshop format. Students first received instruction during a whole group mini-lesson for approximately fifteen minutes, then continued to application time forty minutes, and concluded with a whole group share time of ten minutes. Students were regrouped approximately eight days into each fifteen day period based on a midway, formative assessment to make sure that students were with the appropriate academic level group. During each three week period, the researcher tallied engagement on one selected day half way through each period marking studentsô engagement by the number of times they raised their hand during the mini-lesson.

During the first fifteen days students received instruction with no hands-on, inquiry-based instruction. The first fifteen days focused on the understanding of fractions being part of a whole and the ability to represent fractions on number lines. This period began with a pretest focusing on the Number & Operationsð Fractions standards NF 1.1, 2.1, 2.2, and 2.3 from the Common Core State Standards (CCSS) (Appendix A). Standard NF 1.1 focused on the understanding of a fraction as a partition of a whole, standard N.F 2.1 addressed representing a fraction on a number line by partitioning the line into equal parts. In addition there was the similar standard NF 2.2 which dealt with recognizing that each partition of the whole needs to be the same size while standard NF 2.3 tied the previous two standards together by equally partitioning fractions on a number line. Implementation of regular instruction was carried out as described above. The mini-lessons and guided groups focused on topics specific to the CCSS. On day eight of regular instruction, the researcher tallied the studentsô engagement represented by the number of times a student raised their hand during the mini-lesson. At the end of the fifteen days of instruction, students were administered the exact same assessment as a posttest.

For the following fifteen days, students were taught using hands-on, inquiry-based instruction. Instruction during this session included the same aspects as the control period, but added the inquiry-based emphasis by allowing students to focus on questions about the use of fractions in the real world. The intervention period began with a pretest focusing on the CCSS Number & Operationsð Fractions standards NF 3.1, 3.2., 3.3, and 3.4(Appendix B). Standard NF 3.1 addressed fractions as equivalents when they are the same size, or at the same point on a number line. Standard NF 3.2 addressed the explanation, recognition, and generation of simple equivalent fractions as standard NF 3.3 examined the expression of whole numbers as fractions and NF 3.4 required students to compare fractions with an equivalent numerator and justify their reasoning for why the selected one as greater than the other. This second set of standards concentrated instruction on the equivalent fractions standards of the CCSS and was taught using recipes and measuring cups to follow simple recipes.

Students followed the recipes using only one of the measuring cups and finding the equivalent to carry out the recipe. Students began by creating a recipe using a half cup to follow a paint recipe requiring half and whole cup measures. Then, students were taken to the next level following an ice cream recipe requiring measurements from a third cup to a whole cup, using only the one-third measuring cup. The final recipe was to prepare lemonade using a measuring cup of their choice to find equivalents for measurements between one-half and two cups. Students chose the measuring cup for which they needed to find equivalents to prepare the lemonade. On day nine of the intervention, the researcher tallied the number of times a student raised their hand during the mini-lesson to measure student engagement. Then, the intervention session concluded with the posttest, which was identical to the pretest.

Explanation of the Data Collection

The data recorded came from students pre-assessment and post-assessment scores; the teacher assessed the students at the beginning and end of each fifteen day period. Each question was scored on a five-point rubric, and then the researcher did a comparative analysis of the results of each question on the pre- and post-assessments to find the change in scores of each student. During each three week period, the researcher recorded student engagement in the form of tallies. This method was followed for both the control period and the intervention period.

The control period began and concluded with an assessment (Appendix C) concentrated on the four CCSS attending to the understanding and representation of fractions on a number line from the Number & Operationsð Fractions strand of the CCSS. Two questions addressed standard NF 1.1 focused on the understanding of a fraction as a partition of a whole, one question addressed standard N.F 2.1 focused on representing a fraction on a number line by partitioning the line into equal parts. In addition there was one question that addressed the similar standard NF 2.2 which dealt with recognizing that each partition of the whole needs to be the same size while the final question looked at standard NF 2.3 which tied the previous two standards together by equally partitioning fractions on a number line. The raw data from each assessment was placed into a spreadsheet in order to compile the data necessary for comparative analysis (Appendix D).

The intervention period data came from the pre- and post-assessment (Appendix E) which focused on the CCSS focusing on fraction equivalents. Standard NF 3.1 addressed fractions as equivalents when they are the same size, or at the same point on a number line. Standard NF 3.2 addressed the explanation, recognition, and generation of simple equivalent fractions as standard NF 3.3 examined the expression of whole numbers as fractions and NF 3.4 required students to compare fractions with an equivalent numerator and justify their reasoning for why the selected one as greater than the other.

Each standard was addressed as one of the questions on the assessments; the questions on the intervention assessment were multi-step and required students to use a higher-level thinking necessary during inquiry-based instruction and assessment. While 10 students made a slight gain, 8 students make not gain or showed a negative result. The raw data from each assessment was placed into a spreadsheet in order to compile the data necessary for comparative analysis (Appendix F).

On day eight of regular instruction the researcher recorded student engagement by tallying the number of times a student participated in the mini-lesson. Each time a student would raise their hand or offer a response to the teacher or another student, the teacher noted their engagement in the form of a tally mark. This process was repeated on day nine of the intervention. Both types of instruction show student engagement; however, there was slightly more student participation during the intervention session, as seen in Figure 1.

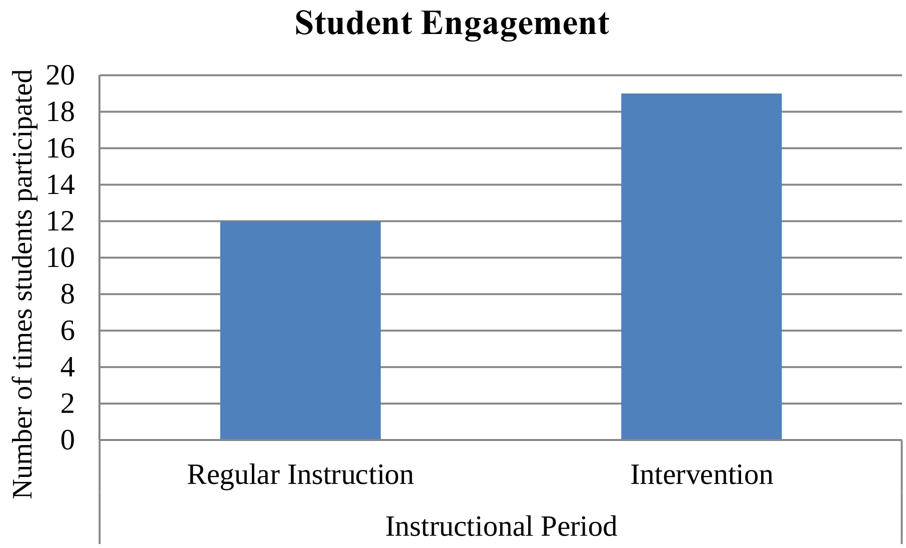

Figure 1. *Amount of student participation*

Conclusion

This action research project focused on the effects of hands-on, inquiry-based mathematics instruction on ELLsô mathematics achievement. This chapter reviewed the student population of the study and their assessment data. The procedures involved a 6 week period for data collection, with three weeks of regular instruction and three weeks of the intervention instruction. The collection of data revealed a difference in improvement when comparing regular instruction to the intervention; the data showed 16 students improving with regular instruction and 10 students improving with the intervention. The following chapter will present the results and analysis of this researcherôs action research.

CHAPTER FOUR

Introduction

Action research presented in the previous chapter aimed to discover whether hands-on, inquiry based instruction with specific content objectives would improve English language learnersô (ELLs) performance in mathematics. The researcher hypothesized studentsô achievement in mathematics would increase through the use of hands-on, inquiry-based instruction using content objectives to guide instruction. In this chapter, the author presents and analyzes the results of what happened as a consequence of the intervention.

Analysis of Data

This section reviews scores per individual student by looking at the positive or negative change in points scored on the pretest and posttest assessments from the period of regular instruction and the intervention period. First, the researcher will review the results of three weeks of regular instruction; and then examine the outcomes after three weeks of instruction including the intervention. The control period began and concluded with an assessment (Appendix C) concentrated on the four Common Core State Standards (CCSS) attending to the understanding and representation of fractions on a number line from the Number & Operationsð Fractions strand of the CCSS. Table 3 demonstrates that all but three students showed some growth. There was a range of points in growth from zero to eight points during regular instruction; correspondingly, the students averaged approximately 2.8 growth points between the administration of the pre- and post-assessments. Table 3 also shows three students showed no growth during regular instruction; nonetheless, half of the class increased their scores by three or more points and a third of the class showed a slight growth of one to two points. The researcher noted significantly higher growth in the CCSS Numbers & Fractions standards NF 1.1b, 2.1, 2.2, and 2.3, than on the first question about standard NF 1.1 which required students to partition two candy bars equally between six students (Appendix C). Standard NF 1.1 stated students can understand a fraction 1/*b* as the quantity formed by 1 part when a whole is partitioned into *b* equal parts; additionally, students can understand a fraction *a*/*b* as the quantity formed by a parts of size 1/*b*. For the final question of the assessment, only one student showed negative results, whereas the other students either stayed the same or increased their scores.

Table 3

Comparative analysis of pre- and post-assessment results during regular instruction

Student	NF 1.1a	NF 1.1b	NF 2.1	NF 2.2	NF 2.3	Difference in Growth Points
All	1	12	11	13	13	50
1	0	0	0	0	0	0
2	1	1	1	1	2	6
3	0	1	2	0	0	3
4	0	0	-1	1	1	2
5	-1	0	1	1	1	2
6	0	1	1	1	1	4
8	0	2	-1	-1	0	0
10	0	0	1	1	1	3
11	0	1	-1	-1	1	0
12	0	0	0	0	1	1
13	1	1	1	-1	0	2
14	2	2	-1	3	1	7
15	-1	-1	0	0	3	2
16	-1	0	2	2	0	3
18	0	2	0	0	1	3
21	0	-1	3	3	0	3
22	0	1	3	3	1	8
24	0	2	0	0	-1	1

A second comparative analysis based on the scores on the pre- and post-assessment before and after the intervention period is displayed in Table 4. Three students showed no growth for any of the standards during the intervention session, while one student showed positive growth for one Numbers & Fractions standard, yet negative outcomes in another area. Six students had negative results during the intervention and another four recorded zero growth.

Table 4

Pre- and Post-assessment Results during Intervention

Change in Scores for the 15 days Intervention Instruction					
Students	NF 3.1	NF 3.2	NF 3.3	NF 3.4	Difference in Growth Points
All	2	9	-1	-3	7
1	0	0	1	1	2
2	0	1	0	1	2
3	0	0	0	-1	-1
4	0	1	0		1
5	0	1	0	-1	0
6	0	1	-1	-1	-1
8	0	0	0	-1	-1
10	1	1	0		2
11	0	0	0		0
12	0	0	0		0
13	0	1	0	1	2
14	0	0	0	-1	-1
15	0	0	0	2	2
16	0	1	0		1
18	0	0	0	-1	-1
21	1	2	-2		1
22	0	0	0		0
24	0	0	1	-2	-1

Eight students showed growth in their overall score as a result of the intervention; however, one of these students had negative results on one of the standards, as seen in Figure 2.

There were nine points of overall growth for standard NF 3.2 which required students to recognize and generate simple equivalent fractions and explain why the fractions are equivalent.

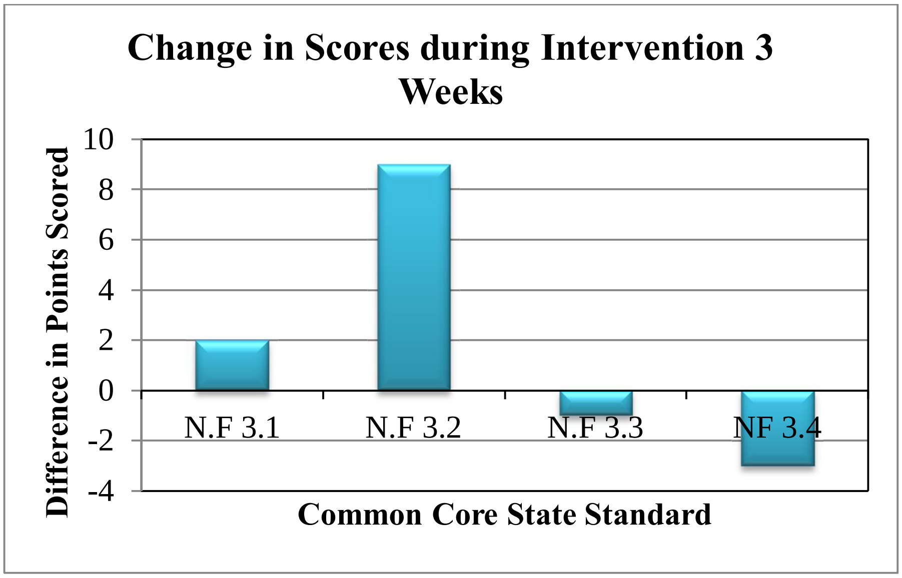

Figure 2 *Average Growth*

Students showed negative outcomes for standard NF 3.3 which asked students to express whole numbers as fractions, and recognize fractions that are equivalent to whole numbers; additionally, studentsô scores decreased for standard NF 3.4 required students to compare fractions with an equivalent numerator and justify their reasoning for why the selected one as greater than the other. Four students showed no growth on the post-test assessment, while six students had negative results. The students scored higher on standards NF 3.1 and 3.2 on the posttest, but less on standards NF 3.3 and 3.4 when looking at the overall points scored per assessment standard, as seen in Figure 2. There was an average growth of 0.39 points per students on the intervention posttest. The researcher took the data for this graph from the raw data shown in Appendix F.

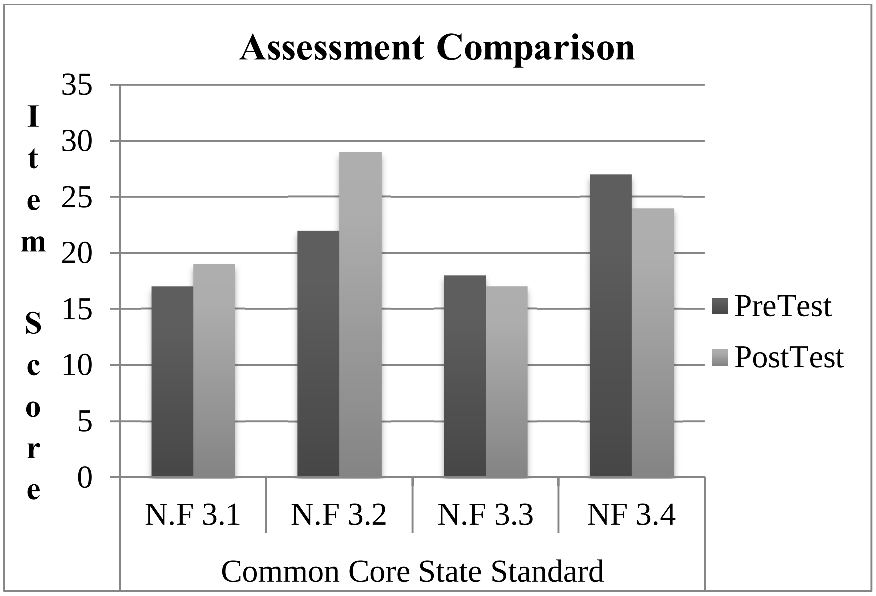

Figure 3 *Total points for all eighteen students*

The results from the intervention showed students increased their combined scores in two of the four standards during the intervention period. However, Numbers & Fractions standards NF 3.3 and NF 3.4 showed an overall negative growth for overall student performance. Nonetheless, studentsô participation did increase during the intervention period. Students participated in discussion during the mini-lessons 7 times more than they had during regular instruction.

Conclusion

In summary, students scored an average growth of 2.8 growth points or more during regular instruction and 0.39 points of growth during the intervention. During regular instruction, students showed positive growth on each of the Common Core State Standards whereas during the intervention there was a negative consequence for standards NF 3.3 and NF 3.4. Students 11 and 24 were the only two students who had the same overall change, positive or negative, during both the intervention and regular instruction. Additionally, students participated more during the mini-lessons during the intervention instruction than during regular instruction. While this chapter presented the results of both regular instruction and the intervention throughout this investigation, and analyzed the results of the action research from the intervention, the next chapter will provide connections to existing research and the Common Core State Standards, as well as an analysis of and reasons for these results of this study. It will conclude with strengths and limitations of this research as well as recommendations for future research.

CHAPTER FIVE

Introduction

The purpose of this action research was to evaluate the effectiveness of inquiry-based mathematics instruction with English language learners (ELLs). In the previous chapter, the researcher presented the data collected for the action research and analyzed this data without providing opinions or explanations for these results. This chapter will answer the question: Will hands- on, inquiry based instructions with specific content objectives improve English Language Learnersô(ELLs') performance in mathematics? First, the researcher will synthesize connections to existing research and make connections to Common Core State Standards (CCSS). Then, she will provide an explanation of the results and define the strengths and limitations particular to this study. Finally, the researcher will give recommendations for future research in inquiry-based instruction.

Connections to Existing Research

Before beginning this action research, the researcher examined previous investigations on the topics of professional development, instructional decisions for working with ELLs, math programming, and inquiry-based instruction.

Current research in professional development stresses the need for teachers to be trained to implement highly effective, standards-based instruction and create assessments and homework that correlate with this instruction (Bailey, 2010). In addition, teachers need to be trained in the use of effective teaching practices for working with ELLs in the content areas as well as participate in ongoing professional development to keep their knowledge current (Lewis, Maerten-Rivera, Adamson, & Lee, 2011). This researcherøs work was developed from professional development provided through the bilingual department of the school district around biliteracy in conjunction with the studies read for this action research. In addition, professional development needs to include an emphasis on the importance of culture and personal connections. Takeuchi and Esmonde (2011) point out there is a higher level of engagement in the activities when students feel represented and proud of whom they are; this is especially true when working with ELLs whose language usually falls under the category of “other”. Professional development was offered in the school around cultural responsiveness, due to the increase in the bilingual population of the school; however, this professional development was mandatory so some teachers may not have been ready to receive this information as a mandate.

According to current research in working with ELLs, teachers need to implement highly effective, culturally relevant instruction and interventions to Hispanic immigrant students before they fall too far behind their English-speaking counterparts (Chang, 2008). To achieve this level of instruction, teachers need to encourage students to use their home language as a resource for learning English (Essien, 2010). ELLs need time to achieve academic language, allow them a silent period to achieve this; focus on teacher-led independent activities to instruct them in the meantime (Chang, 2008). Current research shows that teacher talk dominates the classroom, but this needs to shift to a focus on students talking to the teacher and to each other. This concept relates clearly to my work with student discussion surrounding their inquiries with both their fellow classmates and myself. Students were allowed to share their ideas and have them validated through the inclusion of their ideas on a class anchor chart of questions and ideas. Teachers cannot assume learners understand how to read and write academic texts (Essien, 2010). However, when working with English language learners, current explorations reminded teachers to recall that the quality of instruction is just as important as the techniques for working with ELLs (Bumgarner, Martin, & Brooks-Gunn, 2013).

Recent research in mathematics programming commends teachers to foster studentsô interest and abilities in mathematics starting at a young age. Teachers need to continue working on studentsô mathematic fluency throughout the grade levels, because many students in higher grade levels still have trouble with rapid recall which drastically reduces their effectiveness in solving math problems quickly (Aleven, Kay, Arroyo, Royer, & Woolf, 2011). Also, the importance of foundational skills need to be emphasized until there is automaticity with these skills; when students are required to solve more complex problems that require higher-level thinking, they need to be able to recall these skills quickly so not to squander their mental capacity on the foundational skills (Aleven, et al., 2011). The work of Aleven, et al. compares to mine in that the intent of the regular instruction was to provide the students with a solid understanding of what fractions are and what they represent before embarking on fraction equivalents. Without a foundation in fractions as a part of a whole, students would be unable to represent equivalent fractions and justify the reasoning for their equivalency. Up to date research also recommends that a program be chosen for the impact on student learning, rather than choosing a program that aligns with the state standardized test in order to meet the needs of teachers (Montague, Enders, & Dietz, 2011). The researcher believes this to be true and has demonstrated with this study that while the regular classroom instruction proved to be effective, inquiry-based instruction demonstrated higher student engagement and provided students with ownership of their learning; however, the acceptance of this ownership may not be appropriate for all students, as demonstrated in this action research.

Inquiry-based instruction research notes teachers need to ñcreate and personalize curriculaò (p. 282, McKinney, Chappell, Berry, & Hickman, 2009) that provide students with the quality math lessons that prepare them for academic survival in this era of high-stakes testing. In order to create a classroom environment that is conducive to these practices, teachers need to know their students and how they learn. This means that teachers provide more authentic forms of assessment that allow students to show their learning in a variety of ways and over time. Students need time to talk through their learning in order to make sense of the world around them (Howes, Lim, & Campos, 2009). In this study the student talk from the inquiry-based instruction increased student engagement, but was not as effective of a method for increased achievement. Math problems should be related to real-world contexts and results should be found in concrete ways, rather than being given a formula to solve the problem only symbolically; to do this, teachers need to provide students with more abstract problems that have more than one solution. Educators need to match their practices to their beliefs with regards to the use of inquiry-based instruction in the mathematics and science content areas (Marshall, Horton, Igo, & Switzer, 2009). While the assessments of this action research did provide some real world contexts, such as the partitioning of pizzas and running, students did not seem to make the connection to their world. Inquiry is doing what scientists do and considered set of skills rather than pedagogy, interrelated processes (Howes, et al., 2009). In conclusion, teachers should strive to teach for inquiry not by inquiry in order to develop inquiry skills by allowing students to discover real world evidence to answer their questions with the teacherôs guidance (Howes, et al., 2009). This was the strongest connection related to this study in the need for students to make learning their own and that was why the researcher chose inquiry-based learning as the intervention instruction. Inquiry-based learning was a vehicle for students to choose a question to explore and find answers in a hands-on manner

Connections to the Common Core State Standards

This action research focused specifically on the Numbers & Operations on Fractions standards of the Common Core State Standards. The three weeks of regular instruction focused on CCSS standards NF 1.1, 2.1, 2.2, and 2.3. The main focus of these four standards was to understand a fraction as a part of a whole, that these parts are of an equal size, and to represent these fractions on a number line. Subsequently, the following three weeks of intervention instruction focused on standards 3.1, 3.2, 3.3, and 3.4; these standards were focused on the understanding, recognition, and reasoning behind equivalent fractions and the understanding that whole numbers could be represented as fractions as well. While some research may relate to the standards, this study had direct and strong connections with the specific use of the standards within the investigation. These standards were of significant importance for this study and will be discussed more in depth during the explanation on the results.

Explanation of Results

Overall the result of this study produced neutral outcomes and inconsistent growth amongst students. It was essential for the researcher to find a method of instruction that made mathematics both comprehensible and engaging for students; therefore, the researcher compared regular classroom instruction to inquiry-based instruction. Inquiry-based instruction has been proven to increase studentsô engagement and achievement, but as the third grade teacher bridging the students from mathematics in Spanish in second grade to mathematics in English in fourth grade, I chose to try this method of teaching in English. The researcher believed English level had little to do with the scores, as one of the four students scored a level 6 on the Assessing Comprehension and Communication in English State-to-State (ACCESS) test (WIDA Consortium, 2007). When looking at the data presented in chapter four, all but two students showed some growth during regular instruction. There was a range of points in growth from zero to eight points per student during regular instruction; correspondingly, the students averaged approximately 2.8 growth points between the administration of the pre- and post-assessments. This growth may be attributed to the explicit instruction of the mini-lessons and the small, guided groups for the knowledge about fractions that the average math students were missing. Three students showed no growth during regular instruction; nonetheless, half of the class increased their scores by three or more points and a third of the class showed a slight growth of one to two points.

The researcher noted significantly higher growth in the CCSS Numbers & Fractions standards NF 2.1, 2.2, and 2.3, than on the first question about standard NF 1.1 which required students to partition two candy bars equally between six students. An explanation for this insignificant growth on the first question regarding CCSS NF 1.1 may be due to the fact that the problem involved two wholes, rather than one. Instruction had included only one whole item and the transfer of knowledge appeared to not be made to two whole items. For the final question of the assessment, only one student showed negative results, whereas the other students either stayed the same or increased their scores. The researcher believes the student who scored negatively on the last question scored this way due to low overall math comprehension for which the student was receiving extra support in a math intervention. Two of the students who showed no growth during this period were also receiving math interventions with this student. The third student who showed no growth during regular instruction succeeded with fractions when working with partners or in a small group with the teacher, but when required to work independently submitted inconsistent work. All of these students were in guided math groups that received additional sessions for assistance.

During the intervention four students had negative results and another four recorded zero growth. Three of these students registered no growth during the intervention session, while one student showed positive growth for one Numbers & Fractions standard, yet negative outcomes in another area. Student 6 failed to respond to the last two questions on the posttest, and student 24 failed to respond to the last question which accounts for two of the negative growth points. It was observed and noted during this time the other two students with negative growth presented behavior problems in the classroom and finished their posttest rapidly.

Ten students showed growth in their overall score as a result of the intervention; however, one of these students had negative results on one of the standards. Between the pre- and posttest, both the researcher and students gained insight into the fractions and the expectations that accompanied these questions. The researcher believed that this student may have just overthought the question since the student scored proficient on the pretest. The nine overall points growth standard NF 3.2 which required students to recognize and generate simple equivalent fractions and explain why the fractions are equivalent, come from the extensive focus on number lines during regular instruction, as well as during mini-lessons and guided math groups. Mini-lessons used number lines to extend past one whole; however, students may not have connected the concepts from the first period of regular instruction to the intervention instruction. Additionally, these outcomes could be attributed to students being more actively involved in the inquiry, therefore more involved in talking about it during the intervention period mini-lessons.

Students showed negative outcomes for standard NF 3.3 which asked students to express whole numbers as fractions, and recognize fractions that are equivalent to whole numbers; additionally, studentsô scores decreased for standard NF 3.4 required students to compare fractions with an equivalent numerator and justify their reasoning for why the selected one as greater than the other. Four students showed no growth on the post-test assessment, while six students had negative results. The students scored higher on standards NF 3.1 and 3.2 on the posttest, but less on standards NF 3.3 and 3.4 when looking at the overall points scored per assessment standard. This may be attributed to the fact that standard NF 3.1 required students to compare two fractions equivalent to one-half, but only provided one number line, which was confusing for the students; and, standard NF 3.2 was in a simple format, common to problems from the assessment for the regular instruction period. Standard NF 3.3 had many questions and directions in a small space which ELLs may have found confusing compared to the other items on the assessment. Standard NF 3.4 required students to compare two fractions with a common numerator, which is uncommon, but an expectation of the CCSS.

In review, the positive outcomes of this research may be due to four reasons. Explicit instruction supported the growth because it provided students the knowledge to be successful with fractions. Guided math groups supported students who needed extra help, provided additional support during practice, and enriched the instruction for those who were ready for higher levels of instruction. Another reason for positive outcomes was the appropriateness of the mini-lessons and the teacherõs willingness to adapt the lessons to meet studentsô needs. The final reason for positive results may be attributed to the increased student participation surrounding inquiry during the mini-lessons. The lack of growth could be attributed to four reasons. First, several students received external math intervention for continuously low performance on math performance indicators. The second possible reason for lack of growth may be due to questions the student may have left unanswered, such as the case of student 6. The third reason for positive lack of growth may be the individual studentôs behavior and lack of attention to the task at hand. The final hindrance to growth may have been the test format, which provided a lot of information and requests in a small space.

Strengths and Limitations

This study had both strengths and limitations. One of the strengths was the quality and consistence of instruction. The quality of instruction remained the same for both periods, with the addition of inquiry during the intervention. The students participated in a mini-lesson, guided math groups, independent application time, and share time for both types of instruction. This provided a stable instructional environment in which the students were learning. The second strength of the study was the use of the Common Core State Standards (CCSS) as the focus of instruction and the focus of the assessments. The CCSS require higher level thinking than previous criteria, yet having the standards as expectations from the beginning led to greater achievement during both periods of instruction. In addition, the assessments were created by the same team of professionals and were used across the district. This added validity to the study because these assessments were not created by the researcher specifically for use in this action research, but rather were created for standardized use across the district. The last strength was the use of growth points as the measure because this allowed all students to participate despite their academic level of mathematics and provided a fair comparison of results without impact from the content studied.

Although growth points accounted for differences in math knowledge, one limitation of the study was the inclusion of students receiving outside intervention for their already low math performance. This may have caused lower overall results because the students who received external interventions had lower scores on their assessments than the other students. A second drawback of the study was the use of English as the language of instruction. This fraction unit was the studentsô first exposure to mathematics in English outside of substitute days; while students enjoyed the change, there may have been some benefit to extra assistance outside of independent application time in their home language. The researcher intended to create lessons between second grade mathematics in Spanish and fourth grade mathematics in English by teaching the last unit in English, but achievement during the intervention session would not prove this bridge to have a positive impact on achievement. A third shortcoming, the CCSS were used for the first time this year in our district; while the researcher familiarized herself with these standards; it remained the first year of instruction with these new standards. Also, the questions on the assessments referred to quantities greater than one whole; fractions larger than one whole are beyond the scope of third grade, yet necessary if students are to excel in their performance. Students need to be allowed the opportunity to show advanced proficiency, but by limiting the students to the third grade content standards as they are written, limits students to perform proficiently, not more. Finally, the timeframe in which the researcher conducted this study was a weakness because ideally inquiry would have more time and external resources from which to draw the information.

Recommendations for Future Research

In looking at the strengths and limitations of the study, the researcher has several recommendations for future studies in inquiry-based instruction. The first recommendation is to amend the assessments to better reflect the expectations of the third grade CCSS; several problems required students to represent fractions using more than one whole and although they were provided instruction in these topics, the teaching was limited. This provided a stronger challenge to the students. Therefore amending the assessment to better reflect the CCSS and the higher level thinking necessary for success in mathematics would be recommended. A second proposal is to provide the students with the grading rubric prior to administration of the assessments. Best practice reveals that students perform better when they know the expectations ahead of time. Providing a rubric prior to assessment allows students to know how to achieve a score of proficient or advanced, since the instruction does not always lend itself to achieving at higher levels. Third, it would be beneficial to extend this study beyond the one bilingual classroom and into the mainstream English classrooms to measure the impact of inquiry-based instruction for all students. This would enable a comparison of the impact of inquiry-based instruction for native English speakers and ELLs. A larger sample with which to work may provide more insight into this study. Finally, the researcher recommends further scrutinizing the data into categories based on English proficiency levels, in order to measure the possible interference that proficiency may have on achievement.

Conclusion

Throughout this chapter the researcher connected this action research to current research and the Common Core State Standards, provided reasoning for the findings, presented the strengths and limitations of the study and continued to provide recommendations to remedy issues encountered during the study. The researcher found previous research provided a solid base on which to form the hypothesis that hands-on, inquiry-based instruction would work well for English language learners; however, this study showed that inquiry-based instruction did not significantly impact the achievement of ELLs, but rather adversely affected the studentsô achievement in comparison with regular classroom instruction. The outcome of this research may be due to the positive impact of explicit instruction, guided math groups, and appropriate mini-lessons. The lack of growth may be attributed to the low math performance of individual students, lack of response to test items, individualsô behavior, the transition from Spanish to English instruction and/or the format of the assessment. As the third grade teacher bridging the students from mathematics in Spanish in second grade to mathematics in English in fourth grade, it was essential for the researcher to find a method of instruction that makes mathematics both comprehensible and engaging for students; however, in this case regular classroom instruction outperformed inquiry-based instruction. The results of this study will allow the researcher to redesign instruction in the future. Forthcoming there will be more time provided for student-originated inquiry. Additionally, the researcher will provide rubrics for the students prior to instruction and assessment.

The experience of this action research study has changed me as an educator. As an instructor, I have strived to keep current with research; yet, before conducting my own classroom-based research, I never realized the work involved in the studies I had read. Additionally, the use of claimed best practices does not work for all students, in all situations. Working with the specific population in the school where I teach provided new insight into the impact of teaching strategies on English Language Learners. Furthermore, the coursework for my masterôs has given me a solid foundation on which to plan for my studentsô instruction. I know more than I ever had about my students and teaching them in English. The results from the regular instruction show that my English instruction had little influence on the results of the study. Overall, this action research has provided me with more questions, as well as offering me a vehicle through which I can conduct my own classroom-based research in the future.

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Appendices

Appendix A

Number & Operations— Fractions[1] Standards 1 and 2

Develop understanding of fractions as numbers.

- NF 1.1 Understand a fraction 1/*b* as the quantity formed by 1 part when *a* whole is partitioned into *b* equal parts; understand a fraction *a*/*b* as the quantity formed by a parts of size 1/*b*.
- NF.2.1 Understand a fraction as a number on the number line; represent fractions on a number line diagram.
  - NF.2.2 Represent a fraction 1/*b* on a number line diagram by defining the interval from 0 to 1 as the whole and partitioning it into *b* equal parts. Recognize that each part has size 1/*b* and that the endpoint of the part based at 0 locates the number 1/*b* on the number line.
  - NF 2.3 Represent a fraction *a*/*b* on a number line diagram by marking off a lengths 1/*b* from 0. Recognize that the resulting interval has size *a*/*b* and that its endpoint locates the number *a*/*b* on the number line.
- [1] Grade 3 expectations in this domain are limited to fractions with denominators 2, 3, 4, 6, 8.

Appendix B

Number & Operations— Fractions[1]: Standard 3

Develop understanding of fractions as numbers.

- NF 3 Explain equivalence of fractions in special cases, and compare fractions by reasoning about their size.
  - NF 3.1 Understand two fractions as equivalent (equal) if they are the same size, or the same point on a number line.
  - NF 3.2 Recognize and generate simple equivalent fractions, e.g., 1/2 = 2/4, 4/6 = 2/3. Explain why the fractions are equivalent, e.g., by using a visual fraction model.
  - NF 3.3 Express whole numbers as fractions, and recognize fractions that are equivalent to whole numbers. *Examples: Express 3 in the form 3 = 3/1; recognize that 6/1 = 6; locate 4/4 and 1 at the same point of a number line diagram*.
  - NF 3.4 Compare two fractions with the same numerator or the same denominator by reasoning about their size. Recognize that comparisons are valid only when the two fractions refer to the same whole. Record the results of comparisons with the symbols >, =, or <, and justify the conclusions, e.g., by using a visual fraction model.

[1] Grade 3 expectations in this domain are limited to fractions with denominators 2, 3, 4, 6, 8.

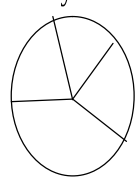
Appendix C

<table>
<tr>
<td>NF.1.1 Understand a fraction 1/b as the quantity formed by 1 part when a whole is partitioned into b equal parts; understand a fraction a/b as a quantity formed by a parts of size 1/b.</td>
<td>

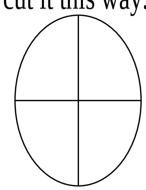
- Six children shared 2 candy bars so that each child receives a fair share. What portion of each candy bar will each child receive? Draw a picture to show your thinking.

- Jennifer was sharing a pizza with her three friends.

Suzie said she could
cut it this way:



Nia said she could
cut it this way:



If Jennifer wants each person to get ¼ of the pizza, which one should she choose and why?

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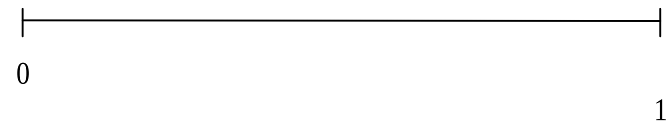
<table>
<tr>
<td>NF.2.1
Represent a fraction 1/b on a number line diagram by defining the interval from 0-1 as the whole and partitioning it into b equal parts.</td>
<td>• Partition the number line into four equal parts. Label each fractional part.

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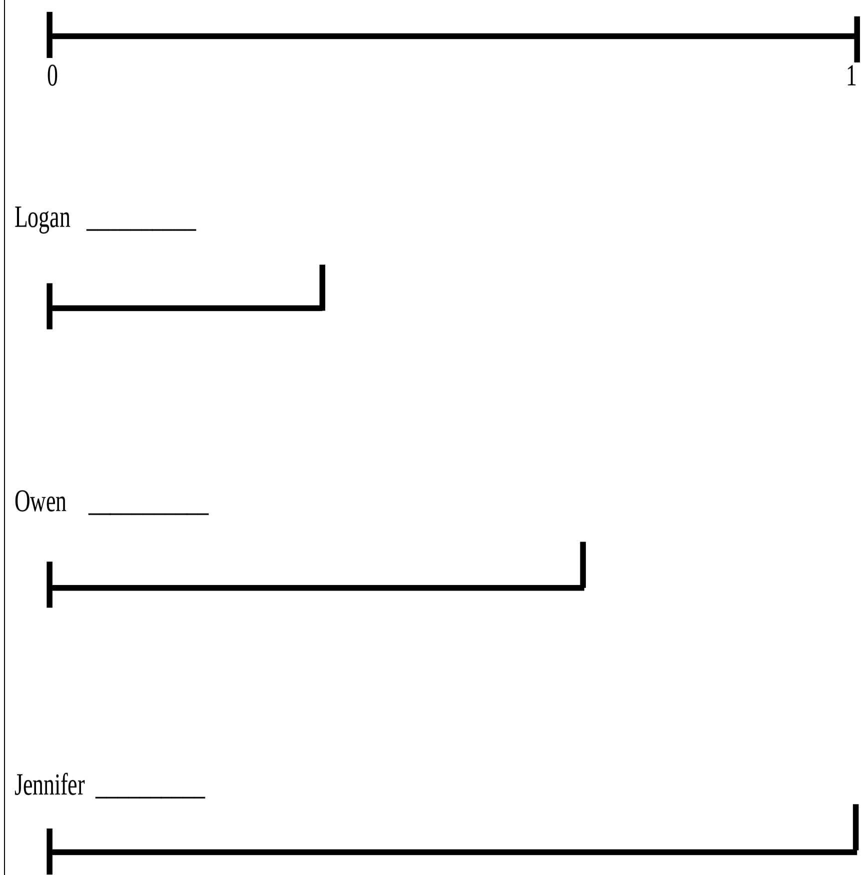
<tr>
<td>NF.2.2
Recognize that each part on a number line has size 1/b and that the endpoint of the part based at 0 locates the number 1/b on the number line.</td>
<td>• Partition the number line into three equal parts. Label each fractional part.

</td>
</tr>
</table>

NF.2.3 Represent a fraction *a/b* on a number line diagram by marking off a lengths *a/b* from 0. Recognize that the resulting interval has size *a/b* and that its endpoint locates the number *a/b* on the number line.	• Logan, Owen, and Jennifer raced each other in the park. The lines represent how far they each ran. What fraction of the field did they each run? Write the fraction next to where they stopped. 

Appendix D

Table D1

Pretest Scores for Regular Instruction

	N.F 1.1	N.F 1.1	N.F 2.1	NF 2.2	NF 2.3
1	2	1	1	1	1
2	2	2	2	2	1
3	1	1	1	1	1
4	1	1	2	2	1
5	2	2	2	2	1
6	1	2	2	2	2
8	2	1	2	2	1
10	1	2	2	2	1
11	1	1	2	2	1
12	1	2	2	2	1
13	1	2	1	2	1
14	1	1	2	1	1
15	2	2	2	2	1
16	2	2	1	1	1
18	1	1	1	1	1
21	1	2	1	1	1
22	1	2	1	1	2
24	1	1	1	1	2

Table D2

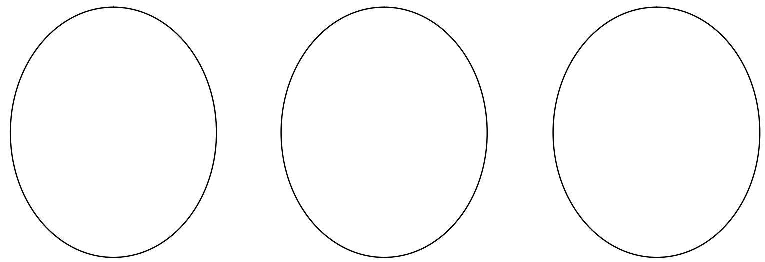
Posttest Scores for Regular Instruction

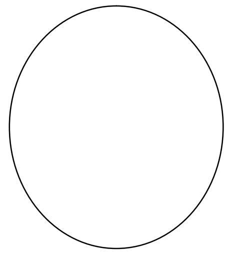
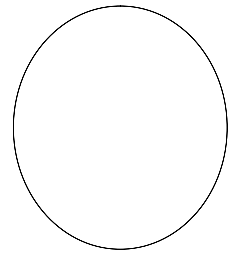
	N.F 1.1	N.F 1.1	N.F 2.1	NF 2.2	NF 2.3
1	2	1	1	1	1
2	3	3	3	3	3
3	1	2	3	1	1
4	1	1	1	3	2
5	1	2	3	3	3
6	1	3	3	3	3
8	2	3	1	1	1
10	1	2	3	3	2
11	1	2	1	1	2
12	1	2	2	2	2
13	2	3	2	1	1
14	3	3	1	4	2
15	3	3	2	2	4
16	1	2	3	3	1
18	1	3	1	1	2
21	1	1	4	4	1
22	1	3	4	4	3
24	1	3	1	1	1

Appendix E

NF.3.1 Understand two fractions as equivalent (equal) if they are the same size, or the same point on a number line.	• Brian has challenged Lupe to a ñmath battle.ò He claims that 5/10 is larger than 3/6, because the numbers are bigger. Lupe told him that he was wrong and that they are actually equivalent, but she didnt know how to prove it. Is Brian or Lupe correct? How do you know? Use the number line to show how you would explain this ñmath battle.ò 

NF.3.2 Explain, recognize, and generate simple equivalent fractions.	• Divide this line into three equal parts. Label each part. Divide this line into six equal parts. Label each part. Looking at the two lines, name two fractions that are equivalent. Explain why they are equivalent fractions. Name another two fractions that are equivalent.

NF.3.3 Express whole numbers as fractions, and recognize fractions that are equivalent to whole numbers.	During the summer, Michelle works at Jumboôs Super Pizza Palace to make extra money. When she slices each pizza for the customers, she likes to cut the pizzas into 8 pieces. If a family orders two pizzas, create a fraction to show how many pieces they are going to get. ____________  If she decided to cut 3 pizzas into 8 pieces, which fraction would show this? ____________ Compare the two fractions using >, < or = and tell how you know. ____ ____

NF.3.4 Compare two fractions with the same numerators or the same denominators, record the results of comparisons with symbols, and justify the conclusions.	While working at Jumbo's Super Pizza Palace, one family wanted their pizza cut into six slices. Another family wanted their pizza cut into eight slices. Show the two pizzas below. In each family, the kids ate 3 slices of pizza. What is the fractional part that the kids ate for each pizza?   Fraction: ______________ Fraction: ______________ Compare the two fractions using >, < or = and tell how you know.

Appendix F

Table F1

Intervention Pretest Scores

	N.F 3.1	N.F 3.2	N.F 3.3	NF 3.4
1	1	1	0	1
2	1	3	1	1
3	1	1	1	2
4	1	1	1	1
5	1	1	1	2
6	0	1	1	1
8	1	1	1	2
10	1	2	1	2
11	1	1	1	1
12	1	1	1	1
13	1	1	1	1
14	1	1	1	2
15	1	1	1	1
16	1	1	1	1
18	1	1	1	2
21	1	1	3	2
22	1	2	1	2
24	1	1	0	2

Table F2

Intervention Posttest Scores

	N.F 3.1	N.F 3.2	N.F 3.3	NF 3.4
1	1	1	1	2
2	1	2	1	2
3	1	1	1	1
4	1	2	1	1
5	1	2	1	1
6	0	2	0	0
8	1	1	1	1
10	2	3	1	2
11	1	1	1	1
12	1	1	1	1
13	1	2	1	2
14	1	1	1	1
15	1	1	1	3
16	1	2	1	1
18	1	1	1	1
21	2	3	1	2
22	1	2	1	2
24	1	1	1	0