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Spatial Temporal Math: Examining the Gender-Related Achievement Gap

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Thesis Abstract

Education is changing rapidly with the integration of educational technology. School districts are adopting various technology programs to assist with intervention, achievement and engagement. The question remains if these programs are worth the investment. A school district in San Diego County implemented the Spatial Temporal approach to teaching mathematics from the MIND Institute's suite of educational technology software. A study was conducted in order to determine if the students, specifically females, were making significant progress on their benchmark tests with the usage of this approach to learning mathematics as part of a blended learning environment. A quantitative approach was used to examine this program's effectiveness amongst both male and female students the second grade. Results from the study indicate that there is no increased achievement for girls or boys on district-wide benchmark tests when students complete more than the average number of objectives compared to their peers in the ST Math program. However, more research is needed in order to investigate the program further.

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Chapter 1: Statement of the Problem

Mathematics education in the United States has always been an evolving process with the adoption of new standards with shifts in curricula. Students graduating from U.S. high schools are underprepared to enter academic fields that require proficiency in mathematics and science. According to the most recent report by PISA (2012), the U.S. ranked 27th in mathematics performance amongst the 34 highest achieving countries throughout the world.

Purpose of Study

The main objective of this study is to add to the current research of a spatial-temporal (ST) approach to teaching mathematics at the elementary age, and specifically between boys and girls. Research has suggested that there is a gender gap in mathematics achievement (AAUW, 2010). ST Math is a technology company that has developed a Computer Assisted Instruction (CAI) program that targets a spatial approach to teaching math beginning at the kindergarten level. The research question are: How will using the ST Math program in a blended learning environment help close the gender-related achievement gap in mathematics? Does using ST Math impact student achievement in relation to ethnicity, homelessness or classroom? The research conducted will help gain further insight into the way a spatial-temporal approach to mathematics may be key to developing a greater foundation in mathematics in the second grade.

Preview Literature

Literature on spatial abilities suggests there is a link between spatial ability and achievement in the areas of science, technology, engineering, and mathematics

(Rutherford et. al, 2010). Studies involving a spatial-temporal approach to learning math have been linked to higher standardized test scores in mathematics. Research conducted by Linn and Peterson (1985) suggests that, on average, girls have lower level spatial ability than boys. A review of the literature suggested that by adapting a spatial-temporal approach to teaching mathematics, confidence would be built in one's ability to succeed in both math and science courses. Significant progress may be made toward closing the gender achievement gap through addressing girls' confidence and abilities in math and science education. The ST Math program may increase this academic ability in girls.

Preview Methodology

In order to verify a relationship between the usage of ST Math in a blended learning environment and gender-related student achievement, a group of 150-second grade students' performances on district benchmark math exams were studied. All 150 students used the ST Math program between their first and second benchmark assessment. Quantitative data was collected for a statistical analysis on the benchmark exam, the Northwest Evaluation Association (NWEA) measures of academic progress (MAP) assessment, which is aligned to Common Core State Standards. The analysis of the data will be used to see if there is a relationship in the data between the student gender variable. Data from the usage of the educational software ST Math was analyzed to see if there was a difference between the second grade boys and girls on the MAP from benchmark 1 to benchmark 2 results to determine if the gender achievement gap was affected as a result of the spatial approach to learning mathematics. Data outcomes were also analyzed to see if a ST approach to mathematics impacted students according to ethnicity, socio-economic status, or classroom placement.

Significance of Research Study

Research was lacking on the study of ST Math with regards to the strength of the program for girls. Thus, my research focused on the implementation of ST Math in a blended learning environment at the elementary level to examine if its usage increased spatial skills in students. It is hoped that the outcome of this study will provide significant insight into the factors that influence gender-related ability to develop the foundational skills necessary to be successful in mathematics.

Conclusion

The objective of this study was to focus on the relationship of girls' spatial ability in mathematics and academic achievement in order to increase their mathematical skills that can be built upon as they continue their educational journey. Chapter two will provide a connection to literature and theories that are relevant to the study at hand.

Definitions

Benchmark testing: Benchmark assessments are computerized adaptive tests administered district-wide in the fall, winter and spring of each school year. The tests are used to project students' achievement levels on statewide-standardized tests, which are administered at the end of every school year starting in the third grade.

Blended Learning: A setting where students spend part of their instructional time with digital curricula and part of their time with more traditional teacher led curricula instruction (Nisbet and Luther, 2014).

Computerized Adaptive Testing: A form of computer-based **testing** that adapts to the examinee's ability level.

Local Control Funding Formula: California's 2013-14 Budget Act approved a new state school finance system that greatly simplifies and makes decisions local in the way schools are funded in California. This new method is known as the Local Control Funding Formula (LCFF) and represents a major shift in how California school districts were previously funded.

Raunch Unit: (RIT) is a score from 150 to 300 on the benchmark (NWEA) test. This tells the students' instructional level.

STEM Education: Science, technology, engineering, and mathematics (STEM) education is used to identify individual subjects, a stand-alone course, a sequence of courses, activities involving any of the four areas, a STEM-related course, or an interconnected or integrated program of study.

Spatial Temporal Math: A large educational suite of software developed by the MIND institute to elevate students' math achievement (Nisbet and Luther, 2014).

Spatial Ability: Spatial ability is the capacity to understand and remember the spatial relations among objects. This ability can be viewed as a unique type of intelligence distinguishable from other forms of intelligence such as verbal ability, reasoning ability, and memory skills. Spatial ability is not a monolithic and static trait, but made up of numerous subskills, which are interrelated among each other and develop throughout life (Sorby, 2009).

Chapter 2: Literature Review

Spatial abilities have been linked to expertise in science, technology, engineering, and mathematics fields (Rutherford et. al, 2010). Currently, students graduating from U.S. high schools are underprepared to enter STEM fields, which require academic proficiency in mathematics and science. In the most recent PISA (2012) assessment, top-performing students in the U.S. ranked well behind students in the highest achieving countries. Additionally, students in the State of California rank near the bottom on national math assessments. Fourth graders scored 46th in the nation in math and eighth graders ranked 43rd (Mongeau, 2013). The MIND Research Institute has developed a large suite of educational software that was designed to elevate students' math achievement (Nisbet and Luther, 2014). Spatial-Temporal Math (ST Math) is an instructional tool that can be used in blended learning environments. Blended learning involves a setting where students spend part of their instructional time with digital curricula and part of their time with more traditional teacher led curricula instruction. Research has been conducted on this particular math program as well as others to gage their impact on student achievement in mathematics (Kibrick et. al., 2010; Rutherford, et. al, 2010; Wendt & Rice, 2013).

Research has often suggested that, on average, girls have lower level spatial ability than boys (AAUW, 2010; Linn & Peterson, 1985). My study focused on giving both boys and girls the tools to build their spatial ability at an early age with ST Math that it might help them close the gender-related achievement gap in mathematics. A review of the literature suggests that by adapting a spatial- temporal approach to teaching mathematics, confidence would be built in one's ability to succeed in both math and science courses (Kibrick et. al., 2010; Rutherford, et. al, 2010; Wendt & Rice, 2013) .

Also, many computer assisted technology programs exist that attempt to improve students' achievement with the challenge being which ones should be adopted at the district level (Hu, Bodnew, Jones, Peterson, & Shaw, 2004). Districts now have increased freedom to make data-driven instructional decisions with the recent shift to localized funding with the implementation of the Local Control Funding Formula (LCFF) (Local Control Funding Formula, 2014).

Data Driven Reform and Computer Assisted Instruction

The push to improve test scores has led to substantial interest in the use of data within schools and districts to drive decision-making and motivate change (Slavin, Holmes, Madden, Chamberlain, & Cheung, 2010). Data-driven reform involves collection, interpretation, and dissemination of data intended to inform and guide decisions. Often, districts embark on data-driven reform by adopting benchmark assessment given three to five times a year to determine whether students are on track to improve on their annual state assessments. In 2004, the US Department of Education funded research and developed the Center for Data-Driven Reform in Education (CDDRE.) This program was intended to help district leaders understand and supplement their data, identify root causes underlying important problems, and then select and effectively implement programs directed toward solving these problems (Center for Data Reform in Education, 2004). The CDDRE found that after working with the sample school districts, just having leaders understand student data was not enough to produce gains in achievement. Schools must actually take action to change teaching and learning (Slavin, Holmes, Madden, Chamberlain, & Cheung, 2010).

Nank (2011) defines that in the traditional math classroom, the teacher is the sole possessor of knowledge. Recently, there has been a shift away from teacher-centered instruction, where the teacher provides step-by-step instruction and the students learn to repeat the process exactly as the teacher has shown. A study conducted by Slavin, Lake, and Goff (2009), sought to help leaders make informed decisions on the effectiveness of alternative approaches to teaching mathematics. The study looked at tools, textbooks, and computer programs to see which were most effective in the teaching and learning of math. The Computer Assisted Instruction (CAI) programs were found to be useful in identifying children's strengths and weaknesses and allowed for self-taught exercises to fill in any gaps. Their findings on the use of CAI mentioned that there is a need for further research into the effectiveness of these programs (Slavin, Lake, & Groff, 2009).

Computer assisted teaching is an interactive teaching method in which computers are used to boost student motivation and to help them keep up with their own pace of learning (Seo & Bryant, 2012). CAI programs have shown to have an overall positive effect on students' math achievement. The integration of CAI as an intervention is well represented in current literature (Karamustafaoglu, 2012; Ke, 2013; Maloy, Edwards, & Anderson, 2010; Seo & Bryant, 2012). These studies found an improvement in math performance when CAI programs were used as a response to intervention. Furthermore, Nisbet and Luther (2014) mentioned ways in which learning can be transformed by technology as it gives students the ability to receive real-time feedback that would be challenging for an individual teacher to provide.

The CAI approach to math intervention has not always been found to be effective (U.S. Department of Education, 2012). The study-assessed the effectiveness of Odyssey

Math, which is a web-based K-6 mathematics curriculum and assessment tools designed to enable teachers to differentiate student instruction and make data-driven decisions. Each Odyssey Math module contains learning activities for students that include narrative descriptions of how to solve problems, practice tasks, complete quizzes, and give feedback. Two thousand four hundred fifty-six fourth-grade students in one hundred and twenty-two classrooms in Delaware, New Jersey, and Pennsylvania used the program as an intervention for sixty minutes each week. The comparison classrooms used their school's standard mathematics curriculum for the total math instruction time. The study assessed the effectiveness of Odyssey Math by comparing the mathematics achievement of students in the intervention and comparison groups in the spring of the implementation year. The study found no discernible effects of Odyssey Math on mathematics achievement (U.S. Department of Education, 2012). With so many CAI programs available, it is difficult for districts to know which programs to implement in order to increase student achievement.

Gender-related spatial-temporal approach

Although brain research shows that a spatial- temporal approach to learning mathematics is crucial for the understanding of math and science at all educational/grade levels, it is essentially ignored in schools (Hu, Bodner, Jones, Peterson, & Shaw, 2004; Miyake, Friedman, Rettinger, Shah, & Hegarty, 2001). Spatial-temporal (ST) reasoning is simply defined as the ability to think in patterns (Hu, Bodner, Jones, Peterson, & Shaw, 2004). ST reasoning has been shown to be innate to the structured columnar cortex of the brain and to be highly trainable. Measures of spatial ability involve activities such as mental rotation of objects, perception of horizontality, and location of simple figures

within complex figures. However, language based approaches (equations, word problems, symbols) are usually the focus when teaching math today. According to research by Miyake, Friedman, Rettinger, Shah, & Hegarty (2001) people generally have less practice on spatial than on verbal tasks, and may have more room for improvement on spatial tasks.

Gender gaps in cognitive skills in the area of spatial skills are prevalent as research suggests that men outscore women by a medium to large margin (Linn & Petersen, 1985; AAUW, 2010). Research conducted by Linn & Peterson (1985) showed that spatial skills can be improved through practice, finding that these skills can be learned and one does not have to be born with them. Sorby's (2009) study of female engineering students at Michigan Technological University in the early 1990's found that individuals could dramatically improve their 3-D spatial-visualization skills within a short time. With proper training, female engineering students with poorly developed spatial skills who received spatial-visualization training were more likely to stay in engineering than their peers who do not receive training. Sorby (2009) conducted a similar study at the middle school level. It was found that girls who took a spatial-visualization course took more advanced-level math and science courses in high school than did girls who did not take the course. The findings also suggested that girls with well-developed spatial skills had the confidence they needed to succeed in math and science courses and ultimately in a STEM career. The research recommended that spatial training happen by middle school or earlier to make a difference in girls' choices (Sorby, 2009).

Gender research related to girls' math motivation and confidence building was found to be positively and significantly related to math and science grades, parents' education, parents' math and science support, parents' English support, gender-related attitudes, and exposure to feminism (Leaper, Farkas, and Brown, 2012; Riegle-Crumb, Moore, and Ramos-Wada, 2011). Researchers reported that females from all backgrounds tended to have less enjoyment and self-concept in math and science than White males. The results indicate that at an early stage of a young person's life, before they enter high school, disparities in science and math career aspirations are apparent. To ensure that future generations of math and science degree recipients and workers better reflect the diversity of the nation, more research is needed that focuses on understanding how to prevent female adolescents from prematurely closing the door on future careers in these fields.

Since gender differences in spatial abilities have been linked to mathematics and science performance as early as adolescence, more needs to be done to further the development of spatial skills at a younger age in order to close the gender-related achievement gap in mathematics. "The propensity of boys to think spatially has even been proposed as one explanation for the science achievement gap between boys and girls" (AAUW, 2010, p. 52). This quote is a call to find ways to increase girls' spatial ability so they can reach their full potential in math and science.

ST Math/Blended Learning

Technology is a rapidly developing area and Computer Aided Instruction programs are becoming ever more sophisticated (Slavin, Lake, & Groff, 2010). Computer games that focus on using ST approaches to learning math according to Slavin,

Lake, & Groff (2010) should be considered at the elementary level in order to address the gender-related gap in mathematics. The ST Math suite of computer software developed by The MIND Research Institute initially minimizes the use of mathematical symbols, terminology, and language (Rutherford et. al, 2010). The spatial temporal approach is innovative as it goes away from traditional CAI math curricula and replaces it with dynamic shapes as representations of the mathematical puzzles to be solved. ST Math is delivered through one to one visual-spatial interactive games that provide an animated learning environment where students work at their own pace. The ST Math software game parallels the classroom standards for K-5 students (Kibrick, Richland, Martinez, & Bodner, 2011). The purpose of the games is to move a penguin, Jiji, from one side of the screen to the other by completing the math puzzles. Each grade contains levels that match curricular units found in more traditional classroom instruction. The game is composed of between one and ten levels of increasing math difficulty. The levels consist of a series of puzzles, and students must finish the required number of puzzles before making two mistakes before the game will continue. ST Math scaffolds student learning of mathematics through the student interactions with the game interface.

Fraij (2010) discussed the ways effect feedback can positively affect the performance of the learner. Through the use of CAI systems, he found that learners who received rapid, effective feedback from the system had an advantage over those who used traditional CAI systems with limited feedback. Fraij (2010) stated, "Feedback assists learners to restructure their knowledge and support their metacognitive process" (p. 67). Since research has found feedback to be so valuable, ST Math provides a very high frequency (on average, twice per minute) of corrective feedback, and allows for the

gradual introduction of mathematics principals within lessons (Rutherford et. al. 2010). Correct solutions in ST Math are animated to show why they are correct. Likewise, incorrect solutions are interactively animated to show why they fall short and often to indicate how the response differs from an ideal solution. CAI programs such as ST Math that provide corrective feedback put the learner at an advantage.

A review of the current literature identifies a link between student achievement and the use of ST Math (Kibrick et. al., 2010; Rutherford, et. al, 2010; Wendt & Rice, 2013). Rutherford's study (2010) sought to address the longstanding dilemma of American students underperforming in the discipline of mathematics. This study used the ST Math curricula to see if students benefitted by this approach to learning mathematical skills and concepts. The study population consisted of two cohorts of ethnically diverse, majority Latino schools in Orange County, California. Thirty-four schools were eligible to participate in the study. There were two criteria for school participation which were either they were not current users of ST Math, and/or they were willing to implement the program at grade levels 2/3 or 4/5 which were selected at random. The students from the various schools were assigned to an intervention group and spent two forty-five minute sessions each week working through the software under the direct supervision of their classroom teacher. The data that were collected were from the California Standardized Test scores, and ST Math. The casual-comparative method for data analysis was used to explore a possible cause and effect relationship between identified variables. The findings concluded that both treatment and control groups made year-to-year gains in CST math raw scores, but treatment group gains were significantly larger. The data suggests that the spatial-temporal approach to mathematics instruction

as expressed the ST Math software can lead to gains in broad mathematics proficiency in the elementary school grades as measured by standards-based state assessments (Rutherford, 2010).

Results seemed to differ when further study suggested that certain population groups might not have benefitted from a spatial-temporal approach to mathematics (Rutherford et. al, 2010). ST Math was intended in part to meet the needs of learners who are underserved by traditional curricula. Achievement gaps persist in mathematics achievement between native speakers and English language learners (ELL), between boys and girls, and between students of different income levels (National Association of Educational Progress, 2013). An analysis of variance (ANOVA) was run to see if possible interactions existed between ST Math and grade, gender, ELL status and economic status. According to this research, no interactions with the subgroup data were significant. However, the study did report some significant gaps in research method analysis and practices with reference to the various subgroups. The findings may be diluted because significant contamination was evident across treatment and control grades as some classrooms were made up of students in multiple grades. Additionally, some students only used ST Math as part of an after school program and thus were not supervised by credentialed teachers while engaging with the program. More importantly, this study did not collect data as to what degree participants participated in the program (Rutherford, 2010). Wendt and Rice (2013) looked at the implementation of ST Math at 45 elementary schools in the Los Angeles Unified School District to see if it had any correlation to improved CST math scores. The study population included more than 9,000 second through fifth grade students. Grade-wide implementation was the one

strength of this study as CST math scores and proficiency level percentages were used to provide data. The comparison group was identified based on similar demographics as well as previous reading and math performance. The study found a statistically significant higher proportion of students who scored at the advanced level in schools using ST Math. Also, the proportion of students who scored either proficient or advanced was well beyond the federal What Works Clearinghouse of criteria of 0.25 for "substantively important" effect (U.S. Department of Education, 2012). The study looked at one year of ST Math implementation and reported a 10.4-point increase in the weighted mean percent of students scoring proficient or advanced on the CST, compared to 6.5 points at the comparison schools (Wendt & Rice, 2013). This study did not collect data from subgroups to determine the effectiveness of ST Math on different populations. Neither did it report on to what extent the program was implemented to detect its findings.

The literature reviewed points to a need for future analysis of ST Math to see if implementation as blended learning might help address the achievement gap in mathematics (Rutherford et. al, 2010; Wendt & Rice, 2013). A blended learning environment involves a setting where students spend part of their day with traditional teacher-led instruction and part of their time using digital curricula (Nisbet & Luther, 2014). There are advantages to implementing ST Math in a blended learning environment because it promotes deeper learning by personalizing student skill building and problem solving as students discover math for themselves. With this approach to learning the teacher's role shifts from lecturer to facilitator. One benefit of blended learning is the ability of the instructor to constantly adjust the structure of educational

materials to best meet student needs. Nisbet and Luther (2013) state, "Harnessing the power of blended learning is an obvious choice for educational leaders who are approaching the new standards and assessments as a way to personalize instruction and better prepare students to be college- and career-ready" (p. 16). With so much expected of educators and students today with the adoption of the Common Core State Standards Initiative, blended learning offers a solution to scaffolding instruction to provide a dynamic learning experience for all students (Common Core State Standards Initiative, 2011).

Conclusion

The research points to the value in investigating a blended learning approach to using ST Math as a means to improve the spatial-temporal differences in gender-related achievement in mathematics. Although computer assisted instruction represents a rather significant departure from traditional pedagogy, the new learning standards call for deeper learning. Improving instruction and meeting the needs of a diverse group of learners is one of many challenges facing educators today. A review of the pertinent literature reveals the importance of the development of spatial skills at an early age to build confidence in girls in mathematics. Since ST Math has proven to increase student proficiency on standardized tests, this study aims to explore how using ST Math might close the gender-related achievement gap in mathematics.

Chapter 3: Methodology

The purpose of the study is to gather benchmark data from students to see if the use of ST Math in a blended learning environment showed relationship to gender in mathematics achievement. School districts across the country have implemented ST Math as new academic standards have been adopted. This study looked at implementation of ST Math as part of computer-assisted instruction in a blended learning environment to increase student achievement, particularly that of girls. The focus of this study was on second grade students in multiple elementary schools in one school district during the 2014-2015 school year.

Design

A casual comparative approach to collecting data was selected as the research method. This method was used to examine if a cause- effect relationship existed between the independent and dependent variables. The purpose for choosing this method was that it provided a way to analyze numerical scores that were collected when students participated in routine benchmark assessments. Data were collected for these reports using standards-based benchmark assessments as part of Northwest Evaluation Association's (NWEA) measures of academic performance assessments (MAP) grade level summary reports for mathematics. The study examined the data to see how the girls performed on the benchmark math test two compared to the boys after receiving instruction in the ST Math curriculum. The data was also analyzed according to ethnicity, socio-economic status and classroom assignment to see if any further correlations could be drawn according to these groupings.

Participants

Data was collected from seven classrooms of heterogeneously grouped second grade students. Each classroom had approximately 23 students enrolled at the beginning of the 2014-2015 academic school year. The total numbers of participants for the study were 75 male and 75 female second grade students. Not included in the study was Special Education students in special day classes or students who were absent the day of the benchmark test. Students were not directly involved in the study, but their data was collected as part of the normal school activities. Standards based computer adaptive (NWEA) (MAP) assessments were the basis for measurement of success. The second grade students all had equal access to ST Math, although usage varied amongst participants.

Setting

A North San Diego suburban elementary school provided the student data for this study. This school is conducive to my study, as it has implemented ST Math as part of a blended learning environment. This was a K-5th grade elementary school that represented the diverse population of San Diego County. The demographics of the sample population included 2% Black or African American, 4.9% American Indian or Alaska Native, 1.1% Asian, 0.8% Filipino, 32.6% Hispanic or Latino, 0% Native Hawaiian/Pacific Islander, 3.7% Two or More Races, and 54.2% White. In addition to the ethnic diversity of the campus, socio-economically disadvantaged students (SES) comprise 35.9%, 16. 9% are English language learners (ELL), 9.6% are students with disabilities.

Instruments

Quantitative data was collected on the Northwest Evaluation Association (NWEA) measures of academic progress (MAP) assessment, which is aligned to Common Core

State Standards. (NWEA) class summary reports for mean language and reading using a Rauch unit (RIT) for measurement were examined to determine a baseline, growth analysis in mathematics, and goal projections. The (RIT) score is a score ranging anywhere from 130-300 that tells the students' instructional level. Based on the students grade level and time of year, the following can be determined: where students stand in comparison to other students in their grade level based on national norms (Percentile Score) and what the expect growth (RIT Points) for the student are.

Analysis of this data is a normal part of instructional practice for this school. Quantitative data was collected using (NWEA) summary grade level reports for mathematics and overall growth by measuring mean (RIT) scores.

Procedures

The principal of the school approved the planned study for the 2014-2015 school year. Data collection and student populations were identified. Next, the second grade teachers who used ST Math and NWEA data for the 2014-2015 school year were made aware of the study. The district has mandated using ST Math in a blended learning environment at this school site for the entire school year. Participating teachers were also made aware of the tracking monitoring provided by the ST Math program. The teachers were informed that (NWEA) Common Core standards assessment data would be utilized to measure academic growth in mathematics by measuring grade level participation in ST Math compared to the mean (RIT) growth, projections, and sub-group achievement. My position is second grade teacher at the school site where the data was collected. All identifiers were stripped from the data collected. No names were associated with the data or the reported results.

Data Analysis

Northwest Evaluation Associates (NWEA) measures of academic performance (MAP) benchmark data from the fall and winter testing windows were disaggregated to identify if a relationship existed between the MAP benchmark exam and male and female second grade students who had access to the ST Math program. The MAP tests have been an approved testing method according to the National Center on Response to Intervention and have been deemed consistently considered statistically significant and reliable. MAP tests were administered to second grade students in the computer lab during a two-week testing period, both in the fall and winter school-wide testing windows. Analyzing this data may reveal patterns across genders based on usage of the ST Math curriculum. Further investigation into ethnicity and gender-related achievement gaps may provide additional data for future studies.

Conclusion

This study employed a casual- comparative research approach to data analysis in order to investigate if a difference existed between second grade boys and girls when integrating ST Math in a blended learning environment and mathematics achievement. Findings from this research will provide a basis for understanding if ST Math is an effective program to develop spatial math skills in elementary school aged girls in order to narrow the gender-related achievement gap.

Chapter 4: Data Analysis

The United States' schools continue to score lower in mathematics achievement compared to other countries throughout the world. Research has suggested that a gender gap in mathematics achievement exists (AAUW, 2010). Research was lacking on the study of Spatial Temporal Math (ST Math) with regards to closing the gender achievement gap. Thus, my research focused on implementation of ST Math in a blended learning environment to show a relationship when students in second grade used it to develop their mathematical spatial skills. In an effort to better understand the gender achievement gap in mathematics, a study was conducted to see if there was a difference between the development of spatial abilities in mathematics and achievement between boys and girls. The research questions for the study were: How will using the ST Math program in a blended learning environment help close the gender-related achievement gap in mathematics? Does using the ST Math program impact student achievement in relation to ethnicity, homelessness or classroom?

The participants in this study were 150-second grade students in seven different classrooms who all attended the same elementary school. Of the participants, 50% (n=75) were male, and 50% (n=75) were female. The participants completed both the fall and winter district-wide Measures of Academic Performance (MAP) benchmark tests. The results of the benchmark tests were compared to the individual student's overall progress in the ST Math online curriculum. Results of the benchmark assessment, including an explanation of data, visual representations, research analysis, and researcher interpretations will be discussed in Chapter 4.

Data Presentation: Demographic Data

According to the district's student registration system, 75 female students and 75 male students completed the Math (NWEA) benchmark tests in the winter and fall testing periods. The male and female demographics were nearly identical (see Apendix A) with 48% of males and 52% of females being White. The next significant group was the Latino, with 37% males and 32% females. The remainder of the students was small numbers of Asian, Native American, and two or more race children. Parents and/or guardians indicate ethnicity as a part of the district's registration process. Based on the data, the largest ethnic group of female participants was White, followed by Hispanic. There is no distinguishable difference in ethnicity between the boys and the girls in the study.

Data Presentation: Benchmark Data

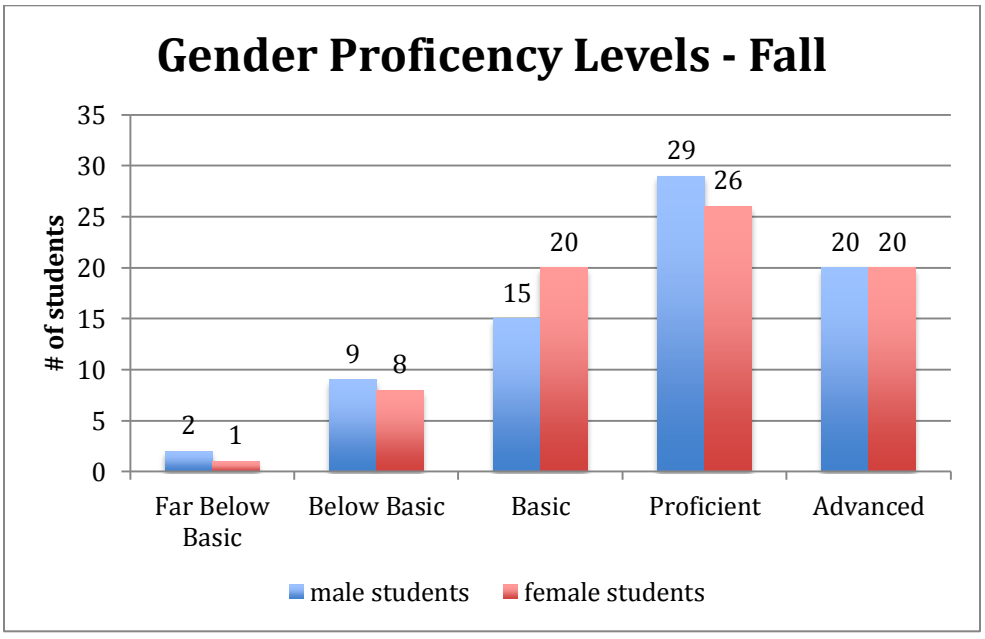

Figure 1. *Gender Proficiency Levels for the Fall MAP Benchmark Test*

One hundred and fifty second grade students took the Math (MAP) benchmark test in the fall. The Common Core aligned (MAP) test has a correlation chart that is uses students mean RIT scores to project proficiency levels on statewide-standardized tests. According to the Correlation chart (see Appendix C) second grade students' norm scores can range anywhere from 157 to 202 for the three benchmark testing periods. Any scores outside of this range are considered far above or far below the grade level norm. The data in Figure 1, labeled "proficient" or "advanced" indicates that a student is performing at or above grade level according to the correlation chart. For the fall benchmark test, 65% of male students and 61% of female students were considered performing at or above grade level proficiency. If the student's mean RIT score correlates to "basic, below basic, or far below basic" it indicates that the student is performing below grade level. According to the fall benchmark data 35% of male students and 39% of female students were not meeting 2nd grade level proficiency. This data reveals that overall both males and females are achieving at similar levels of mathematics proficiency.

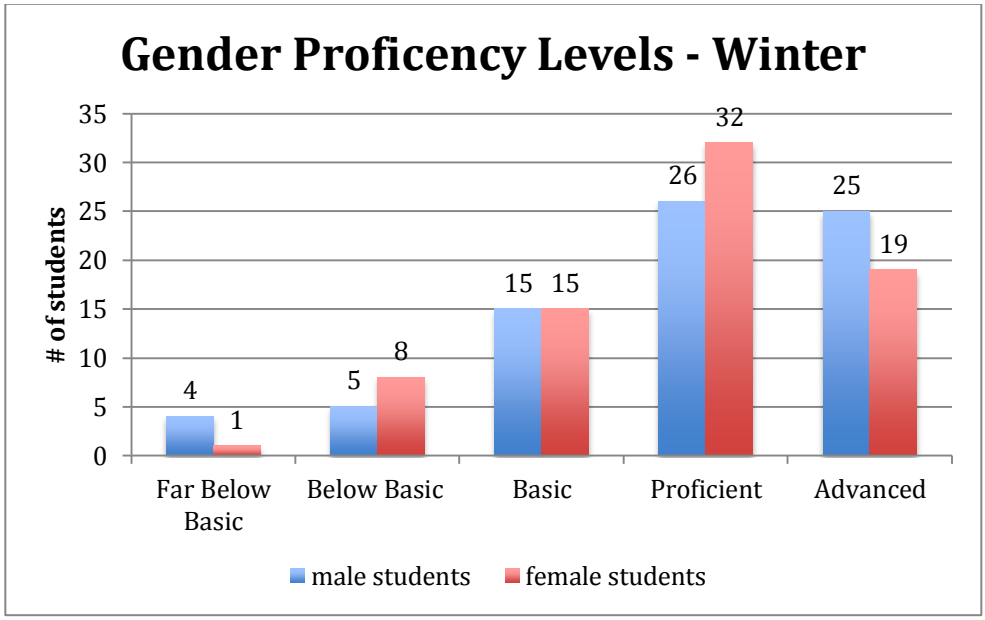

Figure 2. *Gender Proficiency Levels for the Winter MAP Benchmark Test*

The same 150-second grade students took the Math (MAP) benchmark test in the winter. The common core aligned (MAP) test has a correlation chart was used to determine a student's proficiency level by their mean RIT score on the benchmark test. The data in Figure 2, labeled "proficient" and "advanced" indicates whether male and female students were performing at or above grade level. For the fall benchmark test (see Fig. 1), 65% of male students and 61% of female students were considered performing at or above grade level proficiency. The data (see Fig. 2) shows that the percentage of both male and female students that achieved grade level proficiency on the winter benchmark test is identical at 68%.

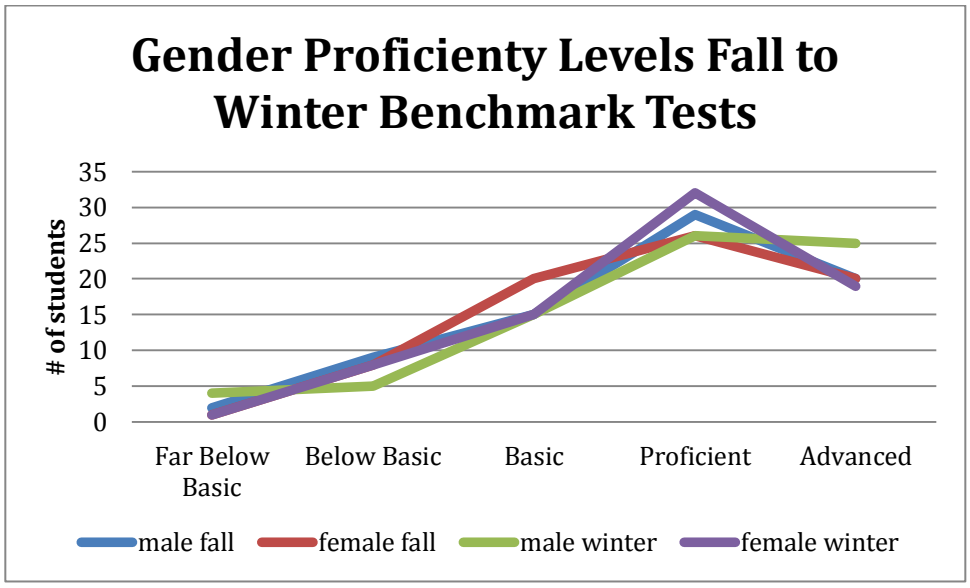

Figure 3. *Gender Proficiency Levels Fall to Winter Benchmark Tests*

When comparing the overall number of male and female students who scored proficient or advanced in the fall and winter benchmark results, males had 3 additional students score "proficient or advanced" compared to females who had 6 additional students do the same. The changes in proficiency levels (see Appendix C) are

representative of students who increased or decreased in proficiency levels by an average of 16 points. This data reveals that although males and females were achieving at similar levels of mathematics proficiency, according to the fall results, the percentages became exactly the same with the winter results.

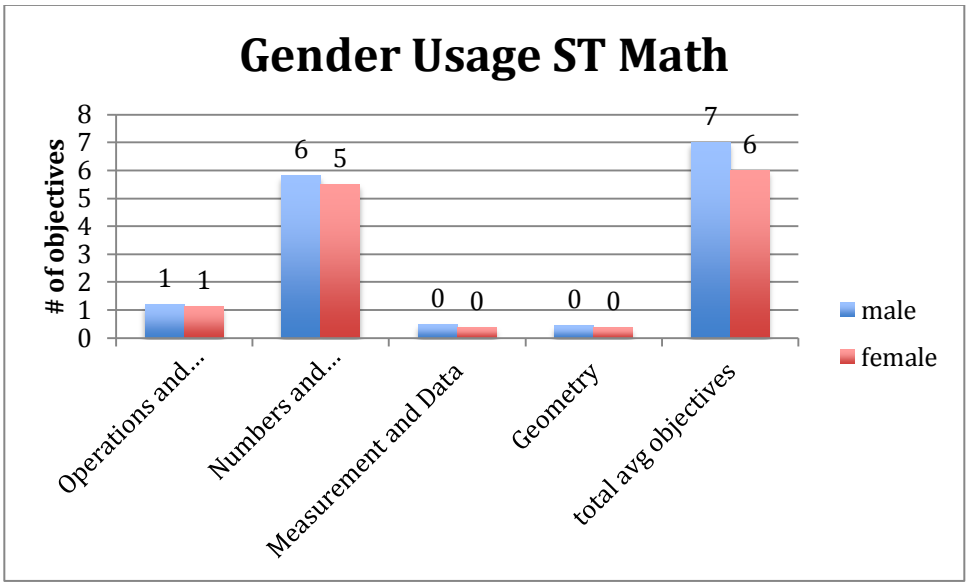

Figure 4. *ST Math Usage Collected After the Winter Benchmark Test*

One hundred and fifty second grade students had access to the ST Math curriculum during the 2014-2015 school year. Students had access to the online curriculum both at school and at home. The data on the number of objectives that students completed was collected immediately after all students involved in this research completed their winter benchmark exam. This was 95 days into a 180 school day calendar. The ST Math Program was used as part of a blended learning environment. The program provides practices on math content in the four math domains defined in the Common Core Standards. The standards curriculum in the program is accessible through objectives defined by the four content areas: operations and algebraic thinking, numbers and operations, measurement and data, and geometry. The content weighs very heavily

in the domain of numbers and operations with 16 of the total 23 objectives falling in that domain area. The domain areas of operations and algebraic thinking and measurement and data both have six objectives in the second grade curriculum, while geometry has five. The curriculum is set to a default order but individual classroom teachers may manipulate the curriculum if desired. The majority of the first objectives in the default order are in the domain area of numbers and operations. Therefore, since most teachers left the curriculum in the default order, the majority of objectives completed by the second grade students were in this domain area. This, along with the high number of overall objectives being in that domain when looking at the program, would explain why this area has a greater completion rate than the other domain areas. Also, the reason there are so many objectives in the domain of number and operations is because that is the domain where the majority of Second Grade Common Core Standards are found. When the data was collected, on average, males completed 30% of the overall curriculum, while females completed 26%. At the time the data were collected 52% of the school days had been completed for the 2014-2015 school year.

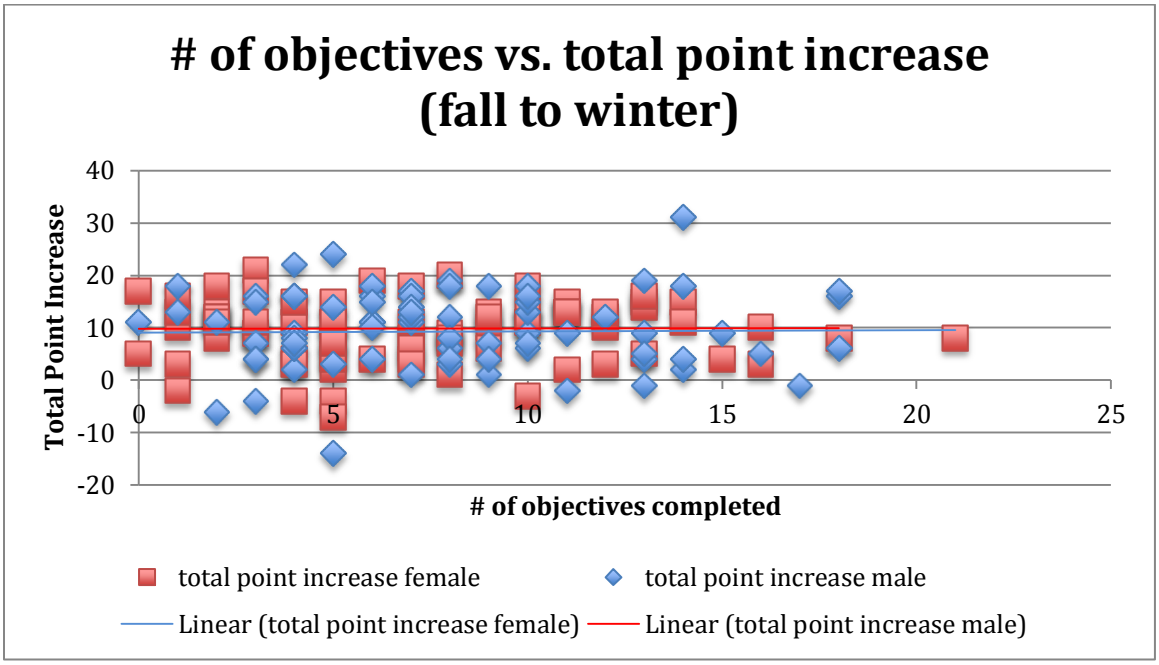

Figure 5. *Individual Performance of Objectives to Total Benchmark Test Point Increase*

The data (see Fig. 5) shows each student's individual point increase on the MAP test combined with how many objectives they completed in the ST Math program. According to the trend lines, both genders averaged around a 10-point increase. The data representing each student is distributed evenly throughout the graph. Thus, the data does not show a correlation of number of objectives completed to an increase in total points on the MAP test. According to the correlation chart for the MAP test, a student must increase their overall test score by an average of eight points in order to maintain their proficiency level from the previous benchmark test.

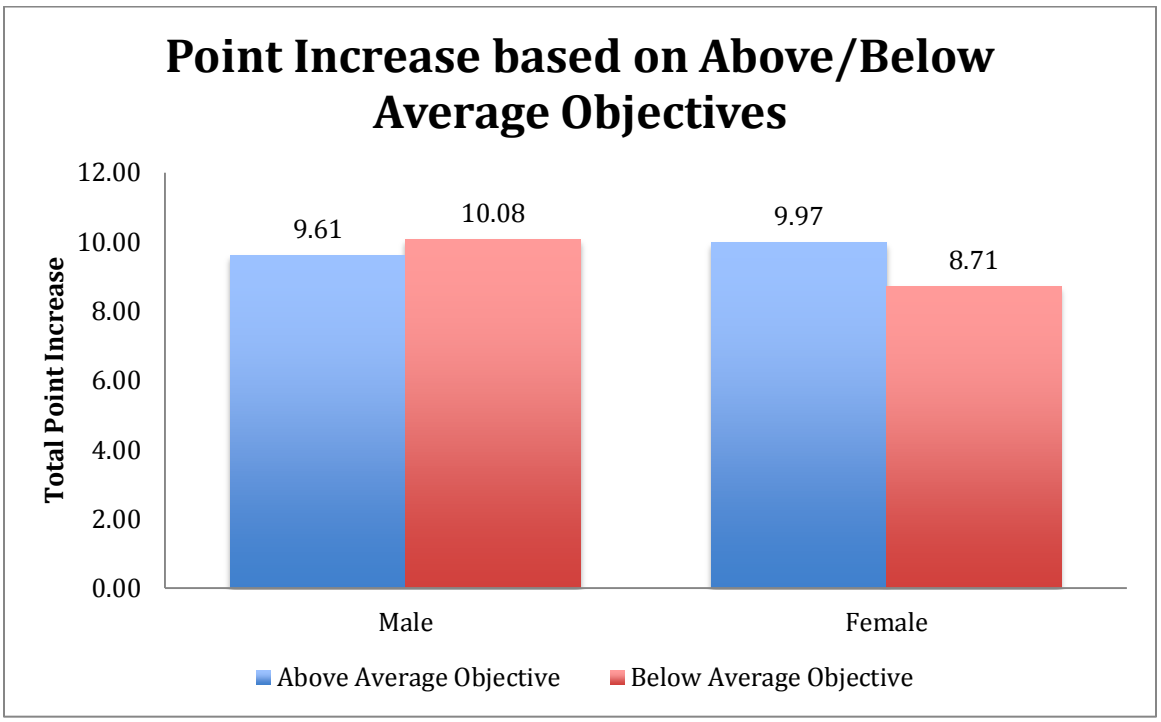

Figure 6. *Total Point Increase On Benchmark Test Based on Above or Below Average Number of Objectives Completed on ST Math Program*

When comparing the average number of objectives students completed in the ST Math program to their total point increase on the MAP test, the male students who completed below the average number of objectives averaged about a half of a point higher than male students who completed a total number of objectives above the average (see Fig. 6). Female students who completed an above average number of objectives in ST Math (see Fig. 6) averaged a little over one point more on their overall MAP test total point gain than the female students who completed below the average number of objectives. A one-point increase is not very significant when the grade level norm scores according to the correlation chart (see Appendix C) can range from 157 to 202. Overall, the average of all participants increased greater than the eight point average greater increase necessary for maintaining a level of proficiency according to the MAP

correlation chart (see Appendix C), however, no correlation can be made between higher achievement and an above average number of objectives completed in the ST Math program. Additionally, when considering the average number of logins per student in ST Math as opposed to the number of objectives completed, the data (see Appendix B) supports the theory that no correlation can be made between logins and achievement.

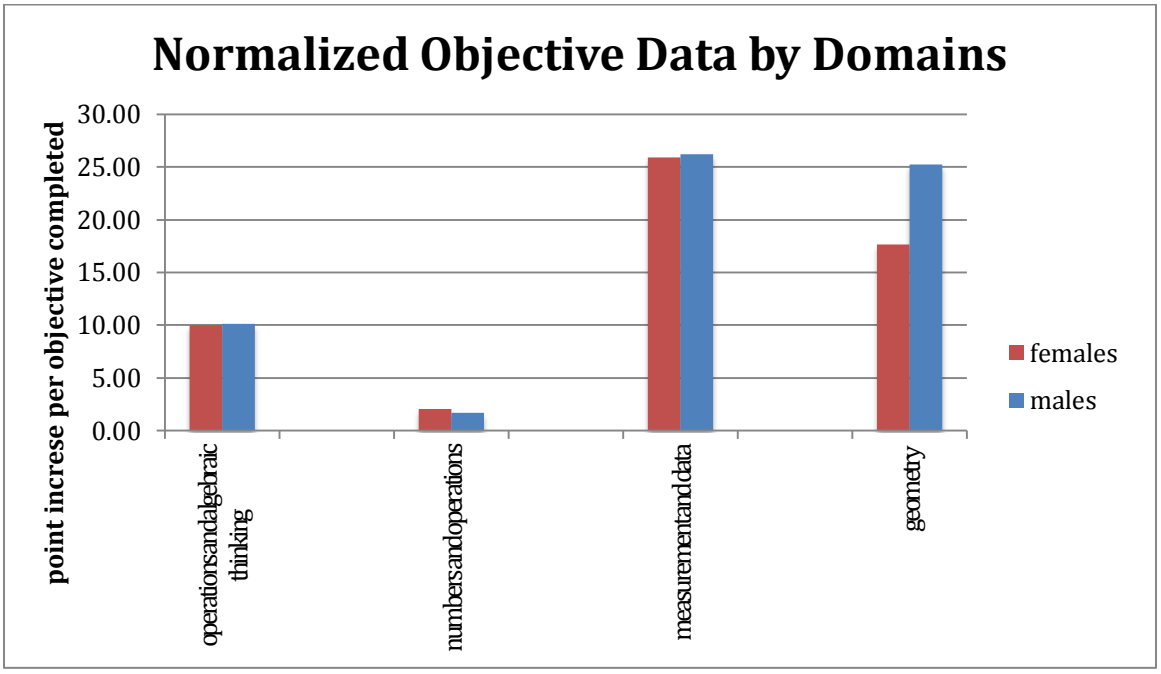

Figure 7. *Normalized Objectives Data by Domains Completed in ST Math*

In order to normalize the data, it was multiplied by a factor that allowed each value to be expressed in terms of one objective completed in the ST Math program. The normalized data compared the number of objectives completed in each of the four domains to the total point gain in that domain area from the MAP benchmark test. Students get a score in each of the four domains on the benchmark test and then their scores in the four domains are averaged to get a total point increase or decrease. From this normalized data, it can be determined that a single objective completed contributed towards an approximate 25-point increase in the domain of "measurements and data", but

only an approximate 2-point increase in the domain of "numbers and operations". This shows that each objective completed was far more beneficial towards an improvement in "measurements and data" rather that "numbers and operations".

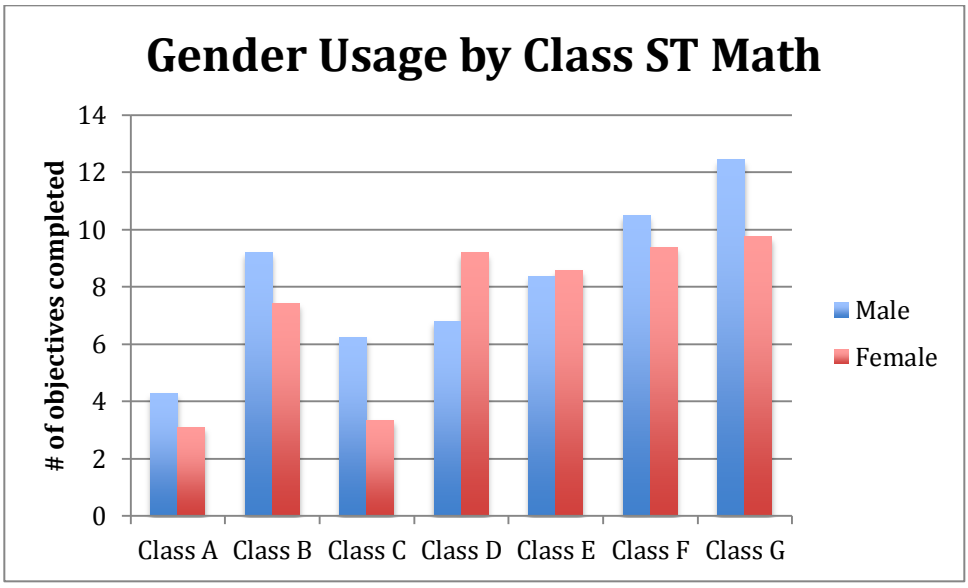

Figure 8. *Gender usage of ST Math by Classroom during the 2014-2015 School Year*

The students were divided amongst seven heterogeneously grouped classrooms that received math instruction as part of a blended learning environment, where students spent part of their time with digital curricula and part of their time with teacher led curricula instruction. The average number of students in a classroom was 22. The usage of the ST Math program varied amongst the second grade students depending on which of the seven classrooms they were in. Usage of the ST Math program was encouraged by the school district but the classroom teachers were not held accountable for the amount of time their students spent on it. The data shows that the usage by males slightly exceeded the usage by females in five of the seven participating classrooms for this research.

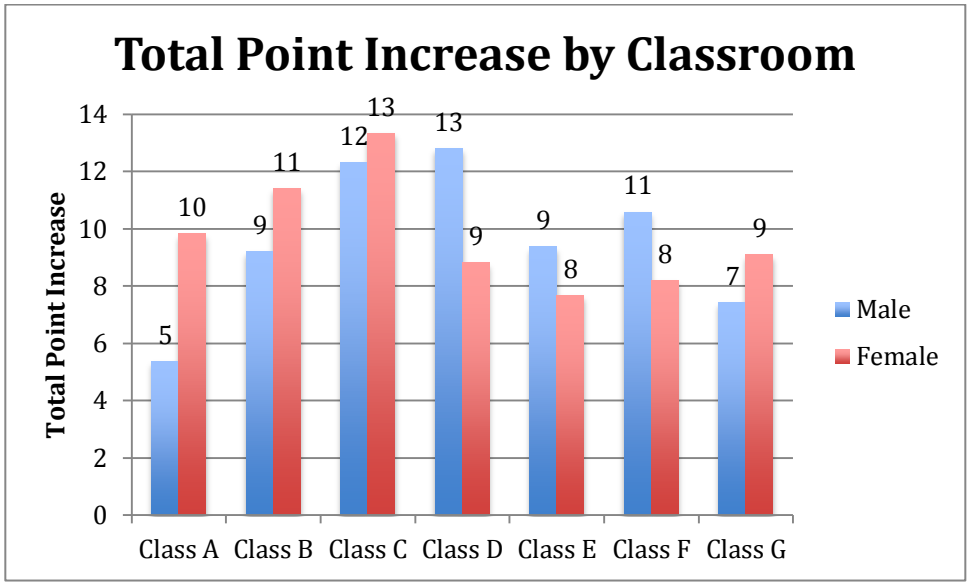

Figure 9. *Total Point Increase by Classroom*

The total point increase by classroom reveals that in the majority of classrooms males and females are increasing similarly in their total points gained. Only in Classroom A was there a significant point increase by males compared to females. Class C has the highest point totals by both males and females which is of interest because they had one of the lowest average number of objectives completed in ST Math (see Fig. 8)

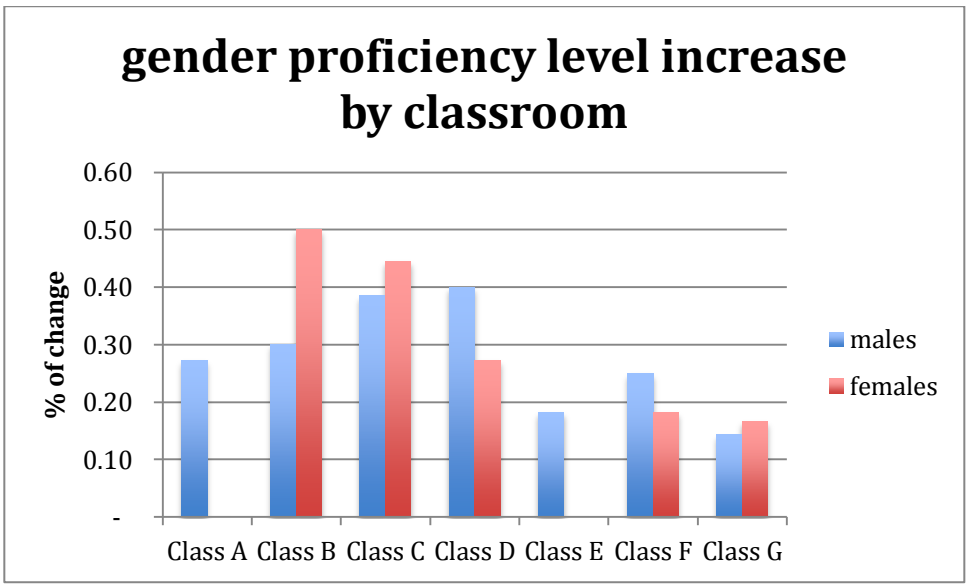

Figure 10. *Gender Proficiency Level Increase by Classroom*

According to the data, the percentage of students according to gender who increased a level of proficiency from the fall to winter benchmark test varied by classroom. Changing a level of proficiency means a student had an average of a 16-point increase in total points gained on their benchmark test. This is a significant increase when the norm scores range from 157-202 (see Appendix C). Class G (see fig. 8) averaged 12 objectives completed in the ST Math program per male student, and consequently had the lowest percentage of male student increase their proficiency level. Class C (see fig. 8) averaged 6 objectives completed in the program per male student, and thus had the highest percentage of male students increase their proficiency level after the winter benchmark test.

Upon further investigation, Class G, which had the highest percentage of objectives completed per student and had the least number of students increase proficiency levels, was able to maintain an average proficiency level of advanced after the winter benchmark test. Where as classes A and D both had proficiency levels of basic (considered below grade level) after the fall benchmark test. It is possible to conclude that since these classes had an average proficiency level below grade after the first benchmark test, they had more room for improving their proficiency levels after the winter benchmark test. Of the two male classes that were below grade level proficiency in the fall, Class A had 27% of its male students increase proficiency levels and Class D had 40% of its male students increase a level of proficiency. Class A was the only male class to average a proficiency level below grade level after the winter benchmark test.

On the other hand, Class G was the only level to have a male average of "advanced" after the winter benchmark test.

When comparing the female data (see Fig. 8) class A and class C both averaged the least number of objectives completed by any class at three. However, their proficiency increase results were very different. Class A had zero females increase a level of proficiency and Class C had 44% of its females increase a proficiency level. Additionally, Classes B, C, and D had average proficiency level of "basic" after the fall benchmark test. However, after the winter benchmark test all three classes had an average proficiency at grade level. The reason Class A did not see many females increase a level of achievement is because they began with an average of "proficient." This data seems to support the theory that the number of objectives completed in the program does not have a direct correlation to student achievement, but rather, that the students in the classes seem to be responding to teacher driven instruction or a possibly even a different educational technology program that was part of their blended learning environment. Or it could be that the students already knew the material.

Table 1

Individual Male Student Data Classroom C

Student Number	Ethnicity	Total Objectives Completed in ST Math	Total Point Increase on Benchmark Assessment: Fall to Winter	Proficiency Level Correlation on Winter Benchmark	Number of Levels of Proficiency Increased on Benchmark Assessment
4	Latino	1	13	Basic	1

18	Latino	4	22	Proficient	2
19	White	4	16	Proficient	1
20	Latino	4	16	Far Below Basic	0
22	2 or more	4	16	Advanced	1
40	White	7	13	Proficient	1

The data in Table 1 is representative of the six male students that had the highest overall point increase on the winter benchmark test in Class C. Class C (see Fig. 8) had the one of the lowest average number of objectives in the ST Math curriculum completed when the data was collected and had the highest percentage of male students increase their proficiency levels. Thus, the individual student data was worth investigating. It is interesting to note that of the six males represented in this table, 66% of the students are non-White. Additionally, 5 of the 6 students scored below proficiency level for the fall benchmark assessment. However, even with the low number of objectives completed in ST Math, 4 of the 6 students were able to meet or exceed grade level proficiency by the winter benchmark test. This confirms the statement that students in the Classroom C are achieving grade level proficiency even with very little usage of the ST Math curriculum. Student number 20 scored in the "far below basic" achievement level in the fall and his score was so below the achievement mark that even with a 16 point gain he was unable to achieve the level of "below basic." His 16-point increase according to the MAP correlation chart (see Appendix C) is still significant and validates that he is making progress towards achievement.

Table 2

Individual Female Data Classroom C

Student Number	Ethnicity	Total Objectives Completed in ST Math	Total Point Increase on Benchmark Assessment: Fall to Winter	Proficiency Level Correlation on Winter Benchmark	Number of Levels of Proficiency Increased on Benchmark Assessment
7	Asian	1	16	Basic	1
17	White	3	17	Advanced	1
23	White	4	15	Basic	1
35	White	6	19	Proficient	1
41	Latino	7	11	Proficient	1

The data in the table above is representative of the five female students that had the highest overall point increase on the winter benchmark test in Class C. Class C (see Fig. 8) had the one of the lowest average number of objectives in the ST Math curriculum completed when the data was collected and had the highest percentage of female students increase their proficiency levels. Four of the five students represented in the table scored below proficiency level for the fall benchmark assessment. However, even with the low number of objectives completed in ST Math, two of the four students were able to meet or exceed grade level proficiency by the winter benchmark test. This confirms the presumption that students in Classroom C are achieving grade level proficiency even with very little usage of the ST Math curriculum.

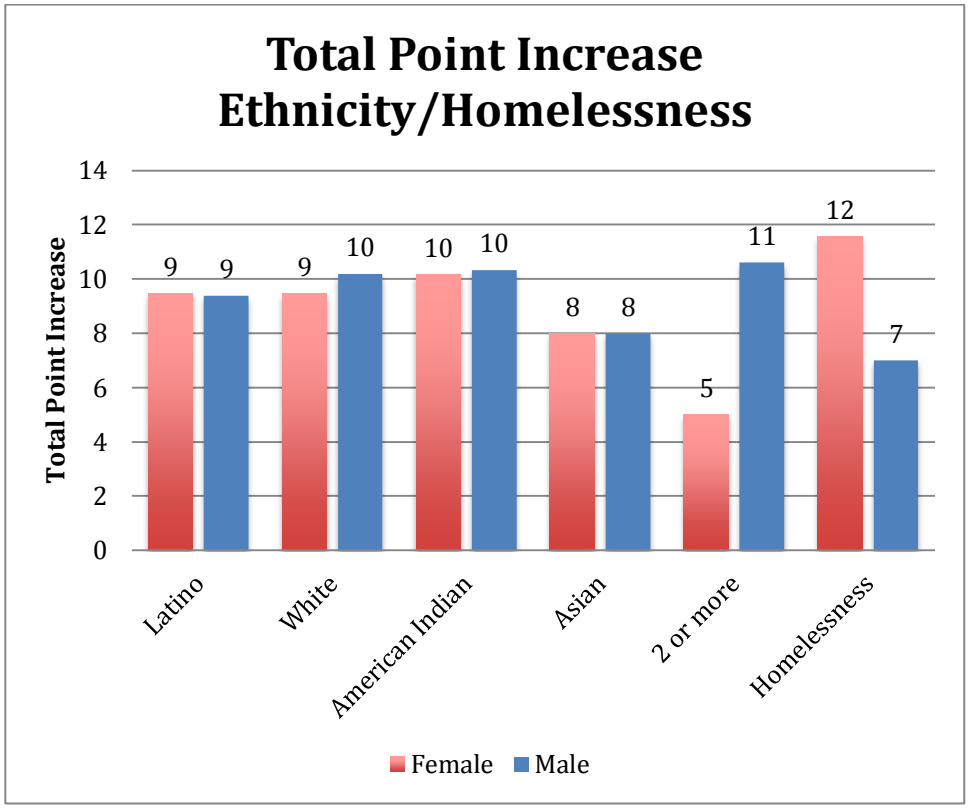

Figure 11. *Total Point Increase on Winter Benchmark Test by Ethnicity*

According to the data (see Fig. 11) students' of various ethnicities are achieving at very similar levels. The majority of the participant's data is represented in the "Latino" and "White" data. These ethnicities seem to be achieving at similar rates. Since fewer participants represent the Asian and two or more races they are greatly impacted by one student's below or above average performance on the benchmark tests.

When considering the achievement levels of students impacted by homelessness, females had a significantly higher point increase on their benchmark tests compared to males. However, it is important to note that this is a very small percent of the total number of participants so the data is easily impacted. When considering the increased proficiency levels of homeless students (see Appendix B), over 40% of females increased proficiency levels from the fall to winter benchmark tests. This is more than the number

of males, as just 20% of males impacted by homelessness increased a level of achievement.

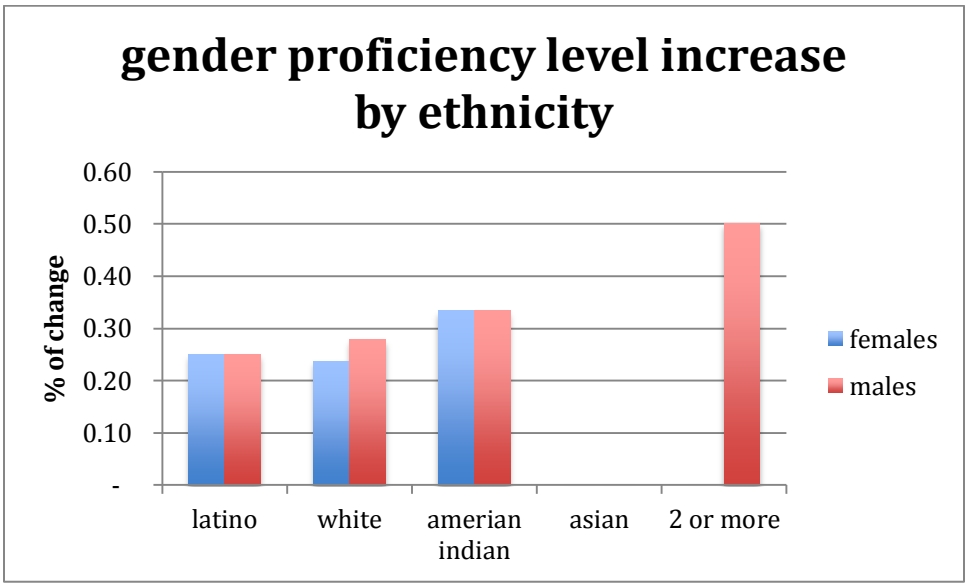

Figure 12. *Gender Proficiency Level Increase by Ethnicity*

The majority of the students that participated in this study were either White or Latino. Therefore, their data in Figure 12 is representative of a larger population of the participants. The male data representative of 2 or more races seems significant but it is only representative of two out of four students who increased their overall proficiency level. From the Latino and White data (see Fig. 12) it seems that both genders of the identified ethnicity groups are increasing a level of proficiency at almost identical levels.

Interpretations

The data in this chapter was presented in order to gain insight into the effectiveness of the ST Math program when considering gender achievement, ethnicity, homelessness, and classroom. Because the researcher was an insider, the data insights were referenced from the perspective of someone who has experience using the program in a blended learning environment. This allowed the findings to be interpreted in a way that the greater educational community could benefit from the study. With so many educational technology programs and approaches to teaching mathematics, it is vital that the ones being considered for implementation be researched before they are executed.

This study had several limitations that must be considered. The sample size as well as the amount of time the program was implemented before the benchmark test both played a role in the findings. These limitations will be discussed further in chapter 5.

Conclusion

The data in the chapter was meant to answer the research question, which focused on closing the gender achievement gap in mathematics with the usage of a technology program that utilized a spatial temporal approach to teaching math. The outcomes of the ST Math program on different ethnicities, socio-economic status and classroom were also discussed. The initial findings suggest that usage of the ST Math has little to no effect on student achievement. In fact, the students who completed more objectives had a slightly lower overall increased score on the benchmark test compared to those who used the program less. There could be many reasons for these findings. These reasons will be further investigated in chapter 5.

Chapter 5: Thesis Recommendations

The purpose of this study was to identify if there was cause/effect relationship between students who used the technology program Spatial Temporal Math as part of a blended learning environment. Seven-second grade classrooms were part of the study. The quantitative study used two benchmark test scores and usage of the ST Math curricula to determine a relationship. This chapter will summarize and interpret findings as well discuss educational implications, limitations, and future research directions.

Finding Summary

Data for this study was collected in an effort to answer the following research question: Will using the ST Math program in a blended learning environment impact student achievement in relation to gender, ethnicity, homelessness or classroom placement? The purpose of the research was to help gain further insight into the way a spatial-temporal approach to mathematics may be key to developing a greater foundation in mathematics in the second grade.

In order to conduct research into the effectiveness of a spatial-temporal approach to learning mathematics, benchmark test data as well as ST Math curricula usage was collected on 150-second grade students. The fall and winter benchmark tests were conducted as part of a regular testing cycle in the school district where the students attended. Based on the baseline data collection from the fall benchmark, overall males and females included in the study were achieving at similar levels of mathematics proficiency before the introduction of the ST Math variable. According to Figure 1, just over 60% of the male and female students were performing at or above grade level according to the fall benchmark results.

Figures 2 and 3 summarize the winter benchmark data that reports that the percentage of both males and females achieved the same percentage of proficiency, as exactly 68% of males and females scored proficient or advanced on the winter benchmark test. Figure 9 examines the data further to determine if achievement was greater in specific classrooms. The findings are that the classrooms that had a "below average" benchmark mean in the fall had a greater overall point increase than those who had an "at grade level" or "above average" on the fall benchmark. This data that showed students in classrooms that did not complete many of the objectives in the ST Math program still were able to achieve mathematical proficiency on the benchmark tests at the same rate as the classrooms that had a higher total number of objectives completed in the program.

The ST Math program was implemented as part of a blended learning environment where the students had access to the program and their usage varied. All students had access to the program at school and at-home usage was minimal. In Figure 4, it is clear that both males and females' completion of the learning objectives in the ST Math program were similar. Even though 52% of the school year had been completed when the data was collected, males only completed 30% of the curriculum and females 26%.

The findings discussed in Figures 5 and 6 suggest that no correlation can be made between higher achievement on the winter benchmark test and the number of objectives a student completed in the ST Math program. Regardless if the number of objectives the students completed was above or below the respective gender mean, the overall average score on the winter benchmark test was greater than the eight-point average necessary for

maintaining a level of proficiency according to the Measures of Academic Performance (MAP) correlation chart for both males and females.

Upon examining the data even further, in Figure 7 the number of objectives completed in each of the four domains was compared to the total point gain in that domain area for the MAP benchmark test. The normalized data revealed that each objective in the domain areas of "measurement and data" and "geometry" equated to an approximate 25-point increase in these domain areas on the MAP benchmark test, while each objective completed in "the number and operations" domain yielded only an average of a 2 point gain. This data brings to the surface the spatial- approach to mathematics. It is possible that the domains of "geometry" and "measurement and data" lend themselves to being skills that thrive when approached from a spatial approach to learning. It would be of interest to see what the data would reveal if more students completed a greater number of objectives in these two domain areas.

A similar conclusion can be made when reviewing the individual data from Class C (see Table 1) that had recorded the highest overall increase of points on the benchmark test compared to the one of the lowest average number of objectives completed. Both female and male students in this particular classroom are achieving grade level proficiency with very little usage of the ST Math curriculum.

In figure 11 it is clear that students from various ethnic backgrounds and well as those impacted by homelessness are achieving mathematical proficiency at the same pace as the grade level norm. Something is clearly contributing to increased student achievement for these second grade students. From this study, it is not clear whether

achievement can be attributed to usage of computerized technology, teacher-led instruction or other influences.

Findings in Context

Research conducted by Rutherford (2010), sought to explore if students benefitted from a spatial-temporal approach to learning mathematical skills and concepts by using the ST Math curriculum. The sample group consisted of mostly Latino students in grade levels 2-5 from 34 schools in Orange County, CA. The students that participated in the study spent two 45-minute sessions on ST Math a week under the direct supervision of their classroom teacher. The findings in the study concluded that both the treatment and control group made year-to-year gains in the standardized CST math tests. However, the treatment group gains were significantly larger than the control group. When comparing these findings to my research, one similarity is that both the students who utilized the ST Math curriculum and those who did not, made necessary gains on their benchmark test. However, the difference in the two studies is that students who completed an above average number of objectives in my study showed no significantly larger gains than those who completed the below average number of objectives.

Research conducted by Wendt and Rice (2013) studied the implementation of ST Math at 45 elementary schools in the Los Angeles Unified School District. The study included more than 9,000 students in second to fifth grade. This study had comparison groups of similar demographics like my study, however it did have a control group and mine did not. The study found a statistically significant higher proportion of students who scored at the advanced level in the schools implementing ST Math. The study by Wendt and Rice (2013) reportedly found a 10.4-percent increase in the weighted mean

percent of students scoring proficient or advanced on the CST at the schools where the ST Math program was used, compared to 6.5 points at the comparison schools. This study did not report on the effectiveness of the program for different populations or on the extent to which the program was implemented. My research was challenging because of the absence of a control group who was not exposed to the ST Math program. This along with the fact that my research had similarly achieving sample groups of males and females participating in the study, made it difficult to find a correlation between student achievement on benchmark tests and usage of the ST Math curriculum.

Educational Implications

As the educational community becomes more data-driven, school districts will be forced to make even more data driven decisions on what educational technology to implement in the future. With ongoing budget constraints, these decisions could have significant implications on a district's performance on standardized tests. Studies such as the ones mentioned in this paper, as well as the one I conducted, provides research and insight into technology programs that boast of increasing test scores and come with a high price tag. When people can make informed decisions on whether or not to implement technology based on the research provided on specific programs such as ST Math, the educational community as a whole benefits. While the number of participants in my study was fairly small, the result of my study puts the focus on technology programs being implemented at my site and grade level.

After conducting this research, I feel it is also valuable to make sure that with all the money and time being spent on technology programs today, it is vital to ensure that they are being utilized and implemented how they were designed to be. If there is no

accountability, then monies spent on programs backed by research will go underutilized. Professional development is key to informing the stakeholders that will implement the programs on how to best monitor students' progress and ensure that students are completing the required amount of material to make the program effective. The ST Math program boasts of increased achievement with implementation and it data showed that the second grade participants underutilized the program I studied.

Recommendations for Future Research

The results suggest that both male and female students are achieving at steady rates, however the study was unable to determine that the ST Math program was contributing to the achievement. Further study into gender achievement should be conducted including: a larger sample population, a control group that had not accessed the ST Math curriculum, a longer time frame for implementation of the educational technology program, a wider range of grade levels, further achievement gap analysis using additional benchmark data, access to technology at home, parents' education levels, and socio-economic status. In hindsight, looking at students who utilized the program for multiple years would have provided more accurate data. Also, with the elimination of the CST standardized tests, no identical benchmark data to compare to previous studies was available for my research.

Limitations

This study was limited because the researcher worked at the school that was being studied. Additionally, the researcher lacked the time to conduct a longer-range study.

Conclusion

Usage of Computer Assisted Instruction (CAI) is becoming commonplace in education today especially when it is used as a response to intervention. There has been a recent shift away from the teacher being the center of instruction, in turn the focus has shifted to technology programs that can provide real-time feedback and increase engagement. Continued research must be done to ensure that leaders are providing the best programs on the market to our students and that they are having a positive effect on student achievement. Leaders must also be aware that the literature points to a gender gap in math between boys and girls, and this must be considered when making decisions and analyzing data.

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Appendix A: Ethnicity Data

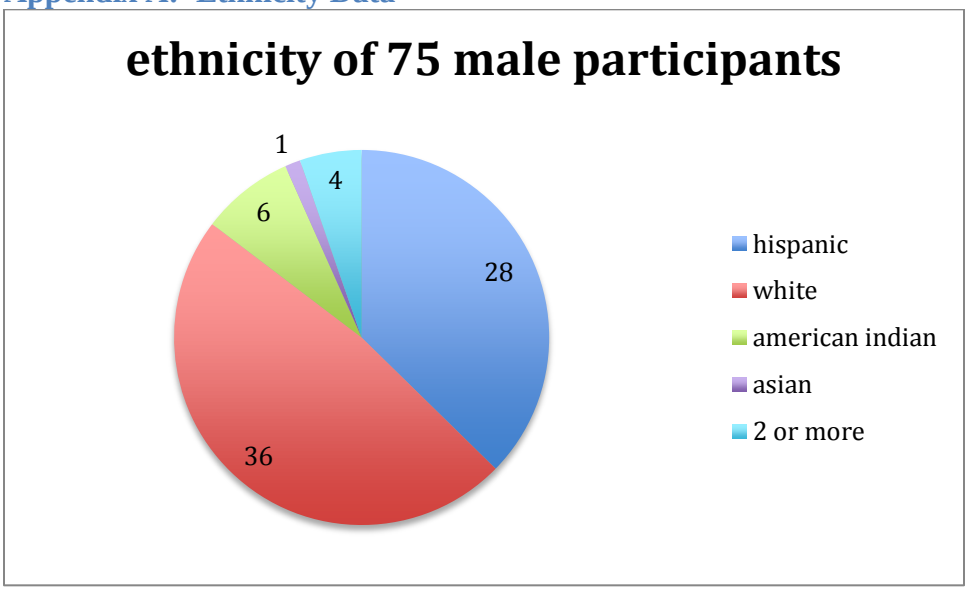

Figure 13. *Ethnicity of 75 Male Participants by Number of Participants*

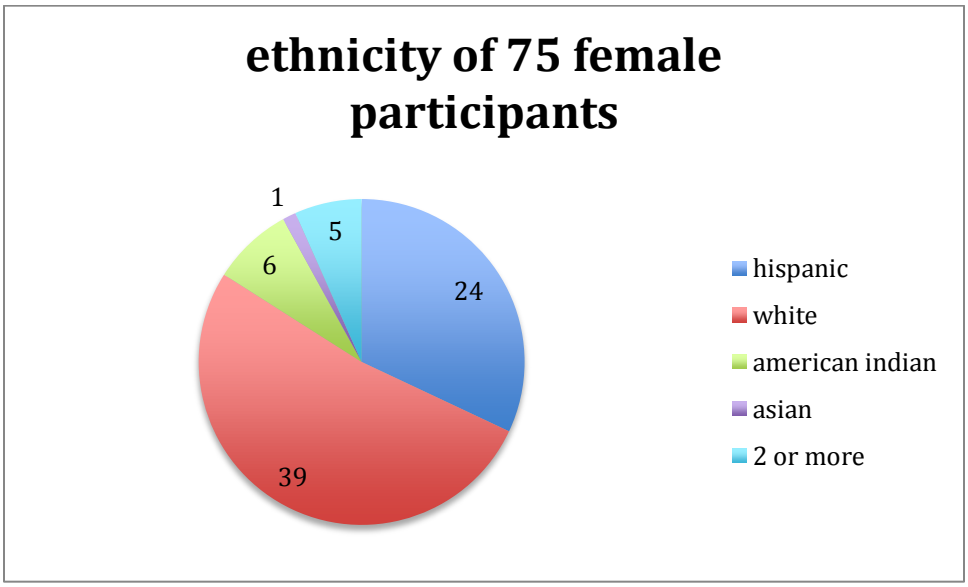

Figure 14. *Ethnicity of 75 Female Participants by Number of Participants*

Appendix B: Student Achievement Data

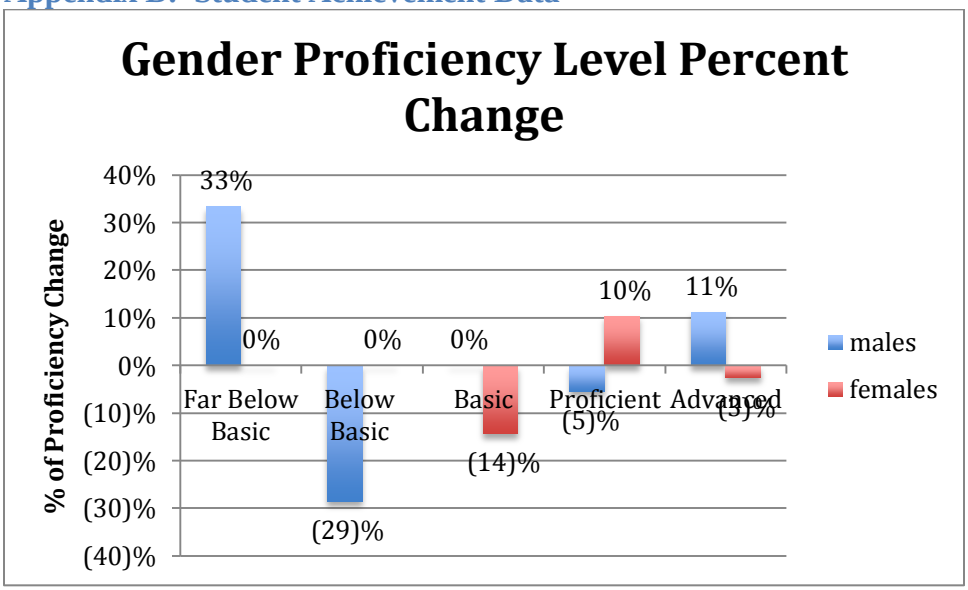

Figure 15. *Gender Proficiency Level Change by Percentage Fall to Winter Benchmark Results*

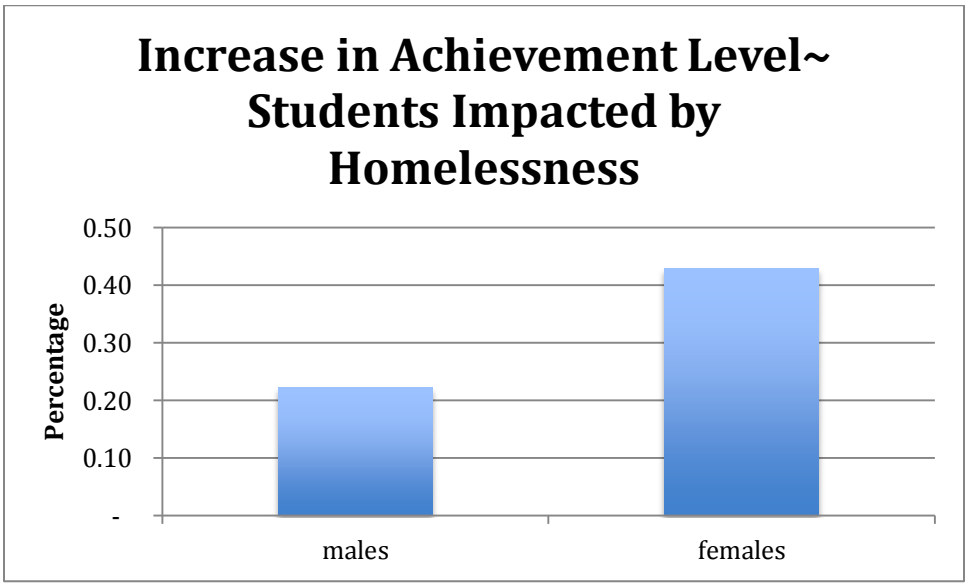

Figure 16. *Gender Proficiency Level Increase by Students Impacted by Homelessness*

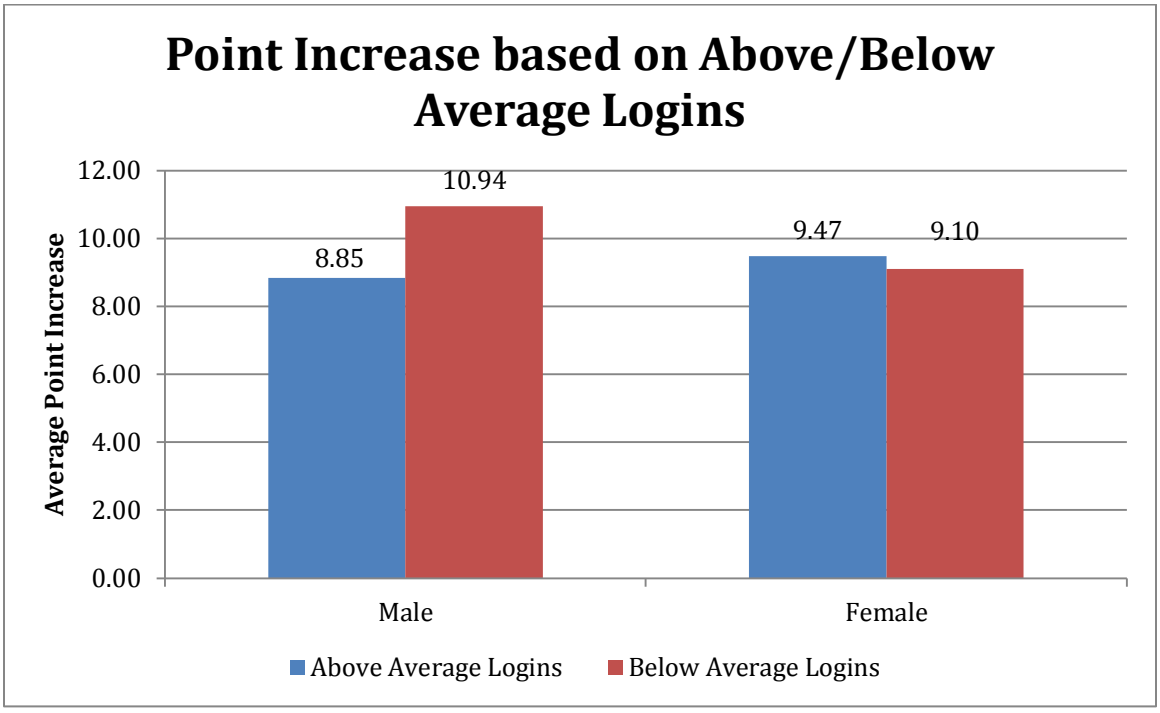

Figure 17: *Total point increase based on above/below average logins in ST Math*

Appendix C: Measures of Academic Performance Correlation Guide

Table C

	Far Below Basic	Below Basic	Basic	Proficient	Advanced
Fall	<157	158	169	177	187
Winter	<170	171	179	186	195
Spring	<183	184	189	195	202