

2011

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David C. Hemphill

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Algebra Readiness Outcomes of Sixth-Grade Boys and Girls Placed in
Challenge Math Based on Measured Math Ability Compared to Sixth-Grade
Boys and Girls Placed in Challenge Math Based on Teachers' Recommendations

By

David C. Hemphill

A Dissertation

Presented to the Faculty of

The Graduate College of the University of Nebraska

In Partial Fulfillment of Requirements

For the Degree of Doctor of Education

In Educational Administration

Omaha, Nebraska

2011

Supervisory Committee

Dr. John W. Hill, Chair

Dr. Peter J. Smith

Dr. Neal F. Grandgenett

Dr. Jody C. Isernhagen

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Abstract

ALGEBRA READINESS OUTCOMES OF SIXTH-GRADE BOYS AND GIRLS
PLACED IN CHALLENGE MATH BASED ON MEASURED MATH ABILITY
COMPARED TO SIXTH-GRADE BOYS AND GIRLS PLACED IN CHALLENGE
MATH BASED ON TEACHERS' RECOMMENDATIONS

David C. Hemphill

University of Nebraska

Advisor: Dr. John W. Hill

The first pretest-posttest hypothesis was tested using the dependent t test. Null hypotheses for test score improvement over time were rejected for the end of fifth-grade pretest compared to ending sixth-grade posttest math Essential Learner Outcome scores converted to standard scores for randomly selected sixth-grade girls meeting measured test score criteria for challenge math placement ($n = 15$): pretest $M = 120.07$, $SD = 4.32$; posttest $M = 121.87$, $SD = 2.17$; $t(14) = 1.73$, $p = .05$ (one-tailed), $d = 0.500$ and rejected for randomly selected sixth-grade girls not meeting measured test score criteria for challenge math placement ($n = 15$): pretest $M = 117.80$, $SD = 3.28$; posttest $M = 119.73$, $SD = 3.13$; $t(14) = 1.95$, $p < .05$ (one-tailed), $d = 0.503$. However, null hypotheses for test score improvement over time were not rejected for the end of fifth-grade pretest compared to ending sixth-grade posttest math Essential Learner Outcome scores converted to standard scores for randomly selected sixth-grade boys meeting measured test score criteria for challenge math placement ($n = 15$): pretest $M = 120.00$, $SD = 2.54$; posttest $M = 121.47$, $SD = 2.85$; $t(14) = 1.59$, $p = .07$ (one-tailed), $d = 0.415$ and not rejected for test score reduction over time for randomly selected sixth-grade boys not

meeting measured test score criteria for challenge math placement ($n = 15$): pretest $M = 119.00$, $SD = 4.52$; posttest $M = 118.80$, $SD = 4.35$; $t(14) = -0.15$, $p = .44$ (one-tailed), $d = -0.038$. Comparisons for sixth-grade boys meeting measured test score criteria for challenge math placement, sixth-grade girls meeting measured test score criteria for challenge math placement, sixth-grade boys not meeting measured test score criteria for challenge math placement, and sixth-grade girls not meeting measured test score criteria for challenge math placement was statistically significant, ($F(3, 56) = 3.03$, $p = .04$).

Because a significant main effect was found *post hoc*, contrast analyses were conducted using independent t tests. Significant differences were found in the A (Boys Tested In) vs. C (Boys Placed In) comparison where $t(28) = 1.99$, $p < .05$ (one-tailed), $d = 1.517$; B (Girls Tested In) vs. C (Boys Placed In) comparison where $t(28) = 2.45$, $p = .01$ (one-tailed), $d = 2.036$; and B (Girls Tested In) vs. D (Girls Placed In) where $t(28) = 2.17$, $p < .05$ (one-tailed), $d = 1.917$. No significant differences were observed for the other *post hoc* comparisons A (Boys Tested In) vs. B (Girls Tested In); A (Boys Tested In) vs. D (Girls Placed In); and C (Boys Placed In) vs. D (Girls Placed In). Importantly, for all groups, a pattern of statistical improvement over time was found for end of fifth-grade pretest compared to ending sixth-grade posttest Orleans-Hanna Algebra Prognosis Test scores, with no significant posttest-posttest ANOVA results observed ($F(3, 56) = 0.47$, $p = .70$) observed. Posttest math test scores for girls, both tested in and placed in, did not decrease significantly while the boys posttest math scores, both tested in and placed In significantly decreased over time. However, final grade test scores for all groups were within the B average range based on school district criteria. Null hypotheses for student math course grades over time were rejected in the direction of lower grade scores for the

first trimester sixth-grade pretest challenge math course grade score compared to last trimester sixth-grade posttest challenge math course grade score for sixth-grade boys meeting measured test score criteria for challenge math placement $t(14) = -3.22, p = .003$ (one-tailed), $d = -0.840$ and rejected for sixth-grade boys not meeting measured test score criteria for challenge math placement $t(14) = -1.80, p = .05$ (one-tailed), $d = -0.466$. Furthermore, null hypotheses for test score improvement over time were not rejected for the first trimester sixth-grade pretest challenge math course grade score compared to last trimester sixth-grade posttest challenge math course grade score for sixth-grade girls meeting measured test score criteria for challenge math placement $t(14) = 0.13, p = .45$ (one-tailed), $d = 0.035$ and not rejected for test score reduction over time for sixth-grade girls not meeting measured test score criteria for challenge math placement $t(14) = 0.32, p = .38$ (one-tailed), $d = 0.033$. Posttest-posttest results were not statistically significant, ($F(3, 56) = 1.18, p = .32$). Overall study results indicate an equivalent positive response to challenge math placement regardless of student gender or placement conditions.

Acknowledgements

My dissertation journey began in 2007. During the past four and a half years it has been both an enjoyable and an arduous process. I can remember taking my first class during the spring semester of 2007 and reveling at the idea of beginning the journey to someday, if all went well, becoming Dr. Hemphill. In many ways, it is that end goal that has kept me going through some of the many bumps on the road of this journey.

It has been said that behind every great man (not that I am placing myself on a pedestal) that there is an even greater woman. I could not have finished this dissertation without the constant pep talks and prodding from my awesome wife, Beth. She has been there to listen to me complain about the hours and hours of reading and writing and then kindly remind me of my abilities and her faith in me to be successful with this journey. Many times I was ready to walk away, but with her persistence and her belief in me she has helped push me through.

My daughters have been very supportive of me throughout my career. Bailey and Carlye were willing to spare some “dad time” while I worked first on my masters and then doctor of education degrees in educational administration. Besides their support, I have viewed my education as an opportunity to teach them through modeling the importance of hard work and that you are never too old to learn.

I am very appreciative of Dr. John W. Hill, my dissertation committee chair. His knowledge and expertise in research, statistics, and writing dissertations were a tremendous help in getting me through the whole process. His positive encouragement along with some shared humor was just what I needed along the way.

I would also like to thank Dr. Peter J. Smith, Dr. Neal F. Grandgenett, and Dr. Jody C. Isernhagen, the members of my dissertation committee, for their time and commitment to my education at UNO. Along with these committee members, I would also like to thank other Educational Administration faculty, Dr. Karen Hayes, Dr. Laura Schulte (Retired), Dr. Jeanne Surface, Dr. Kay Keiser, and Dr. Richard Christie, they challenged and stretched me to be a better human being that in turn has made me a better administrator. A special thank you is given to Mrs. Barbara Mraz, assistant in the office of Educational Administration, for her expert help with editing and also for greeting me with a smile and a cup of coffee during each of my many visits to Dr Hill's office.

A special thank you to my boss, Lori Jasa, principal of Kiewit Middle School and my co-worker, assistant principal Pat Meeker for the support and flexibility they have shown me during my studies and dissertation writing. I also would like to acknowledge the sixth-grade math teachers, Karen Anthony, Kelly Curran, and Kim Rannells for working with me to collect data for my dissertation.

Finally, I would like to express my thanks to Dr Tami Williams, Director of Assessment, Research and Evaluation who opened the door for me at a crucial time in my career to allow me to proceed with the statistics portion of this study. To all of these family, friends, and mentors, I am thankful you have been traveling this journey with me.

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CHAPTER ONE

Introduction

Over the past two decades there has been a push to offer algebra coursework earlier and earlier to all elementary and middle school students (Dulaney, 1996; Fensterwald, 2010; Steen, 1999). Currently, the goal of *algebra for all* mathematics policy in the United States is to provide early math experiences that will prepare students for the more formal study of algebra in high school (NCTM, 2000; Rivera, 2008). However, it is not clear what early algebra experiences should be and whether or not these early abstract math experiences will result in improved advanced math achievement for all students (Knuth et al., 2005; Schmidt, 2004; U.S. Dept of Ed, 2008). The push to have all middle school students complete math before they are ready has resulted in what Bracey (2008) has referred to as the great *algebra hoax* in California, where it has recently been determined that nearly 120,000 eighth-grade students, currently taking algebra, have math ability scores measured at the second-grade level. Algebra, as recently as the 1990s, was considered a class for gifted math students. By 2007, 31% of all students in the eighth-grade nationally were taking algebra. Given Bracey's aforementioned *algebra hoax* it is troubling that California has adopted a state algebra test and is pushing for all eighth-grade students to be in algebra classes by 2011 (Loveless, 2008).

Poor U.S. Math Test Results

The push for accelerated algebra courses in the middle school years is motivated, at least in part, by the results of the math scores of students in the United States compared to students internationally on the Trends in International Mathematics and Science Study

(TIMSS, 1999). In the TIMSS report United States students in the fourth-grade ranked 12th out of 26 nations, eighth-grade students ranked 28th out of 41 nations, and 12-grade students ranked 19th out of 21 nations on the math examination covering content and cognitive dimensions. Assessed within the mathematics content dimension are number, algebra, measurement, geometry, and data. Assessed within the mathematics cognitive dimension are the knowledge of facts and procedures, the use of concepts, solving routine problems and reasoning skills. While the math scores for fourth-grade students in the United States were measured above the international average for students in the fourth-grade the math scores for eighth-grade students and 12th-grade students in the United States were measured below the international average. However, by 2007, TIMSS results saw the United States students in fourth-grade with an average score of 529 and eighth-graders with an average of 508. These scores were above the TIMSS scale average. Eight of the 35 nations that participated in the test, scored higher than our American fourth-grade students and 5 of the 47 nations scored better than our eighth-graders. Improvement was made by both groups on these tests compared with the 1995 results. No 12th-grade results were available for 2007 (TIMSS 2007).

However, on the Program for International Student Assessment (PISA) test completed in 2006, United States 15 year old students' average math score was lower than the Organization for Economic Co-operation and Development (OECD) student average score. United States students averaged 474 and the OECD average was 498. This placed the United States students in the bottom quarter when compared with other participating nations. Altogether, 23 out of 29 nations outperformed the United States 15 year old students on this 2006 assessment. Even more troublesome is that the United

States students' scores from 2003 to 2006 showed no measurable change in its relation to other countries (U.S. Department of Education, 2010).

Low scores on international measures often result in government mandates for sweeping reform in educational practices often dissociated from the real-world needs and abilities of students (Board, 2010; Guttenplan, 2010). While calls for reform are appropriate they often suggest classroom practices not informed by the research literature and the skill levels of our neediest children who while ready for basic math concepts may not be ready for rigorous math classes (Palacios, 2005; Wu, 2001). Unfortunately, a student who is misplaced in a more rigorous math class without the automatic basic skills need to complete and solve more complex problems may only learn failure (GreatSchools, 2010; Stacey, 2009). As with the California *algebra hoax* (Bracey, 2008) this is not a prescription for improving national math test scores. By the very fact of including students who are not ready for advanced coursework such as algebra, in an algebra class, who should be taking rigorous but developmentally appropriate classes, the resulting school failure of these students will be iatrogenic to the schools, teachers, parents, and politicians who advocate coursework for students before the students have the skills needed to succeed.

Problems with Algebra for All

The National Assessment of Education Progress (NAEP) data suggests that the effort to push more kids into algebra math classes before students are ready is an unfortunate national trend. For example, students on the NAEP reported enrolling in higher-level classes, increasing the percentage from 26.7 to 36.6 over a five-year period and those saying they enrolled in lower level math classes dropped from 66.6% to 50.8%.

While lower achieving students only accounted for 8% of the students in higher-level math classes in 2000 by 2005 the number taking higher-level math courses rose to 28.6% (Lee, Grigg, & Dion 2007; Loveless, 2008).

Currently, California is leading the charge for algebra for all eighth-grade students. From 2003-2008, students taking algebra increased 63%. However, only 42% of those taking algebra scored proficient on the state algebra test. Many students' who fail algebra, in California, must retake this course while neglecting other required courses. A study found that large numbers of eighth-grade students are retaking algebra in ninth-grade and doing worse the second time through the course (Fensterwald, 2010). Even more noteworthy, 60% of the students who scored proficient on the state algebra test were forced to repeat the class in ninth-grade (Fensterwald, 2010).

At stake is the students' education and potential career aspirations. Students being forced to repeat algebra in ninth-grade appear to be turning away from interest in technical and science careers. When students are promoted into geometry, they are often grouped with peers that use peer pressure to help each other perform well. The opposite is true of the students repeating algebra, they view themselves as failures and use peer pressure to influence students to not do well (Fensterwald, 2010).

Algebra Too Early

In our current system of mathematics teaching, tradition plays a large roll. Children are taught the basic math computational methods (addition, subtraction, multiplication, and division) often in order, and then once the basic math is learned they progress to algebra, geometry, and then higher levels in a very prescriptive progression. The teaching of algebra requires the use of variables, which some researchers feel that

adolescents are too young and not developed enough to handle the abstract thinking that goes into studying algebra (Carraher & Schliemann, 2007; Rivera, 2006). For example, recently, neuroscientists have learned that the human brain is not fully formed in most young adults until the early to mid-twenties. Before the technology existed to do imaging of the brain, it was thought that students' brains were fully functioning by the time of puberty (Brownlee, Hotinski, Pailthorp, Ragan, & Wong, 1999).

Students who take algebra before they have a strong foundation in basic math and have the mental development may find themselves unprepared for college or the work force. Students that are not prepared usually have to relearn math in a remedial class later which can hurt students chances for success when compared with students who are prepared for algebra and were enrolled in algebra when they were ready (GreatSchools, 2010; Steen, 1992; Steen, 1999).

Purpose of the Study

The purpose of the study is to determine the math test scores, algebra achievement predictor scores, and challenge math course grades of sixth-grade students meeting measured test score criteria for challenge math placement compared to the math test scores, algebra achievement predictor scores, and challenge math course grades of sixth-grade students not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations.

Research Questions and Data Analysis

The following research question will be used to analyze student participation in challenge math placement measuring pretest-posttest Essential Learner Outcome (ELO) math scores converted to standard scores.

Overarching Pretest-Posttest Achievement Research Question #1. Do (a) sixth-grade boys meeting measured test score criteria for challenge math placement or (b) sixth-grade girls meeting measured test score criteria for challenge math placement or (c) sixth-grade boys not meeting measured test score criteria for challenge math placement, but receiving challenge math placement based on fifth-grade teachers' recommendations, or (d) sixth-grade girls not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations lose, maintain, or improve their end of school year pretest fifth-grade Essential Learner Outcome (ELO) math scores converted to standard scores compared to their end of school year posttest sixth-grade Essential Learner Outcome (ELO) math scores converted to standard scores?

Sub-Question 1a. Will there be a significant difference between boys' meeting measured test score criteria for challenge math placement beginning of school year pretest compared to ending of school year posttest research school district administered Essential Learner Outcome (ELO) math scores converted to standard scores?

Sub-Question 1b. Will there be a significant difference between girls' meeting measured test score criteria for challenge math placement beginning of school year pretest compared to ending of school year posttest research school district administered Essential Learner Outcome (ELO) math scores converted to standard scores?

Sub-Question 1c. Will there be a significant difference between boys' not meeting measured test score criteria for challenge math placement but receiving

challenge math placement based on fifth-grade teachers' recommendations beginning of school year pretest compared to ending of school year posttest research school district administered Essential Learner Outcome (ELO) math scores converted to standard scores?

Sub-Question 1d. Will there be a significant difference between girls' not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations beginning of school year pretest compared to ending of school year research school district administered Essential Learner Outcome (ELO) math scores converted to standard scores?

Overarching Posttest-Posttest Achievement Research Question #2. Do (a) sixth-grade boys meeting measured test score criteria for challenge math placement or (b) sixth-grade girls meeting measured test score criteria for challenge math placement or (c) sixth-grade boys not meeting measured test score criteria for challenge math placement, but receiving challenge math placement based on fifth-grade teachers' recommendations or (d) sixth-grade girls not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations have congruent or different posttest end of school year sixth-grade Essential Learner Outcome (ELO) math scores converted to standard scores?

Sub-Question 2a. Will there be a significant difference between boys' meeting measured test score criteria for challenge math placement ending of school year posttest compared to ending of school year posttest research school district administered Essential Learner Outcome (ELO) math scores converted to standard scores?

Sub-Question 2b. Will there be a significant difference between girls' meeting measured test score criteria for challenge math placement ending of school year posttest compared to ending of school year posttest research school district administered Essential Learner Outcome (ELO) math scores converted to standard scores?

Sub-Question 2c. Will there be a significant difference between boys' not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations ending of school year posttest compared to ending of school year posttest research school district administered Essential Learner Outcome (ELO) math scores converted to standard scores?

Sub-Question 2d. Will there be a significant difference between girls' not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations ending of school year posttest compared to ending of school year posttest research school district administered Essential Learner Outcome (ELO) math scores converted to standard scores?

Overarching Pretest-Posttest Achievement Research Question #3. Do (a) sixth-grade boys meeting measured test score criteria for challenge math placement or (b) sixth-grade girls meeting measured test score criteria for challenge math placement or (c) sixth-grade boys not meeting measured test score criteria for challenge math placement, but receiving challenge math placement based on fifth-grade teachers' recommendations or (d) sixth-grade girls not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers'

recommendations lose, maintain, or improve their end of school year pretest fifth-grade Orleans Hanna Algebra Prognosis test scores converted to standard scores compared to their end of school year posttest sixth-grade Orleans Hanna Algebra Prognosis test scores?

Sub-Question 3a. Will there be a significant difference between boys' meeting measured test score criteria for challenge math placement end of school year pretest fifth-grade Orleans Hanna Algebra Prognosis test scores compared to their end of school year posttest sixth-grade Orleans Hanna Algebra Prognosis test scores?

Sub-Question 3b. Will there be a significant difference between girls' meeting measured test score criteria for challenge math placement end of school year pretest fifth-grade Orleans Hanna Algebra Prognosis test scores compared to their end of school year posttest sixth-grade Orleans Hanna Algebra Prognosis test scores?

Sub-Question 3c. Will there be a significant difference between boys' not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations end of school year pretest fifth-grade Orleans Hanna Algebra Prognosis test scores compared to their end of school year posttest sixth-grade Orleans Hanna Algebra Prognosis test scores?

Sub-Question 3d. Will there be a significant difference between girls' not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations end of school year pretest fifth-grade Orleans Hanna Algebra Prognosis test scores compared to their end of school year posttest sixth-grade Orleans Hanna Algebra Prognosis test scores?

Overarching Posttest-Posttest Achievement Research Question #4. Do (a) sixth-grade boys meeting measured test score criteria for challenge math placement or (b) sixth-grade girls meeting measured test score criteria for challenge math placement or (c) sixth-grade boys not meeting measured test score criteria for challenge math placement, but receiving challenge math placement based on fifth-grade teachers' recommendations or (d) sixth-grade girls not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations have congruent or different posttest end of school year sixth-grade Orleans Hanna Algebra Prognosis test scores?

Sub-Question 4a. Will there be a significant difference between boys' meeting measured test score criteria for challenge math placement ending of school year posttest compared to ending of school year posttest sixth-grade Orleans Hanna Algebra Prognosis test scores?

Sub-Question 4b. Will there be a significant difference between girls' meeting measured test score criteria for challenge math placement ending of school year posttest compared to ending of school year posttest sixth-grade Orleans Hanna Algebra Prognosis test scores?

Sub-Question 4c. Will there be a significant difference between boys' not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations ending of school year posttest compared to ending of school year posttest sixth-grade Orleans Hanna Algebra Prognosis test scores?

Sub-Question 4d. Will there be a significant difference between girls' not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations ending of school year posttest compared to ending of school year posttest sixth-grade Orleans Hanna Algebra Prognosis test scores?

Overarching Pretest-Posttest Achievement Research Question #5. Do (a) sixth-grade boys meeting measured test score criteria for challenge math placement or (b) sixth-grade girls meeting measured test score criteria for challenge math placement or (c) sixth-grade boys not meeting measured test score criteria for challenge math placement, but receiving challenge math placement based on fifth-grade teachers' recommendations or (d) sixth-grade girls not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations lose, maintain, or improve their first trimester sixth-grade, challenge math course first exam grade scores compared to their third trimester sixth-grade, challenge math course final exam grade scores?

Sub-Question 5a. Will there be a significant difference between boys' meeting measured test score criteria for challenge math placement beginning of school year pretest first trimester sixth-grade, challenge math course first exam grade scores compared to ending of school year posttest third trimester sixth-grade, challenge math course first exam grade scores?

Sub-Question 5b. Will there be a significant difference between girls' meeting measured test score criteria for challenge math placement beginning of school year pretest first trimester sixth-grade, challenge math course first exam grade scores

compared to ending of school year posttest third trimester sixth-grade, challenge math course first exam grade scores?

Sub-Question 5c. Will there be a significant difference between boys' not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations beginning of school year pretest first trimester sixth-grade, challenge math course first exam grade scores compared to ending of school year posttest third trimester sixth-grade, challenge math course first exam grade scores?

Sub-Question 5d. Will there be a significant difference between girls' not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations beginning of school year pretest first trimester sixth-grade, challenge math course first exam grade scores compared to ending of school year posttest third trimester sixth-grade, challenge math course first exam grade scores?

Overarching Posttest-Posttest Achievement Research Question #6. Do (a) sixth-grade boys meeting measured test score criteria for challenge math placement or (b) sixth-grade girls meeting measured test score criteria for challenge math placement or (c) sixth-grade boys not meeting measured test score criteria for challenge math placement, but receiving challenge math placement based on fifth-grade teachers' recommendations or (d) sixth-grade girls not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations have congruent or different posttest end of school third trimester sixth-grade, challenge math course final exam grade score?

Sub-Question 6a. Will there be a significant difference between boys' meeting measured test score criteria for challenge math placement ending of school year posttest compared to ending of school year posttest third trimester sixth-grade, challenge math course final exam grade score?

Sub-Question 6b. Will there be a significant difference between girls' meeting measured test score criteria for challenge math placement ending of school year posttest compared to ending of school year posttest third trimester sixth-grade, challenge math course final exam grade score?

Sub-Question 6c. Will there be a significant difference between boys' not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations ending of school year posttest compared to ending of school year posttest third trimester sixth-grade, challenge math course final exam grade score?

Sub-Question 6d. Will there be a significant difference between girls' not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations ending of school year posttest compared to ending of school year posttest third trimester sixth-grade, challenge math course final exam grade score?

Overarching Pretest-Posttest Achievement Research Question #7. Do (a) sixth-grade boys meeting measured test score criteria for challenge math placement or (b) sixth-grade girls meeting measured test score criteria for challenge math placement or (c) sixth-grade boys not meeting measured test score criteria for challenge math placement, but receiving challenge math placement based on fifth-grade teachers' recommendations

or (d) sixth-grade girls not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations lose, maintain, or improve their end of first trimester sixth-grade, challenge math report card grade scores compared to their third trimester sixth-grade, challenge math course final exam grade scores?

Sub-Question 7a. Will there be a significant difference between boys' meeting measured test score criteria for challenge math placement beginning of school year pretest first trimester sixth-grade, challenge math report card grade score compared to ending of school year posttest third trimester sixth-grade, challenge math report card grade score?

Sub-Question 7b. Will there be a significant difference between girls' meeting measured test score criteria for challenge math placement beginning of school year pretest first trimester sixth-grade, challenge math report card grade score compared to ending of school year posttest third trimester sixth-grade, challenge math report card grade score?

Sub-Question 7c. Will there be a significant difference between boys' not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations beginning of school year pretest first trimester sixth-grade, challenge math report card grade score compared to ending of school year posttest third trimester sixth-grade, challenge math report card grade score?

Sub-Question 7d. Will there be a significant difference between girls' not meeting measured test score criteria for challenge math placement but receiving

challenge math placement based on fifth-grade teachers' recommendations beginning of school year pretest first trimester sixth-grade, challenge math report card grade score compared to ending of school year posttest third trimester sixth-grade, challenge math report card grade score?

Overarching Posttest-Posttest Achievement Research Question #8. Do (a) sixth-grade boys meeting measured test score criteria for challenge math placement or (b) sixth-grade girls meeting measured test score criteria for challenge math placement or (c) sixth-grade boys not meeting measured test score criteria for challenge math placement, but receiving challenge math placement based on fifth-grade teachers' recommendations or (d) sixth-grade girls not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations have congruent or different posttest end of third trimester sixth-grade, challenge math report card grade score?

Sub-Question 8a. Will there be a significant difference between boys' meeting measured test score criteria for challenge math placement ending of school year posttest compared to ending of school year posttest end of third trimester sixth-grade, challenge math report card grade score?

Sub-Question 8b. Will there be a significant difference between girls' meeting measured test score criteria for challenge math placement ending of school year posttest compared to ending of school year posttest end of third trimester sixth-grade, challenge math report card grade score?

Sub-Question 8c. Will there be a significant difference between boys' not meeting measured test score criteria for challenge math placement but receiving

challenge math placement based on fifth-grade teachers' recommendations ending of school year posttest compared to ending of school year posttest end of third trimester sixth-grade, challenge math report card grade score?

Sub-Question 8d. Will there be a significant difference between girls' not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations ending of school year posttest compared to ending of school year posttest end of third trimester sixth-grade, challenge math report card grade score?

Data Collection Procedures

All study achievement data were retrospective, archival, and routinely collected school information. Permission from the appropriate school research personnel was obtained. All study subjects were randomly selected--15 boys in arm one placed in challenge math based on measured math ability, 15 girls in arm two placed in challenge math based on measured math ability, 15 boys in arm three placed in challenge math based on teacher recommendation and 15 girls in arm four placed in challenge math based on teacher recommendation. Non-coded numbers were used to display individual de-identified achievement data. Aggregated group data, descriptive statistics, and parametric statistical analysis were utilized and reported with means and standard deviations on tables.

Performance site. The research was conducted in the public school setting through normal educational practices. The study procedures did not interfere with the normal educational practices of the public school and did not involve coercion or discomfort of any kind. Data were stored on spreadsheets and computer flash drives for

statistical analysis in the office of the primary researcher and the dissertation chair. Data and computer files were kept in locked file cabinets. No individual identifiers were attached to the data.

Institutional Review Board (IRB) for the protection of Human Subjects

Approval Category. The exemption categories for this study were provided under 45CFR.101(b) categories 1 and 4. The research was conducted using routinely collected archival data. A letter of support from the district was provided for IRB review.

Assumptions

The study has several strong points including: (a) district wide assessment process is used for placing students in middle school math classes, (b) the challenge math program is an established and widely respected course option, (c) all subjects were enrolled in the same school district during the study and were in the same school within the district during the sixth-grade year, (d) students placed in the challenge math class were taught the same district math curriculum, (e) all students were assessed by the same standardized prognosis test.

Delimitations of the Study

This study was delimited to the incoming sixth-grade students of one middle school in a suburban school district who were in attendance from the fall of 2008 to the spring of 2009. All fifth-grade students in 2007-2008 were required to take the Math Essential Learner Outcome assessment in the spring of 2008. Most fifth-grade students in 2007-2008 were required to take the Orleans Hanna Algebra Prognosis test in the spring of 2008. A small number of students were excluded by the elementary school from taking the Orleans Hanna test. Data on challenge math class test scores and retake

data was collected routinely throughout the school year included in the study. Study findings were delimited to the students participating in the challenge math course offering.

Limitations of the Study

This exploratory study was confined to sixth-grade students ($N = 60$) participating in a yearlong challenge math course. Study participants in the first arm ($n = 15$) boys that met the measured test score criteria for placement in challenge math class. Study participants in the second arm ($n = 15$) girls met the measured test score criteria for placement in challenge math class. Study participants in the third arm ($n = 15$) boys that did not meet the measured test score criteria for placement in challenge math class but were placed in challenge math based on teacher or parent recommendation. Study participants in the fourth arm ($n = 15$) girls that did not meet the measured test score criteria for placement in challenge math class, but were placed in challenge math based on teacher or parent recommendation. Students in the four arms were randomly selected from a group of students that were given the placement exam and met the study criteria. The small number of study subjects could limit the utility and generalizability of the study results and findings.

Definition of Terms

Algebra. For the purpose of this study, algebra is the course that all successful challenge math students will take in eighth-grade. It is seen by many as the first in a series of higher-level math classes or a gateway to higher mathematics (McCoy 2005). This course is considered on grade level when taken at the ninth-grade level.

Algorithms. An algorithm is a step by step process by which an operation can be carried out.

Assessment. Assessment is defined as a process of collecting data for the purposes of making decisions about individuals and groups. In this study, the Orleans Hanna Algebra Prognosis test and Essential Learner Outcome Math test were utilized as an assessment to determine student proficiency in math ability in order to successfully place students in an appropriate math class.

Barely proficient. Barely proficient is defined as when a student just produces work with a quality that shows minimal demonstration of mastery. In this study students were determined to be non-proficient if they did not meet the cut score on the fifth-grade or sixth-grade math essential learner outcome.

Below proficient. Below proficient is defined as when a student cannot produce the designated quality of work to demonstrate mastery of a particular standard for a particular subject matter. In this study students were determined to be non-proficient if they did not meet the cut score on the fifth-grade or sixth-grade math essential learner outcome.

Challenge Math. A class offered in the research school to sixth-grade students. This class is one year advanced above grade level. This course is the same as seventh-grade math.

Central Tendency. The central tendency is a measure that denotes where the middle of a set of data lies. The three most common measures of central tendency are; mean (average), median (middle point), and mode (greatest frequency) of the set of data.

Congruence. Two figures are congruent to each other if they have the same size and shape.

Coordinate Plane. A coordinate plane is a plane with a point selected as an origin, some length selected as a unit of distance, and two perpendicular lines that intersect at the origin, with positive and negative direction selected on each line. Typically the line that runs from left to right is referred to as the x-coordinate and the line that runs vertically is referred to as the y-coordinate.

Curriculum Standards. The objectives or learning goals that are laid out in the foundation of course work that a teacher teaches. The standards are the gauge to which teaching and learning success are measured.

Cut score. A cut score is defined as the established score, at or above which, a student is expected to perform to demonstrate proficiency.

Grading for Learning. A grading practice in which the students earned grade is a true reflection of what the student knows and able to demonstrate regarding the taught concepts.

Grade point average (GPA). Grade point average is defined as the average on a scale of 4.0 of the grades received by a student throughout a school based on the Infinite Campus system.

Exponents. An exponent is an expression used to denote the number of times a base is used as a factor. For example $a \cdot a \cdot a = a^3$.

Formative Assessment. Formative assessments in the research school district will mean daily assignments, chapter tests, chapter or section quizzes, activities, and projects.

Histogram. A histogram is a bar graph that represents the relative frequencies of data with a specific interval.

Inequalities. An inequality is a statement regarding how the relative size or order of two objects is the same (equal) or not. The notation $a < b$, denotes that a , is a number that is less than b , but it could be any number as long as it is less than b . In the case of a statement such as, $a \neq b$, a , could be any number less than or greater than b , but does not denote which.

Integers. An integer is any positive or negative number including zero that does not include a fraction or decimal.

Irrational Number. An irrational number is a real number that cannot be written as a simple fraction.

Linear Equation. A linear equation is an equation or a graph that represents a straight line. This equation is usually found in the form $f(x) = mx + b$.

Math 6. This is the sixth-grade level math course. Any student that is on grade-level in regard to their math skills would be placed in the Math 6 course.

Math Essential Learner Outcome (ELO). Essential learner outcome is defined as an academic standard for which students must demonstrate proficiency by meeting established standards on district wide assessments.

Normal curve equivalent (NCE). Normal curve equivalent is defined as standard scores with a mean equal to 50 and a standard deviation equal to 21.06. Running from 1 to 99, the numbers on the NCE line indicate how many students out of a hundred had a lower score. NCE scores are often used to compare standardized test performance over a period of years.

Norm-referenced test (NRT). Norm-referenced tests are defined as tests that measure and compare an individual's performance to the performance of a similar group of students who have taken the same test. The NRT used in this study was the Terra Nova Achievement Test.

Orleans Hanna Algebra Prognosis Test. A norm referenced test used to help predict student's readiness for algebra courses. Percentile ranks and stanines can be given for students completing grade seven and eight mathematics to determine the students' readiness for completing a one-year algebra course the next year. The research school uses a raw score out of 50 possible points as one part of a triangulated placement score (Toone, 2011).

Parallelogram. A parallelogram is a polygon that contains four line segments with two sets of parallel sides.

Perimeter. The perimeter of a polygon is the sum of all the lengths of all the sides.

Polygon. A polygon is a closed plane figure formed by three or more line segments that do not cross each other.

Pre-Algebra. This course is the grade-level math course for eighth-grade students at the research school. It is designed to introduce students to algebra skills in order to develop the algebra readiness needed to take algebra. Students who are gifted in the area of mathematics as sixth-graders will be placed in this course as sixth-graders.

Proficient. Proficient is defined as when a student can produce the designated quality of work to demonstrate mastery of a particular standard for a particular subject matter.

Pythagorean Theorem. The Pythagorean Theorem is used to find the side lengths of a right triangle. It states that the square of the hypotenuse is equal to the squares of the two sides or $A^2 + B^2 = C^2$, where C is the hypotenuse.

Radical Expression. A radical expression is an expression that contains a square root, for example, $5 \pm \sqrt{9}$.

Rational Number. A rational number is any number that can be expressed as the quotient or fraction of two integers, with the denominator not equal to zero.

Real Number. A real number is any point that falls on number line in a coordinate plane.

Rotational Symmetry. An object with rotational symmetry will look the same after a certain amount of rotation. A star fish would be an example of an object that could have rotational symmetry.

Scientific Notation. Scientific notation is a way of writing numbers that accommodates values too large or small to be easily written in standard decimal form. Scientific notation uses exponents or the power of 10 to represent these numbers.

Similarity. Similarity or symmetry corresponds to the size, shape, form, or arrangement of parts on a plane or line

Square Root. A square root of a number x is a number r such that $r^2 = x$, or, in other words, a number r whose square, the result of multiplying the number by itself, or $r \times r = x$.

Stem and Leaf Plot. A stem and leaf plot is used in statistics as a way of representing quantitative data in graphical format. It is similar to a histogram in allowing

the observer to visualize the data set in an appearance that represents the distribution of the numbers in the data set.

Summative Assessment. Summative assessments in the research district math curriculum refer to those assessments that occur at the end of a unit of study. This will include district prepared tests and projects.

Transversal. A transversal is any line that divides any other line or ray.

Trapezoid. A trapezoid is a four sided polygon with exactly one pair of parallel sides.

Zero Property of Multiplication. The zero property of multiplication states that any number multiplied by zero will give a product or answer of zero.

Significance of the Study

This study has the potential to contribute to research, practice, and policy. It is of significant interest to educators seeking ways to help place students in appropriate ability-level math classrooms in order to have students' achieve at their highest level.

Contribution to research. There is a great deal of research in the area of algebra readiness and early algebra, but little is focused on determining the effectiveness of placement procedures. This study could help to inform those that struggle with math placement issues from elementary school into middle school.

Contribution to practice. This study has the potential of contributing to educational practice by examining math placement processes used at the research school, as well as other middle schools. The findings of this study will inform the research school about math placement processes and the need to continue the existing process or change the process to better meet the needs of students.

Contribution to policy. The results of this study could inform the research school district to make policy changes in the math placement process. It could further assist other school districts in developing a math placement process to be used in placing students in the appropriate math course as they enter middle school.

Organization of the Study

The literature review relevant to this study is presented in Chapter 2. This chapter reviews professional literature on algebra, gender differences, and instructional strategies. Chapter 3 describes the research design, methodology, and procedures used to gather and analyze the data of the study. Chapter 4 reports the research results and findings-- including data analysis, tables, and descriptive statistics. Chapter 5 provides conclusions and a discussion of the research findings.

CHAPTER TWO

Why Challenge Math

At the heart of any education issue is the push from society at any given time in history. Mathematics has been no stranger to this societal pressure. A close look at the number of students taking algebra in high school for the years of 1909 to 1955 shows the number falling from 56.9% to 24.8% (Klein, 2003). A look at history offers some reasons for these falling numbers. The 1930's saw a trend to the "Activity Movement" where teachers taught children and not subject matter. The 1940's found the army having to teach math to its recruits so they could do bookkeeping or basic gunnery. The "Life Adjustment Movement" of the 1940s was taking place and students were to learn about consumer buying, insurance, and home budgeting, not algebra, geometry, and trigonometry. Then in 1957, the launching of the Soviet satellite, Sputnik, embarrassed the United States and called attention to the lack of quality math and science education in the public schools. As a result, President Kennedy called on the nation to step up the rigor in math and science and put a man on the moon. Congress followed suit by enacting the 1958 National Defense Education Act to increase the number of math and science majors in colleges (Klein, 2003).

With the publishing of *A Nation at Risk* (1983) math shortcomings were called into public scrutiny. The report cited remedial math courses taught in public four year colleges had risen by 72% over the period of 1975 to 1980. During this same period, only 31% of high school graduates completed intermediate algebra. As the 1980's came to a close the National Council of Teachers of Mathematics created the *Curriculum and Evaluation Standards for School Mathematics*, these standards were broken into grade

levels K-4, 5-8, and 9-12 but were met with some skepticism for not involving a connected progression of concepts for teachers to follow.

President Clinton had a part in math history by challenging public schools to do more with math. In his *Call to Action for American Education in the 21st Century* speech (1997), Clinton challenged math teachers saying, "...what 20% of our eighth-grade students learn in math is learned by most Japanese seventh-grade students" (Warren, 2008). In his speech then President Clinton claimed that as a nation we do not expect enough of our students and one of his charges was for every eighth-grade student to know algebra.

The 2000's saw President Bush and his "*leave no child behind*" legislation with an emphasis on a new focus on math and science education by requiring a rigorous exam before graduation (Gill, 2004). President Obama followed suit during his September 2010 address stating that he had set a goal of moving America from the middle of the pack in science and math education to the top. To accomplish this President Obama, pledged to recruit 10,000 new math and science teachers over the next two years to support and strengthen our nation's math and science education.

As a result of these political figures, we have seen a more focused effort on the part of national organizations such as, the National Council of Teachers of Math (NCTM), state education departments, and local school districts making efforts to strengthen math standards throughout K-12 education.

Contemporary Challenge Math Curriculum

In this study, two groups of sixth-grade students, those meeting the assessment requirements for placement and those not meeting the assessment requirement for

placement, but were placed due to parent or teacher recommendation, were placed in the same Challenge Math class--the grade level equivalent of seventh-grade math. With successful completion of Challenge Math, students would move to seventh-grade and take Pre-Algebra, and then Algebra in eighth-grade. Students taking these classes are taught concepts in four main standard areas; (a) number sense, (b) geometric/measurement, (c) algebraic, and (d) data analysis/probability. The concern is whether sixth-grade students, particularly those placed based on teacher and/or parent pressure are ready to meet the conceptual and computational challenges required to learn and master this rigorous curriculum.

Number sense standard. In the number sense standard, students are to represent and show relationships among rational numbers such as ordering rational numbers with fractions, decimals, and percents and demonstrate the meaning of arithmetic operations with positive fractions, decimals, and integers such as:

$\frac{2}{3} \times 6$ as two-thirds of six or $6 \times \frac{2}{3}$ as six groups of two-thirds

Students are to compute fluently and accurately with appropriate strategies and tools and estimate and check reasonableness of answers using appropriate strategies and tools.

Student in the pre-algebra class studying the number sense standard will represent and show relationship among real numbers. These students will convert between scientific notation and standard form including negative numbers. Proficiency with arithmetic operations with integers will be expected and the use of words and symbols will be used to explain properties such as the zero property of multiplication:

If $ab = 0$ then a or b or both must be zero

Students will investigate calculation of square integers, the square roots of perfect squares, and the square roots of whole numbers using technology. Problems involving ratios and percents will be solved such as:

$$x/5 = 10/17$$

As students study algebra this standard asks students to represent and show relationships among real numbers. Equivalent forms of irrational numbers are explored, such as:

$$\sqrt{8} = 2\sqrt{2}$$

Students have to do more with arithmetic operations and numbers by demonstrating the meaning of these operations with real numbers. Students will investigate the effects of multiplication and division and computing positive powers and roots on the magnitude of quantities, for example:

If you take the square root of a number, will the result be smaller than the original? $\sqrt{1/4} = 1/2$

Students will be able to multiply and divide numbers using scientific notation and simplify exponential expressions using powers. Students must be able to explain the method of computation when problem solving. Finally they need to be able to distinguish between relevant and irrelevant information in a given problem.

Geometric and Measurement. In the geometric/measurement standard students are to compare and contrast properties and relationships of geometric shapes and objects. Students will learn how to use coordinate geometry to specify locations and describe relationships of those locations:

What is the distance between (0,3) and (0,9)?

Students will use transformations and symmetry to analyze geometric shapes, use visualization to create geometric models in solving problems, and select and apply appropriate procedures, tools, and formulas to determine measurements.

In the pre-algebra geometric and measurement standard, students will be describing, comparing, and contrasting characteristics, properties, and relationships of geometric shapes and objects. Similar and congruent objects will be explored. The angles created by transversals dissecting parallel lines will be explored and understanding the relationship of the interior angles of a triangle will be examined. Students will use strategies to find the area and perimeter of complex shapes. And finally, the Pythagorean theorem will be used to find the missing lengths in right triangles and solve problems.

When investigating this standard, students in algebra will use coordinate geometry to analyze and describe relationships in the coordinate plane. They will learn to apply slope to write and graph parallel and perpendicular lines. This standard also has students converting equivalent rates, such as:

Feet/second to miles/hour

Students will be able to apply units, systems, and formulas to solve problems.

Algebraic standard. The Challenge Math algebraic standard asks students to represent and analyze relationships using algebraic symbols, such as:

$$2X = 6$$

Students will create, use, and interpret models of quantitative relationships:

Two times some number equals six or six less some number equals thirteen

And, finally students can apply properties to solve equations and inequalities:

$$2(x+3) = 2x+6 \text{ or } 7 + -7=0$$

In the pre-algebra algebraic standard the focus is centered around beginning algebra concepts such as; describing relationships using algebraic expressions, equations and inequalities, identifying slope from tables and graphs, and determining rate of change from the slope of a line. An emphasis will be on graphing two variable equations using tables of ordered pairs and slope-intercept form. Students will graph linear inequalities and graphically solve linear systems of equations and inequalities. Evaluation of numerical expressions containing whole number exponents such as,

$$\text{If } x = 4, \text{ then } (x + 3)^2 + 5x = ??$$

will be central to this standard.

In the algebra course, the algebraic standard requires students to generalize, represent, and analyze linear, quadratic and exponential relationships using algebraic symbols. Students will use tables, graphs, and algebraic notation to convert among linear, quadratic, and exponential representations. Graphing and using ordered pairs to determine slope and intercepts of linear relationships from an equation or graph is a key objective to this standard. Students also need to model and analyze quantitative relationships by using a variety of methods such as; graphs, tables, one variable equalities, one variable inequalities, linear equations in slope intercept form, inequalities in slope intercept form, and system of linear equations with two variables. Another large concept in this standard is representing and solving equations and inequalities. Students should be able to simplify algebraic expressions involving exponents, such as:

$$(3x^4)^2 = 3x^4 \times 3x^4 \text{ or } 9x^8$$

Students should be able to multiply and divide a polynomial by a monomial:

$$\text{Divide, } x^4 - 5x^3 - 2x \text{ by } x^2$$

This standard asks students to be able to solve quadratic equations by graphing, factoring, extracting the root, and quadratic formula. They should be able to multiply, divide, and simplify rational expressions, as well as, analyze and solve systems of two linear equations in two variables algebraically and graphically. Finally, students should simplify radical expressions and solve radical equations.

Data analysis and probability standard. Challenge math students in this standard will find and interpret mean, median, mode, and range of data sets. They will tackle such concepts as explaining the difference between a population and a sample, selecting an appropriate measure of central tendency, evaluate predictions and inferences based on data, as well as, applying basic concepts of probability.

In this standard, pre-algebra students are asked to formulate questions that can be answered with data and then organize, display, and analyze the relevant data to answer their questions. Data will be presented in the form of circle graphs and box plots with and without technology. Central tendency along with quartiles for sets of data are explored. Along with the data analysis, students will explore the basic concepts of probability by computing the probabilities for independent compound events, dependent events and determining the odds of an event.

A key focus to this standard in algebra coursework is being able to formulate a question and design a survey, or an experiment, in which data is collected and displayed in a variety of formats, then select and use appropriate statistical methods to analyze the data. Students will interpret data represented by the normal distribution and formulate conclusions, as well as, explaining how sample size and transformations of data affect measure of central tendency. Students will develop and evaluate inferences to make

predictions and apply concepts of probability as they solve problems to answer their own questions.

National Council of Teachers of Math (NCTM) Standards

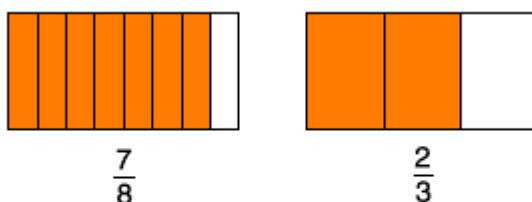
The United States does not have an official national math curriculum. In comparison with other industrialized and productive nations of the world, the United States relies on state and local control of the curriculum that is taught and assessed (Reys, Oscar, & Reys, 2003; Schmidt, Houang, & Cogan, 2002). This system can lead to an unfocused curriculum that fosters a culture of teaching what teachers feel like or what the textbook says to teach. Before 1985, no offering of a math national standard stating what should be taught and when it should be taught existed. The first year in which the NCTM standards arrived on the scene was 1989. These standards were updated in 2000, as a way to provide a focus for school leadership and teachers of math to key in on the necessary components of a sound mathematics curriculum (Reys, Chavez, & Reys, 2003).

The U.S. mathematics curriculum found in textbooks is characterized as a *mile wide by an inch deep* (Katz 2007; Schmidt & Cogan, 2009; Schmidt, McKnight, & Raizen, 1997). There is a growing consensus that while math textbooks typically cover lots of material few cover math concepts with substantial depth. In an effort to focus the math curriculum across the country the NCTM published updated standards in 2000. It is hoped that these standards will provide for learning goals for specific grade levels. These standards are organized in five content strands and five process strands (NCTM, 2002).

Content Strands

NCTM number and operations standard. According to the NCTM students should be able to understand numbers, ways of representing numbers, relationships among numbers, and numbering systems. They should be able to understand meanings of operations and how they relate to one another. Finally students should compute fluently and make reasonable estimates. Within these three main objectives are a host of more specific learning objectives such as:

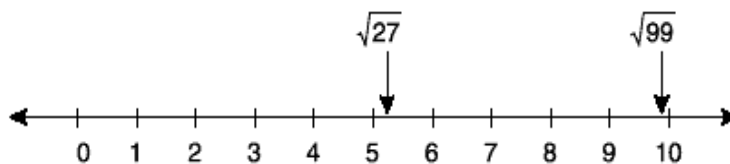
- Compare and order fractions, decimals, and percents to solve problems



The $\frac{7}{8}$ portion is one piece less than a whole, and so is $\frac{2}{3}$. But the missing piece for $\frac{7}{8}$ is smaller than the missing piece for $\frac{2}{3}$. So $\frac{7}{8}$ is bigger than $\frac{2}{3}$.

(NCTM, 2002)

- Develop an understanding of large numbers and recognize and appropriately use exponential, scientific and calculator notation
- Use factors, multiples, prime factorization and relatively prime numbers to solve problems



$\sqrt{27}$ is a little more than 5 because $5^2 = 25$.
 $\sqrt{99}$ is a little less than 10 because $10^2 = 100$.

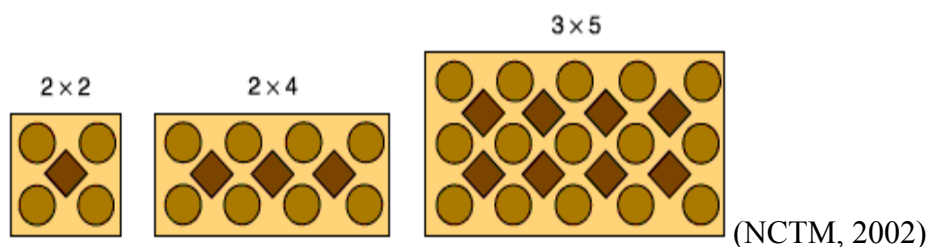
(NCTM, 2002)

- Understand the meaning and effects of arithmetic operations with fractions, decimals, and integers
- Use the associative and commutative properties of addition and multiplication and distributive property over addition to simplify computations with integers, fractions and decimals
- Develop and analyze algorithms for computing with fractions, decimals and integers and develop fluency in their use
- Develop, analyze, and explain methods for solving problems involving proportions, such as scaling and finding equivalent rates

NCTM algebra standard. In the algebra standard, students are to understand patterns, relations, and functions. In this standard students are also expected to be able to represent and analyze mathematical situations and structures using algebraic symbols. Students should be able to use mathematical models to represent and understand quantitative relationships and analyze change in various contexts. More specific learning goals will include items such as:

- Represent, analyze, and generalize a variety of patterns with tables, graphs, words, and when possible, symbolic rules

Super Chocolates are arranged in boxes so that a caramel is placed in the center of each array of four chocolates, as shown below. The dimensions of the box tell you how many columns and how many rows of chocolates come in the box. Develop a method to find the number of caramels in any box if you know its dimensions. Explain and justify your method using words, diagrams, or expressions.



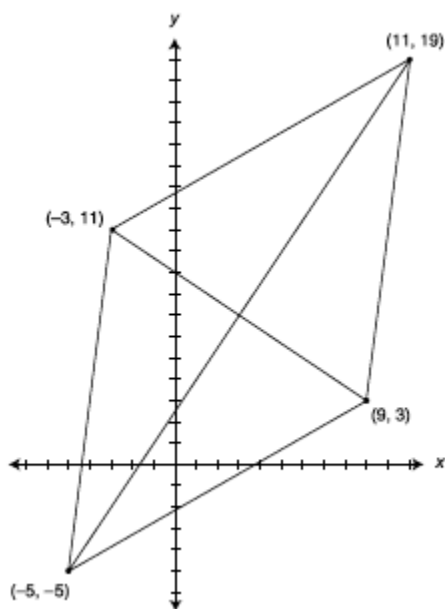
- Identify functions as linear or nonlinear and contrast their properties from tables, graphs, or equations
- Explore relationships between symbolic expressions and graphs of lines, paying particular attention to the meaning of intercept and slope
- Use symbolic algebra to represent situations and to solve problems, especially those that involve linear relationships

$$27 = 4x + 3 \text{ or } y = 3x$$

- Model and solve contextualized problems using various representations, such as graphs, tables, and equations
- Use graphs to analyze the nature of changes in quantities in linear relationships

NCTM geometry standard. Within the geometry standard, students will analyze characteristics of properties of two and three dimensional geometric shapes and develop mathematical arguments about geometric relationships. Students will specify locations and describe spatial relationships using coordinate geometry and other representational systems. Another large concept area is applying transformations and using symmetry to analyze mathematical situations. Finally, students will use visualization, spatial, reasoning, and geometric modeling to solve problems. More specific learning goals will include items such as:

- Understand relationships among the angles, side lengths, perimeters, areas, and volumes of similar objects
- Create and critique inductive and deductive arguments concerning geometric ideas and relationships, such as congruence, similarity, and the Pythagorean relationship
- Use coordinate geometry to examine special geometric shapes, such as regular polygons or those with pairs of parallel or perpendicular sides



Using slope from a coordinate plane

to determine observations about a rhombus

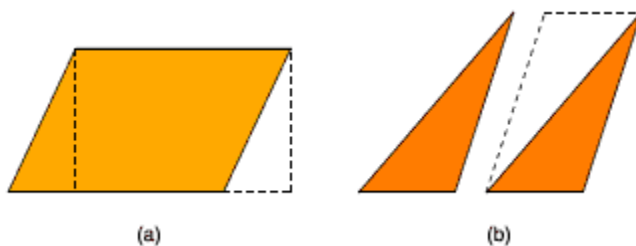
$$\frac{19 - (-5)}{11 - (-5)} = \frac{24}{16} = \frac{3}{2} \quad \text{and} \quad \frac{11 - 3}{-3 - 9} = \frac{8}{-12} = \frac{-2}{3}. \quad (\text{NCTM, 2002})$$

- Examine the congruence, similarity, and line or rotational symmetry of objects using transformations

- Use two dimensional representations of three dimensional objects to visualize and solve problems such as those involving surface area and volume
- Use geometric models to represent, apply geometric relationships in areas outside mathematics to solve problems in everyday life

NCTM measurement standard. The measurement standard has students understanding measurable attributes or objects and the units, systems, and processes of measurement. Applying appropriate techniques, tools, and formulas to determine measurements is also a key component of this standard. More specific learning goals will include items such as:

- Understand relationships among units and convert from one unit to another within the same system and to other systems
- Understand, select, and use units of appropriate size and type to measure angles, perimeter, surface area, and volume
- Select and apply techniques and tools to accurately find length, area, volume, and angles to appropriate levels of precision
- Develop and use formulas to determine the circumference of circles, triangles, parallelograms, trapezoids, and circles and develop strategies to find area for more complex shapes



In (a) students could rearrange the trapezoid into a rectangle to learn that the formula to find area of a trapezoid is $L \times W$ or in (b) learn that a triangles area can be found by $1/2bh$ (NCTM, 2002).

- Solve problems involving scale factors, using ratio and proportion
- Solve problems involving rates and derived measurements for such attributes as velocity and density

NCTM data analysis and probability standard. In the data analysis and probability standard, students will formulate questions that can be addressed with data and collect, organize, and display relevant data to answer the questions. Students will be able to select and use appropriate statistical methods to analyze data. This standard asks students to develop and evaluate inferences and predictions that are based on data, as well as, understand and apply basic concepts of probability. Again underlying these broad concepts are more specific learning goals that include items such as:

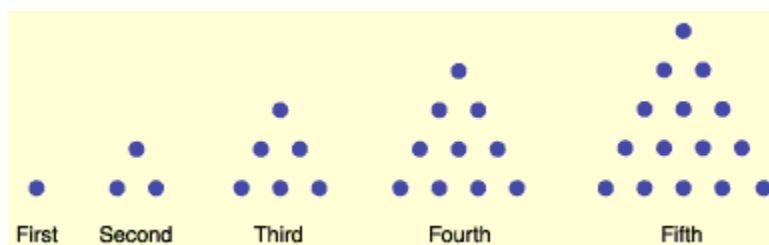
- Formulate questions, design studies, and collect data about a characteristic shared by two populations or different characteristics within one population
- Discuss and understand the correspondence between data sets and their graphical representations, especially histograms, stem and leaf plots, box plots and scatterplots
- Make conjectures about possible relationships between two characteristics of a sample on the basis of scatterplots of the data and approximate lines of fit

- Use proportionality and a basic understanding of probability to make and test conjectures about the results of experiments and simulations

Process Strands

NCTM problem solving standard. This is the first of the five process standards within the NCTM's curriculum. The NCTM feels that math instructional programs should incorporate problem solving in the curriculum from pre-kindergarten through 12th-grade. Students should be able to build new mathematical knowledge through problem solving, solve problems that arise in mathematics and in other contexts, apply and adapt a variety of appropriate strategies to solve problems, and monitor and reflect on the process of mathematical problem solving. According to the NCTM, these processes should not be done by individual students but the teacher encourages students to communicate with each other in problem solving.

NCTM Reasoning and Proof Standard. In the second of the five process standards, students are to recognize reasoning and proof as fundamental aspects of mathematics, make and investigate mathematical conjectures, develop and evaluate mathematical arguments and proofs, and finally, select and use various types of reasoning and methods of proof. Again these are not just sixth through eighth-grade standards but are meant to be incorporated across the entire math curriculum. An example might look like this:



Students were asked to generate the next number in the pattern, but the teacher might ask students to find the 100th term. So students would have to apply their mathematics reasoning and arrive at a solution and be able to defend that solution. (NCTM, 2002)

NCTM communication standard. The communication standard is the third of the five process standards to be woven throughout the entire mathematics curriculum. It asks students to organize and consolidate their mathematical thinking through communication, communicate their mathematical thinking coherently and clearly to peers, teachers, and others, analyze and evaluate the mathematical thinking and strategies of others, and use the language of mathematics to express mathematical ideas precisely.

NCTM connections standard. The fourth of the process standards is the connection standard. This standard asks students to recognize and use connections among mathematical ideas, understand how mathematical ideas interconnect and build on one another to produce a coherent whole, and recognize and apply mathematics in contexts outside of mathematics. At the heart of the NCTM middle level math curriculum is rational numbers, proportionality, and linear relationships. It is paramount that students understand the connection between these three main concepts to extend students learning and abilities.

NCTM representation standard. The fifth and final of the process standards is the representation standard. This has students creating and using representations to organize, record, and communicate mathematical ideas, selecting, applying, and translating among mathematical representations to solve problems, and use representations to model and interpret physical, social, and mathematical phenomena. By

using representation students can broaden their understanding of math concepts and the relationships within those math concepts. An example problem could look like this:

The Copy Cat printing shop has a printer that uses only black, red, and blue cartridges. All the cartridges print the same number of pages. The black cartridges are replaced 4 times as often as the red ones. And during the time in which 3 red cartridges need to be replaced, 5 blue cartridges will also need to be replaced. »

1. *What fraction of Copy Cat's printing is in black?*
2. *What percent of the printing is in blue?*
3. *In a month, 60 black cartridges are used. What is the total number of red and blue cartridges used in that month? (NCTM, 2002)*

It is important that the teacher help students develop the skills and confidence in developing their own representations as well as being able to communicate and defend their representations appropriately.

Algebra throughout the K-12 Curriculum

As seen in the curriculum laid out by the research school and the National Council of Teachers of Math, there is a real effort to include problem solving and mathematical investigation into our students' math curriculum. This concerted effort to bolster our math curriculum, no doubt comes from reports such as the Program for International Student Assessment (PISA) as reported by the U.S. Department of Education (2010). From chapter one of this document, data were given to show the United States poor performance when compared to other nations. A closer look at that data shows that PISA describes six mathematics literacy proficiency levels ranging from 1 to 6, the later being the most advanced. Twenty-seven percent of U.S. students scored at or above level 4 (above proficiency). This is lower than the other 32% of students in OECD countries on average that scored at or above level 4. A level 4 student is able to complete higher order

tasks like solving problems involving visual or spatial reasoning in unfamiliar contexts. While these results are not terrible, what is concerning is that nearly one-quarter of United States students scored below level 2. A level 2 student is not able to consistently use basic computational skills to draw accurate conclusions regarding problems in real-life situations (U.S. Department of Education, 2010).

“Algebrafying” the K-12 curriculum. Algebra has always acted as the gateway class to all higher-level math courses (McCoy, 2005). However, for some, algebra is the reform gateway to K-12 math curriculum for the next century. To some it is thought that the key to this algebra reform is integrating algebra across the K-12 math curriculum (Katz, 2007; Kaput, 2000). Kaput (2000) refers to algebra in two ways; “algebra the institution” and “algebra the web of knowledge and skill” (p. 2). For many it is claimed that *algebra for all* is the charge of this institution. As Kaput states, “But this algebra is the disease for which it purports to be the cure!” It is this “algebra the web of knowledge and skill” that is needed in the math classrooms of today.

Justification for teaching algebra to elementary age students. When we think about including algebra into earlier and earlier grades, it is not the “algebra institution” we are referring too but the “algebra the web of knowledge and skill” in which we intend to transform mathematics curriculum (Kaput 2000). In much of the research that falls into math or algebra curriculum reform we find less talk about the X’s and Y’s and more discussion of the connections, thought processes, and generalizations that can come from studying math concepts at a deeper level. Early algebra is an approach to educating students in the early grades that explores the deeper meanings of mathematics. It includes two foci: (1) Generalizing, identifying, expressing, and justifying math structure,

properties, and relationships and (2) reasoning and actions based on the forms of generalizations (Katz, 2007). According to many, early algebra is not a curriculum addition. It is not thought to be a separate list of activities or lessons that should be taught after the students have been taught math computation skills. As soon as students in elementary school are able to count and use math symbols, early algebra should be embedded in the math lessons being taught (VanNoy, 2010). It is also believed that early algebra is a way to bring depth of understanding to the mathematics understanding of young children by digging deeper into the concepts being taught so that students can generalize relationships and properties of those concepts. Early algebra is not a “moving to earlier grade levels” of algebra skills that are usually taught in middle school as a pre-algebra class. The goals of early algebra are for students to learn to reason algebraically as they begin to acquire the ideas behind symbolic algebraic language and explore math situations that draw on students’ mathematical knowledge in order to reflect, build arguments, and justify new ideas (Katz, 2007).

Gender Issues and Mathematics

There has been a great deal of research over gender differences in math abilities. Much research focuses on the underrepresentation of women in the area of math and science (Else-Quest, Hyde, & Linn, 2010; Halpern et al., 2007; Hyde, Fennema, & Lamon, 1990; Penner, 2008; Valentine, 1998). Scores from the 2009 PISA show that 15-year-old boys outperformed girl classmates by 20 points in overall math proficiency (NAESP 2011). However, when looking at the results of the National Assessment of Educational Progress over the last ten years, the reported gap between boys and girls is 2% (Geist & King 2008). A closer look at NAEP data reveals that while girls do equally

as well as boys and have made gains in math more recently, there is a difference in moderately complex procedures and reasoning for 13-year-olds. Boys are more proficient in this area, outperforming girls, 32.6% proficient to 25.6% proficient. When comparing 17-year-olds, boys are 8.8% proficient on multi-step problem solving and algebra compared to girls at 5.1% (James, 2007).

Women have had great success in college. American women receive more college degrees than men every year, a trend that began in 1982, and continues to grow today. Even with these successes, females score significantly lower on many high stakes standardized tests, including the verbal and mathematics section of both the Scholastic Aptitude Test (SAT) and the Graduate Record Examination (GRE) (Halpern et al., 2007). Females also score lower on mathematics tests that do not closely resemble the material which was taught in school, despite earning higher grades than males in school (Halpern, 2007; Willingham & Cole, 1997).

In a meta-analysis study of gender differences in math performance it was learned that there has been gender differences in math performance for years and that those differences are still with us today. Conclusions around the world tend to suggest simply that males outscore females on math tests. A closer look at the research reveals that the difference is not visible in early childhood, but becomes more prevalent during adolescents. It is thought that boys are better able to handle more complex problem solving and girls favor the less complex computation tasks (Hyde, Fennema, & Lamon, 1990).

Biological and Social Factors in Early Mathematics Achievement

In research there appear to be two themes that come to surface as you look at gender difference in mathematics; biological and social factors.

Biological factors. At first glance there may not appear to be much difference in the male and female brain, but a much closer look is needed to notice the difference between males and females. Through magnetic resonance imaging (MRI), scientist, have been able to learn a great deal about the differences of the brain between genders. In a paper on the differences between boys and girls brains, Anita Pringle (2011) summarizes these differences. The cerebral cortex is thicker on the right side in men and thicker on the left side in women. This indicates that the thicker side of the brain is more developed than the opposite side of the brain. The hemispheres of a female's brain will appear to be more identical where a male's brain is asymmetrical (Halpern, 2000). This difference means that a female will process spatial abilities in both hemispheres while males use one hemisphere (Penner, 2008)--a fact evidenced in research of damaged brains by Gazzaniga, Ivry, & Magnum (as cited in Penner, 2008). Furthermore, males with damaged left hemispheres show a loss of verbal abilities and damaged right hemispheres experience a loss of spatial abilities. Females with damage to the left hemisphere see a decrease in spatial and verbal abilities but no apparent decrease is found with damage to the right hemisphere in females. Males have larger inferior parietal lobes so they are better at judging speed, estimating time, and rotating objects mentally. In fact, at very early ages, boys perform better than girls in this area, in many cases by close to a full standard deviation (Halpern, 2004). In a meta-analysis study of gender differences in math, data from the content domain of Space/Shape on the PISA, an area that measures

understanding of spatial relationships, showed boys were slightly favored in this content area with a low effect size of ($d = 0.15$; Else-Quest, Hyde, & Linn, 2010).

However, girls are better at retrieving information from the long-term memory and typically score better than boys on tests of verbal learning and the creation and understanding of complex prose (Halpern, 2004). Male brains seem to be more specialized overall, whereas female brains seem to be more multipurpose (Pringle, 2011). This brain difference is apparent in elementary school when math involves math facts, calculations, and the quick retrieval similar to that needed in language generation and understanding favor girls. In algebra, girls perform better on problems where the solution involves a process similar to those of language processing (Gallagher, Levin, & Cahalan, 2002; Hyde, Fennema, & Lamon, 1990).

Another area of biological difference between males and females is the developmental process. Magnetic Resonance Imaging and Electro Encephalograph scans of male and female brains have given us images that show the brain of a 17 year-old boy are equivalent to the brain of an 11 year-old girl (Pringle 2011). Another way of measuring brain maturation is to look at the degree of myelination. Myelin is a waxy material that coats the axons in the brain. An infant will have no myelin and by adulthood the brain will be full of the substance. Using this substance scientist show a three to four year gap in brain development between boys and girls. Males did not catch up to females until the age of 29 (Pringle 2011).

Social Factors. We know that there are developmental difference in the brains and bodies of our children, but research is also trying to assess how much impact social factors play into the mathematics learning of our boys and girls. In July of 1992, a

talking Barbie hit the shelves of stores and much to the public's dismay uttered the phrase, "math class is tough." According to Sax (2010) and Geist and King (2008) research shows that girls feel less confident in their ability to perform well on math tests while boys often show greater confidence or over-confidence in their abilities.

Kloosterman, Tassell, Ponniah, & Essex (2008) found that most students, seventh through 12th-grade, believed that math is a gender-neutral domain but female students were stronger in those beliefs than males. Boys who rated themselves as good or excellent in math felt more strongly that math is not a female domain. Another study showed that students', when asked to nominate who is best in their class in language arts and math, named boys and girls equally in language arts, but in math the boys nominated only boys and the girls started nominating more boys than girls from the fourth-grade on (Räty, Kasanen, Kiiskinen, & Nykky, 2004).

Social factors are also determined by parent influence. For example, in research by Leedy, LaLonde, and Runk in 2003 (as cited in Geist & King, 2008) parents of sons tend to expect their sons to learn math skills earlier than do parents of girls and as the children get older they expect their daughters to work hard to get good grades in math while parents of boys emphasize the learning of math. Regardless of the gender, higher levels of parental involvement with their children's education equates to higher levels of performance in mathematics (Muller, 1998). According to a meta-analysis study by Lytton and Romney in 1991 (as cited by Halpern et al., 2007) there was no significant difference in how parents treated males and females in encouraging achievement but this study did not break the encouragement into different areas of study, for example language arts or mathematics. One area noted in the study is that fathers did tend to encourage sex-

typed behaviors such as discouraging their sons from playing with dolls. Furthermore, boys tend to gain more spatial experience because they tend to be allowed to roam over a greater area than girls who chose activities that are closer to home. This roaming of the neighborhood allows boys to have a better spatial understanding of the area as represented on drawings of maps between boys and girls (Halpern et al., 2007). This influence is an extension of the parent influence but is reinforced throughout the neighborhood as parents in the neighborhood allow boys more freedom to venture further from home.

Admission Standards for Early Algebra Course Participation

Understanding biological and social factors, math curriculum, and the readiness of students for taking algebra is important, but of equal importance is having an effective placement process to enroll students into the correct math courses. The placement process should help place a student on a track for mathematics success throughout the middle school experience and into high school. In chapter one of this research document, Bracey (2008) and Loveless (2008) discuss that algebra once was a class for the gifted but now has become a class that all students must take, whether they are ready or not. During the 2008-2009 school year, 144 students were taking algebra as eighth-graders. That is 43% of the total eighth-grade population. There were also 19 seventh-grade students that were taking algebra during their seventh-grade year. In a check of enrollment numbers for algebra in 2005-2006, there were 82 students taking algebra. This is a trend that appears to be growing in the research school as well as nationally.

Research school's method of placement. The process used to select student into their current math track has recently been changed. The former placement process used

by the research school, placed students into sixth-grade math courses based on the students Orleans-Hanna Algebra Prognosis Test (OH) raw score. Students who were identified as *gifted* in math were assessed with the OH test to see how they scored out of 50 possible questions. A student scoring 36 raw score points out of 50 or higher would be placed in a pre-algebra class as a sixth-grader, if the student scored between 28 raw score points and 36 raw score points then the student would be placed in the Challenge Math course. Those students that scored below 28 raw score points would be placed in Math 6 course that is the grade level math course.

The current method of selecting students uses a triangulated composite score. It uses the OH score as one part, the math section of the fourth-grade Terra Nova for the second, and the fourth-grade math Essential Learner Outcome (ELO) test as the third component. These three scores are scaled to 15 points. Each component shares an equal part in the 15 points. The triangulation of scores is bypassed if a student scores 35 raw score points or higher on the Orleans-Hanna. These students are placed in pre-algebra for sixth-grade. This path means that they will be in algebra as a seventh-grade student and geometry as an eighth-grade student. If students score less than 35 raw score points on the Orleans-Hanna, then the triangulation of scores is used. If a student is on the bubble between being placed in Math 6 or Challenge Math, the student's fifth-grade teacher, is contacted by the middle school registrar in order to give his/her input on the best math placement. This recommendation involves the fifth-grade teacher making a decision for each student based on the knowledge that he/she was on the bubble for placement in Math 6 or Challenge Math 6. Fifth-grade teachers are not given detailed OH scores to assist in their placement decisions

Orleans-Hanna algebra prognosis test. The Orleans-Hanna test, originated in 1928 for the purpose of determining the algebra readiness of student in grades 7-11, was updated in 1950, revised in 1968, and again in 1982. The test has technical data to back up its reliability as a prognosis test. The author of the test used multiple-regression predictions and presented evidence that the test attains predictive qualities by considering the test along with past grades as a predictor of success in algebra (Ciechalski, 2005; Toone, 2011).

In a 1985 review of the Orleans-Hanna Test by Kuchemann and Secolsky, the test appeared to be a useful predictor of algebra success. These reviewers asserted that the author had eliminated some of the weakness found in early versions of the test, but also felt further evidence to support content validity was needed, while the existing validity and reliability evidence was sound--leading them to conclude that of the test should be recommended to anyone in need of an algebra prognosis test (as cited in Ciechalski, 2005).

Having used this test as a prognosis test at the research school, it appears to give credible information regarding the success of students in pre-algebra. Yet, one cannot help but wonder if this test is appropriate with fifth and sixth-grade students. All evidence that has been studied has been on seventh and eighth-grade students. In other schools, the OH is used in combination with other indicators to determine math placement of students in middle school. In doing so, these school districts use a heavier weighting on the OH scores and less emphasis on the other scores (Daubert, 2006).

Other schools math placement procedures. The Davis School District of Farmington, Utah uses the OH along with criterion reference test scores from a student's

elementary math courses along with the results of the fifth-grade Iowa Test of Basic Skills. The OH is administered at the end of the sixth-grade year in order to accurately place students in the appropriate seventh-grade math course, pre-algebra, or algebra.

Furthermore, in the Wake County Public School System of Raleigh, North Carolina, it was noticed during the mid-1990s that more and more students in middle school were starting to take algebra. The screening process was based on the Iowa Algebra Aptitude Test (IAAT), which was given near the end of the sixth or seventh-grade. Data was also used from the North Carolina End of Grade (EOG) test to aid in appropriate placement. However, neither test was accurate in predicting the success of students in algebra. Statistical correlations between the IAAT or EOG and the Algebra I End-of-Course test showed moderately positive correlation ($r = .36$ to $r = .49$) but failed to include some lower scoring students who went on to be successful and included some higher scoring students who ended up struggling with algebra (Dulaney, 1996).

Finally, the Richmond Diocese gathered leaders from nearly twenty different schools to determine an appropriate placement procedure for those seventh or eighth-graders wanting to take algebra at the middle school. The requirements agreed upon were; a minimum score of 85% or higher on the Math Terra Nova, 85% or higher on the end of the year math exam, an 80 percentile score on the OH or an 85 percentile on the IAAT. Along with those score requirements, students had to sign a contract indicating their willingness to engage in a class that is rigorous. While in the class students must maintain a grade of a "B" or better in order to stay in the class. Successful completion of algebra at the middle school would earn the student high school math credit.

Conclusion

It appears that over the past two decades a growing trend of placing more and more students in algebra at earlier grades may be becoming the norm. This relatively new norm has potentially devastating consequences if not handled appropriately. Educators cannot take existing algebra curriculum and push it into lower grade levels and expect that all students will be successful. As previously mentioned, algebra is a *gateway* course. A successful completion of algebra opens more opportunities for students. These students are able to complete more advanced coursework in mathematics and pursue the studies of more advanced careers such as, engineering and the medical field. *Algebra for all* is a noble educational goal, but it is not a realistic goal when attempting to do so at the eighth-grade level. Not all students are ready for the abstract thinking involved in understanding algebraic concepts. However, government officials see algebra as the way to put the United States on top in the global assessment race. Parents see algebra as a rigorous course to push their child, while others see it as a key to a lucrative career (Steen, 1999). All educators need to ask some practical questions: Are all students ready for algebra? Is our mathematics curriculum getting kids ready for algebra? And finally, what is the rush to get to algebra? The answers to these questions are the key to providing a quality, student ready, mathematics program.

CHAPTER THREE

Methodology

The purpose of the study is to determine the math test scores, algebra achievement predictor scores, and challenge math course grades of sixth-grade students meeting measured test score criteria for challenge math placement compared to the math test scores, algebra achievement predictor scores, and challenge math course grades of sixth-grade students not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations.

Participants

Number of participants. The maximum accrual ($N = 60$) for this study will include a randomly selected group of students ($n = 30$) who met the measured test score criteria for challenge math placement and a randomly selected group of students ($n = 30$), who did not meet the measured test score criteria for challenge math placement but received challenge math based on fifth-grade teachers' recommendations.

Gender of participants. Of the total number of selected subjects who met the measured test score criteria for challenge math placement ($N = 60$) 15 (50%) were boys and 15 (50%) were girls. Of the total number of selected subjects who did not meet the measured test score criteria for challenge math placement but received challenge math based on teacher or parent recommendation 15 (50%) were boys and 15 (50%) were girls. The gender distribution of the study participants is congruent with the research school districts gender demographics for fifth-grade and sixth-grade students.

Age range of participants. The age range for all study participants was from 10 years to 12 years. All participants were in the fifth-grade during pretest measures and in

the sixth-grade during posttest measures. The age range of the study participants is congruent with the research school districts age range demographics for fifth-grade and sixth-grade students.

Racial and ethnic origin of participants. Of the total number of selected subjects who met the measured test score criteria for challenge math placement ($n = 30$) 30 (100%) were White. Of the total number of selected subjects who did not meet the measured test score criteria for challenge math placement but received challenge math based on teacher or parent recommendation ($n = 30$) 26 (86.6%) were White, 3 (10%) were Asian, 1 (3.3%) was African-American. The racial and ethnic origin of participants is congruent with the research school districts racial and ethnic origin demographics for fifth-grade and sixth-grade students.

Inclusion criteria of participants. Sixth-grade students who attended the research school district middle school during their sixth-grade year and completed the challenge math placement test.

Method of participant identification. Sixth-grade students meeting measured test score criteria for challenge math placement and sixth-grade students not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on teacher or parent recommendation identified as research participants.

Description of Procedures

Research design. The pretest-posttest four-group comparative efficacy experimental study design is displayed in the following notation.

Group 1 $X_1 O_1 Y_1 O_2$

Group 2 $X_1 O_1 Y_2 O_2$

Group 3 $X_1 O_1 Y_3 O_2$

Group 4 $X_1 O_1 Y_4 O_2$

Group 1 = study participants #1. A randomly selected group of fifth-grade boys ($n = 15$) participating in challenge math.

Group 2 = study participants #2. A randomly selected group of fifth-grade girls ($n = 15$) participating in challenge math.

Group 3 = study participants #3. A randomly selected group of fifth-grade boys ($n = 15$) participating in challenge math.

Group 4 = study participants #4. A randomly selected group of fifth-grade girls ($n = 15$) participating in challenge math.

$X_1 =$ study constant. All study participants have been in the Millard Public Schools from the beginning of the fifth-grade through the end of the sixth-grade. All students participated in sixth-grade challenge math coursework in three sixth-grade classrooms at the research school.

$Y_1 =$ study independent variable, challenge math placement, condition #1. Sixth-grade boys meeting measured test score criteria for challenge math placement.

$Y_2 =$ study independent variable, challenge math placement, condition #2. Sixth-grade girls meeting measured test score criteria for challenge math placement.

$Y_3 =$ study independent variable, challenge math placement, condition #3. Sixth-grade boys not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations.

Y₄ = study independent variable, challenge math placement, condition #4.

Sixth-grade girls not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations.

O₁ = study pretest dependent measures. (1) Achievement as measured by (a) the research school districts end of school year fifth-grade Essential Learner Outcome (ELO) math scores converted to standard scores, (b) fifth-grade Orleans Hanna Algebra Prognosis Test scores, (c) first trimester sixth-grade, challenge math course first exam grade score, (d) end of first trimester sixth-grade, challenge math report card grade score.

O₂ = study posttest dependent measures. (1) Achievement as measured by (a) the research school districts end of school year sixth-grade Essential Learner Outcome (ELO) math scores converted to standard scores, (b) sixth-grade Orleans Hanna Algebra Prognosis Test scores, (c) third trimester sixth-grade, challenge math course final exam grade score, (d) end of third trimester sixth-grade, challenge math report card grade.

Implementation of the Independent Variables

The independent variables for this study were sixth-grade students meeting measured test score criteria for challenge math placement compared to the math test scores, algebra achievement predictor scores, and challenge math course grades of sixth-grade students not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on teacher or parent recommendation. Each group of students must have taken the four pretest measures and have been a Millard student since the beginning of fifth-grade. These groups comprise the four research arms of the study. All groups of students were selected from the same student population and were in attendance at the same research middle school.

Dependent Measures

The study's dependent variable is achievement. Achievement was analyzed using the following dependent measures (a) Millard Essential Learner Outcome scores, (b) Orleans Hanna Prognosis Test, (c) students' last sixth-grade challenge math test scores, and (d) students' last trimester grades.

Research Questions and Data Analysis

The following research question was used to analyze student participation in challenge math placement measuring pretest-posttest Essential Learner Outcome (ELO) math scores converted to standard scores.

Overarching Pretest-Posttest Achievement Research Question #1. Do (a) sixth-grade boys meeting measured test score criteria for challenge math placement or (b) sixth-grade girls meeting measured test score criteria for challenge math placement or (c) sixth-grade boys not meeting measured test score criteria for challenge math placement, but receiving challenge math placement based on fifth-grade teachers' recommendations, or (d) sixth-grade girls not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations lose, maintain, or improve their end of school year pretest fifth-grade Essential Learner Outcome (ELO) math scores converted to standard scores compared to their end of school year posttest sixth-grade Essential Learner Outcome (ELO) math scores converted to standard scores?

Sub-Question 1a. Will there be a significant difference between boys' meeting measured test score criteria for challenge math placement beginning of school year pretest compared to ending of school year posttest research school district

administered Essential Learner Outcome (ELO) math scores converted to standard scores?

Sub-Question 1b. Will there be a significant difference between girls' meeting measured test score criteria for challenge math placement beginning of school year pretest compared to ending of school year posttest research school district administered Essential Learner Outcome (ELO) math scores converted to standard scores?

Sub-Question 1c. Will there be a significant difference between boys' not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations beginning of school year pretest compared to ending of school year posttest research school district administered Essential Learner Outcome (ELO) math scores converted to standard scores?

Sub-Question 1d. Will there be a significant difference between girls' not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations beginning of school year pretest compared to ending of school year research school district administered Essential Learner Outcome (ELO) math scores converted to standard scores?

Analysis. Research Sub-Questions #1a, 1b, 1c, and 1d were analyzed using dependent t tests to examine the significance of the difference between (a) sixth-grade boys meeting measured test score criteria for challenge math placement or (b) sixth-grade girls meeting measured test score criteria for challenge math placement or (c) sixth-grade

boys not meeting measured test score criteria for challenge math placement, but receiving challenge math placement based on fifth-grade teachers' recommendations or (d) sixth-grade girls not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations beginning of school year compared to ending of school year research school district administered Essential Learner Outcome (ELO) math scores converted to standard scores. A one-tailed .05 alpha level was employed to reject null hypotheses. Means and standard deviations were displayed on tables.

The following research question was used to analyze student participation in challenge math placement measuring posttest-posttest Essential Learner Outcome (ELO) math scores converted to standard scores.

Overarching Posttest-Posttest Achievement Research Question #2. Do (a) sixth-grade boys meeting measured test score criteria for challenge math placement or (b) sixth-grade girls meeting measured test score criteria for challenge math placement or (c) sixth-grade boys not meeting measured test score criteria for challenge math placement, but receiving challenge math placement based on fifth-grade teachers' recommendations or (d) sixth-grade girls not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations have congruent or different posttest end of school year sixth-grade Essential Learner Outcome (ELO) math scores converted to standard scores?

Sub-Question 2a. Will there be a significant difference between boys' meeting measured test score criteria for challenge math placement ending of school year

posttest compared to ending of school year posttest research school district administered Essential Learner Outcome (ELO) math scores converted to standard scores?

Sub-Question 2b. Will there be a significant difference between girls' meeting measured test score criteria for challenge math placement ending of school year posttest compared to ending of school year posttest research school district administered Essential Learner Outcome (ELO) math scores converted to standard scores?

Sub-Question 2c. Will there be a significant difference between boys' not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations ending of school year posttest compared to ending of school year posttest research school district administered Essential Learner Outcome (ELO) math scores converted to standard scores?

Sub-Question 2d. Will there be a significant difference between girls' not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations ending of school year posttest compared to ending of school year posttest research school district administered Essential Learner Outcome (ELO) math scores converted to standard scores?

Analysis. Research Question #2a, 2b, 2c, and 2d were analyzed using a single classification Analysis of Variance (ANOVA) to determine the main effect congruence or difference between (a) sixth-grade boys meeting measured test score criteria for challenge math placement or (b) sixth-grade girls meeting measured test score criteria for challenge math placement or (c) sixth-grade boys not meeting measured test score criteria

for challenge math placement, but receiving challenge math placement based on fifth-grade teachers' recommendations or (d) sixth-grade girls not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations ending of school year posttest compared to ending of school year pretest research school district administered Essential Learner Outcome (ELO) math scores converted to standard scores. An F ratio will be calculated and an alpha level of .05 will be utilized to test the null hypothesis. Independent t tests will be used for contrast analysis when a significant F ratio is observed. Means and standard deviations will be displayed in tables.

The following research question was used to analyze student participation in challenge math placement measuring pretest and posttest Orleans Hanna Algebra Prognosis test scores.

Overarching Pretest-Posttest Achievement Research Question #3. Do (a) sixth-grade boys meeting measured test score criteria for challenge math placement or (b) sixth-grade girls meeting measured test score criteria for challenge math placement or (c) sixth-grade boys not meeting measured test score criteria for challenge math placement, but receiving challenge math placement based on fifth-grade teachers' recommendations or (d) sixth-grade girls not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations lose, maintain, or improve their end of school year pretest fifth-grade Orleans Hanna Algebra Prognosis test scores converted to standard scores compared to their end of school year posttest sixth-grade Orleans Hanna Algebra Prognosis test scores?

Sub-Question 3a. Will there be a significant difference between boys' meeting measured test score criteria for challenge math placement end of school year pretest fifth-grade Orleans Hanna Algebra Prognosis test scores compared to their end of school year posttest sixth-grade Orleans Hanna Algebra Prognosis test scores?

Sub-Question 3b. Will there be a significant difference between girls' meeting measured test score criteria for challenge math placement end of school year pretest fifth-grade Orleans Hanna Algebra Prognosis test scores compared to their end of school year posttest sixth-grade Orleans Hanna Algebra Prognosis test scores?

Sub-Question 3c. Will there be a significant difference between boys' not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations end of school year pretest fifth-grade Orleans Hanna Algebra Prognosis test scores compared to their end of school year posttest sixth-grade Orleans Hanna Algebra Prognosis test scores?

Sub-Question 3d. Will there be a significant difference between girls' not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations end of school year pretest fifth-grade Orleans Hanna Algebra Prognosis test scores compared to their end of school year posttest sixth-grade Orleans Hanna Algebra Prognosis test scores?

Analysis. Research Sub-Questions #3a, 3b, 3c, and 3d were analyzed using dependent t tests to examine the significance of the difference between (a) sixth-grade boys meeting measured test score criteria for challenge math placement or (b) sixth-grade girls meeting measured test score criteria for challenge math placement or (c) sixth-grade boys not meeting measured test score criteria for challenge math placement, but receiving

challenge math placement based on fifth-grade teachers' recommendations or (d) sixth-grade girls not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations end of school year pretest fifth-grade Orleans Hanna Algebra Prognosis test scores compared to their end of school year posttest sixth-grade Orleans Hanna Algebra Prognosis test scores. A one-tailed .05 alpha level was employed to reject null hypotheses. Means and standard deviations were displayed on tables.

The following research question was used to analyze student participation in challenge math placement measuring posttest-posttest Orleans Hanna Algebra Prognosis test scores.

Overarching Posttest-Posttest Achievement Research Question #4. Do (a) sixth-grade boys meeting measured test score criteria for challenge math placement or (b) sixth-grade girls meeting measured test score criteria for challenge math placement or (c) sixth-grade boys not meeting measured test score criteria for challenge math placement, but receiving challenge math placement based on fifth-grade teachers' recommendations or (d) sixth-grade girls not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations have congruent or different posttest end of school year sixth-grade Orleans Hanna Algebra Prognosis test scores?

Sub-Question 4a. Will there be a significant difference between boys' meeting measured test score criteria for challenge math placement ending of school year posttest compared to ending of school year posttest sixth-grade Orleans Hanna Algebra Prognosis test scores?

Sub-Question 4b. Will there be a significant difference between girls' meeting measured test score criteria for challenge math placement ending of school year posttest compared to ending of school year posttest sixth-grade Orleans Hanna Algebra Prognosis test scores?

Sub-Question 4c. Will there be a significant difference between boys' not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations ending of school year posttest compared to ending of school year posttest sixth-grade Orleans Hanna Algebra Prognosis test scores?

Sub-Question 4d. Will there be a significant difference between girls' not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations ending of school year posttest compared to ending of school year posttest sixth-grade Orleans Hanna Algebra Prognosis test scores?

Analysis. Research Question #4a, 4b, 4c, and 4d were analyzed using a single classification Analysis of Variance (ANOVA) to determine the main effect congruence or difference between (a) sixth-grade boys meeting measured test score criteria for challenge math placement or (b) sixth-grade girls meeting measured test score criteria for challenge math placement or (c) sixth-grade boys not meeting measured test score criteria for challenge math placement, but receiving challenge math placement based on fifth-grade teachers' recommendations or (d) sixth-grade girls not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations ending of school year posttest compared to ending

of school year posttest sixth-grade Orleans Hanna Algebra Prognosis test scores. An F ratio will be calculated and an alpha level of .05 will be utilized to test the null hypothesis. Independent t tests will be used for contrast analysis when a significant F ratio is observed. Means and standard deviations will be displayed in tables.

The following research question was used to analyze student participation in challenge math placement measuring pretest-posttest exam grade scores.

Overarching Pretest-Posttest Achievement Research Question #5. Do (a) sixth-grade boys meeting measured test score criteria for challenge math placement or (b) sixth-grade girls meeting measured test score criteria for challenge math placement or (c) sixth-grade boys not meeting measured test score criteria for challenge math placement, but receiving challenge math placement based on fifth-grade teachers' recommendations or (d) sixth-grade girls not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations lose, maintain, or improve their first trimester sixth-grade, challenge math course first exam grade scores compared to their third trimester sixth-grade, challenge math course final exam grade scores?

Sub-Question 5a. Will there be a significant difference between boys' meeting measured test score criteria for challenge math placement beginning of school year pretest first trimester sixth-grade, challenge math course first exam grade scores compared to ending of school year posttest third trimester sixth-grade, challenge math course first exam grade scores?

Sub-Question 5b. Will there be a significant difference between girls' meeting measured test score criteria for challenge math placement beginning of school

year pretest first trimester sixth-grade, challenge math course first exam grade scores compared to ending of school year posttest third trimester sixth-grade, challenge math course first exam grade scores?

Sub-Question 5c. Will there be a significant difference between boys' not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations beginning of school year pretest first trimester sixth-grade, challenge math course first exam grade scores compared to ending of school year posttest third trimester sixth-grade, challenge math course first exam grade scores?

Sub-Question 5d. Will there be a significant difference between girls' not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations beginning of school year pretest first trimester sixth-grade, challenge math course first exam grade scores compared to ending of school year posttest third trimester sixth-grade, challenge math course first exam grade scores?

Analysis. Research Sub-Questions #5a, 5b, 5c, and 5d were analyzed using dependent t tests to examine the significance of the difference between (a) sixth-grade boys meeting measured test score criteria for challenge math placement or (b) sixth-grade girls meeting measured test score criteria for challenge math placement or (c) sixth-grade boys not meeting measured test score criteria for challenge math placement, but receiving challenge math placement based on fifth-grade teachers' recommendations or (d) sixth-grade girls not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations

beginning of school year pretest first trimester sixth-grade, challenge math course first exam grade scores compared to ending of school year posttest third trimester sixth-grade, challenge math course first exam grade scores. A one-tailed .05 alpha level was employed to reject null hypotheses. Means and standard deviations were displayed on tables.

The following research question was used to analyze student participation in challenge math placement measuring posttest-posttest final exam grade score

Overarching Posttest-Posttest Achievement Research Question #6. Do (a) sixth-grade boys meeting measured test score criteria for challenge math placement or (b) sixth-grade girls meeting measured test score criteria for challenge math placement or (c) sixth-grade boys not meeting measured test score criteria for challenge math placement, but receiving challenge math placement based on fifth-grade teachers' recommendations or (d) sixth-grade girls not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations have congruent or different posttest end of school third trimester sixth-grade, challenge math course final exam grade score?

Sub-Question 6a. Will there be a significant difference between boys' meeting measured test score criteria for challenge math placement ending of school year posttest compared to ending of school year posttest third trimester sixth-grade, challenge math course final exam grade score?

Sub-Question 6b. Will there be a significant difference between girls' meeting measured test score criteria for challenge math placement ending of school year

posttest compared to ending of school year posttest third trimester sixth-grade, challenge math course final exam grade score?

Sub-Question 6c. Will there be a significant difference between boys' not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations ending of school year posttest compared to ending of school year posttest third trimester sixth-grade, challenge math course final exam grade score?

Sub-Question 6d. Will there be a significant difference between girls' not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations ending of school year posttest compared to ending of school year posttest third trimester sixth-grade, challenge math course final exam grade score?

Analysis. Research Question #6a, 6b, 6c, and 6d were analyzed using a single classification Analysis of Variance (ANOVA) to determine the main effect congruence or difference between (a) sixth-grade boys meeting measured test score criteria for challenge math placement or (b) sixth-grade girls meeting measured test score criteria for challenge math placement or (c) sixth-grade boys not meeting measured test score criteria for challenge math placement, but receiving challenge math placement based on fifth-grade teachers' recommendations or (d) sixth-grade girls not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations ending of school year posttest compared to ending of school year posttest third trimester sixth-grade, challenge math course final exam grade score. An F ratio will be calculated and an alpha level of .05 will be utilized to test

the null hypothesis. Independent t tests will be used for contrast analysis when a significant F ratio is observed. Means and standard deviations will be displayed in tables.

The following research question was used to analyze student participation in challenge math placement measuring pretest-posttest math report card grade score.

Overarching Pretest-Posttest Achievement Research Question #7. Do (a) sixth-grade boys meeting measured test score criteria for challenge math placement or (b) sixth-grade girls meeting measured test score criteria for challenge math placement or (c) sixth-grade boys not meeting measured test score criteria for challenge math placement, but receiving challenge math placement based on fifth-grade teachers' recommendations or (d) sixth-grade girls not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations lose, maintain, or improve their end of first trimester sixth-grade, challenge math report card grade scores compared to their third trimester sixth-grade, challenge math course final exam grade scores?

Sub-Question 7a. Will there be a significant difference between boys' meeting measured test score criteria for challenge math placement beginning of school year pretest first trimester sixth-grade, challenge math report card grade score compared to ending of school year posttest third trimester sixth-grade, challenge math report card grade score?

Sub-Question 7b. Will there be a significant difference between girls' meeting measured test score criteria for challenge math placement beginning of school year pretest first trimester sixth-grade, challenge math report card grade score compared

to ending of school year posttest third trimester sixth-grade, challenge math report card grade score?

Sub-Question 7c. Will there be a significant difference between boys' not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations beginning of school year pretest first trimester sixth-grade, challenge math report card grade score compared to ending of school year posttest third trimester sixth-grade, challenge math report card grade score?

Sub-Question 7d. Will there be a significant difference between girls' not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations beginning of school year pretest first trimester sixth-grade, challenge math report card grade score compared to ending of school year posttest third trimester sixth-grade, challenge math report card grade score?

Analysis. Research Sub-Questions #7a, 7b, 7c, and 7d were analyzed using dependent t tests to examine the significance of the difference between (a) sixth-grade boys meeting measured test score criteria for challenge math placement or (b) sixth-grade girls meeting measured test score criteria for challenge math placement or (c) sixth-grade boys not meeting measured test score criteria for challenge math placement, but receiving challenge math placement based on fifth-grade teachers' recommendations or (d) sixth-grade girls not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations beginning of school year pretest first trimester sixth-grade, challenge math report card

grade score compared to ending of school year posttest third trimester sixth-grade, challenge math report card grade score. A one-tailed .05 alpha level was employed to reject null hypotheses. Means and standard deviations were displayed on tables.

The following research question was used to analyze student participation in challenge math placement measuring posttest-posttest report card grade score.

Overarching Posttest-Posttest Achievement Research Question #8. Do (a) sixth-grade boys meeting measured test score criteria for challenge math placement or (b) sixth-grade girls meeting measured test score criteria for challenge math placement or (c) sixth-grade boys not meeting measured test score criteria for challenge math placement, but receiving challenge math placement based on fifth-grade teachers' recommendations or (d) sixth-grade girls not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations have congruent or different posttest end of third trimester sixth-grade, challenge math report card grade score?

Sub-Question 8a. Will there be a significant difference between boys' meeting measured test score criteria for challenge math placement ending of school year posttest compared to ending of school year posttest end of third trimester sixth-grade, challenge math report card grade score?

Sub-Question 8b. Will there be a significant difference between girls' meeting measured test score criteria for challenge math placement ending of school year posttest compared to ending of school year posttest end of third trimester sixth-grade, challenge math report card grade score?

Sub-Question 8c. Will there be a significant difference between boys' not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations ending of school year posttest compared to ending of school year posttest end of third trimester sixth-grade, challenge math report card grade score?

Sub-Question 8d. Will there be a significant difference between girls' not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations ending of school year posttest compared to ending of school year posttest end of third trimester sixth-grade, challenge math report card grade score?

Analysis. Research Question #8a, 8b, 8c, and 8d were analyzed using a single classification Analysis of Variance (ANOVA) to determine the main effect congruence or difference between (a) sixth-grade boys meeting measured test score criteria for challenge math placement or (b) sixth-grade girls meeting measured test score criteria for challenge math placement or (c) sixth-grade boys not meeting measured test score criteria for challenge math placement, but receiving challenge math placement based on fifth-grade teachers' recommendations or (d) sixth-grade girls not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations ending of school year posttest compared to ending of school year posttest end of third trimester sixth-grade, challenge math report card grade score. An F ratio will be calculated and an alpha level of .05 will be utilized to test the null hypothesis. Independent t tests will be used for contrast analysis when a significant F ratio is observed. Means and standard deviations will be displayed in tables.

Data Collection Procedures

All study achievement data were retrospective, archival, and routinely collected school information. Permission from the appropriate school research personnel was obtained. Achievement data were obtained for a randomly selected group of 15 boys in arm one placed in challenge math based on measured math ability, a randomly selected group of 15 girls in arm two placed in challenge math based on measured math ability, a randomly selected group of 15 boys in arm three placed in challenge math based on teacher recommendation, and a randomly selected group of 15 girls in arm four placed in challenge math based on teacher recommendation. Non-coded numbers were used to display individual de-identified achievement data. Aggregated group data, descriptive statistics, and parametric statistical analysis were utilized and reported with means and standard deviations on tables.

Performance site. The research was conducted in the public school setting through normal educational practices. The study procedures did not interfere with the normal educational practices of the public school and did not involve coercion or discomfort of any kind. Data were stored on spreadsheets and computer flash drives for statistical analysis in the office of the primary researcher and the dissertation chair. Data and computer files were kept in locked file cabinets. No individual identifiers were attached to the data.

Institutional Review Board (IRB) for the protection of Human Subjects

Approval Category. The exemption categories for this study were provided under 45CFR.101(b) categories 1 and 4. The research was conducted using routinely collected archival data. A letter of support from the district was provided for IRB review.

CHAPTER FOUR

Results

Purpose of the Study

The purpose of the study is to determine the math test scores, algebra achievement predictor scores, and challenge math course grades of sixth-grade students meeting measured test score criteria for challenge math placement compared to the math test scores, algebra achievement predictor scores, and challenge math course grades of sixth-grade students not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on fifth-grade teachers' recommendations.

Implementation of the Independent Variables

The independent variables for this study were sixth-grade students meeting measured test score criteria for challenge math placement compared to the math test scores, algebra achievement predictor scores, and challenge math course grades of sixth-grade students not meeting measured test score criteria for challenge math placement but receiving challenge math placement based on teacher or parent recommendation. Each group of students must have taken the four pretest measures and have been a Millard student since the beginning of fifth-grade. These groups comprise the four research arms of the study. All groups of students were selected from the same student population and were in attendance at the same research middle school.

Dependent Measures

The study's dependent variable was achievement. Achievement will be analyzed using the following dependent measures (a) Orleans Hanna Prognosis Test (b) Millard

Essential Learner Outcome scores (c) students' last sixth-grade challenge math test scores, and (d) students' last trimester grades.

All study achievement data related to each of the dependent variables were retrospective, archival, and routinely collected school information. Permission from the appropriate school research personnel was obtained before data were collected and analyzed.

Table 1 displays demographic information of individual sixth-grade boys meeting measured test score criteria for challenge math placement. Table 2 displays demographic information of individual sixth-grade girls meeting measured test score criteria for challenge math placement. Table 3 displays demographic information of individual sixth-grade boys not meeting measured test score criteria for challenge math placement. Demographic information of individual sixth-grade girls not meeting measured test score criteria for challenge math placement is displayed in Table 4.

Research Question #1

Table 5 displays end of fifth-grade pretest Math Essential Learner Outcome scores compared to ending sixth-grade posttest Math Essential Learner Outcome scores for sixth-grade boys meeting measured test score criteria for challenge math placement, sixth-grade girls meeting measured test score criteria for challenge math placement, sixth-grade boys not meeting measured test score criteria for challenge math placement, and sixth-grade girls not meeting measured test score criteria for challenge math placement. The first pretest-posttest hypothesis was tested using the dependent t test. As seen in Table 5, null hypotheses for test score improvement over time were rejected for the end of fifth-grade pretest compared to ending sixth-grade posttest math Essential

Learner Outcome scores converted to standard scores for sixth-grade girls meeting measured test score criteria for challenge math placement: pretest $M = 120.07$, $SD = 4.32$; posttest $M = 121.87$, $SD = 2.17$; $t(14) = 1.73$, $p = .05$ (one-tailed), $d = 0.500$ and rejected for sixth-grade girls not meeting measured test score criteria for challenge math placement: pretest $M = 117.80$, $SD = 3.28$; posttest $M = 119.73$, $SD = 3.13$; $t(14) = 1.95$, $p < .05$ (one-tailed), $d = 0.503$. Also as seen in Table 5, null hypotheses for test score improvement over time were not rejected for the end of fifth-grade pretest compared to ending sixth-grade posttest math Essential Learner Outcome scores converted to standard scores for sixth-grade boys meeting measured test score criteria for challenge math placement: pretest $M = 120.00$, $SD = 2.54$; posttest $M = 121.47$, $SD = 2.85$; $t(14) = 1.59$, $p = .07$ (one-tailed), $d = 0.415$ and not rejected for test score reduction over time for sixth-grade boys not meeting measured test score criteria for challenge math placement: pretest $M = 119.00$, $SD = 4.52$; posttest $M = 118.80$, $SD = 4.35$; $t(14) = -0.15$, $p = .44$ (one-tailed), $d = -0.038$.

Research Question #2

Table 6 displays results of Analysis of Variance ending sixth-grade posttest math Essential Learner Outcome scores for sixth-grade boys meeting measured test score criteria for challenge math placement, sixth-grade girls meeting measured test score criteria for challenge math placement, sixth-grade boys not meeting measured test score criteria for challenge math placement, and sixth-grade girls not meeting measured test score criteria for challenge math placement. The second hypothesis was tested using Analysis of Variance (ANOVA). Math Essential Learner Outcome posttest-posttest ANOVA results comparisons for (A) Boys Tested In ($M = 121.47$, $SD = 2.85$); (B) Girls

Tested In ($M = 121.87$, $SD = 2.17$); (C) Boys Placed In ($M = 118.80$, $SD = 4.35$); and D = Girls Placed In ($M = 119.73$, $SD = 3.13$). As seen in Table 6, the null hypothesis was rejected for the math Essential Learner Outcome ANOVA results research question #2 comparisons.

The overall main effect of comparisons for sixth-grade boys meeting measured test score criteria for challenge math placement, sixth-grade girls meeting measured test score criteria for challenge math placement, sixth-grade boys not meeting measured test score criteria for challenge math placement, and sixth-grade girls not meeting measured test score criteria for challenge math placement was statistically significant, ($F(3, 56) = 3.03$, $p = .04$). Because a significant main effect was found *post hoc*, contrast analyses were conducted using independent t tests and the results were displayed in Table 7. As found in Table 7 significant differences were found in the A (Boys Tested In) vs. C (Boys Placed In) comparison where $t(28) = 1.99$, $p < .05$ (one-tailed), $d = 1.517$; B (Girls Tested In) vs. C (Boys Placed In) comparison where $t(28) = 2.45$, $p = .01$ (one-tailed), $d = 2.036$; and B (Girls Tested In) vs. D (Girls Placed In) where $t(28) = 2.17$, $p < .05$ (one-tailed), $d = 1.917$. For the other *post hoc* comparisons found in Table 7 A (Boys Tested In) vs. B (Girls Tested In); A (Boys Tested In) vs. D (Girls Placed In); and C (Boys Placed In) vs. D (Girls Placed In) no significant contrast analyses were observed.

Research Question #3

Table 8 displays end of fifth-grade pretest Orleans-Hanna Algebra Prognosis Test scores compared to ending sixth-grade posttest Orleans-Hanna Algebra Prognosis Test scores for sixth-grade boys meeting measured test score criteria for challenge math placement, sixth-grade girls meeting measured test score criteria for challenge math

placement, sixth-grade boys not meeting measured test score criteria for challenge math placement, and sixth-grade girls not meeting measured test score criteria for challenge math placement. The pretest-posttest hypothesis was tested using the dependent t test. As seen in Table 8, null hypotheses for test score improvement over time were rejected for the end of fifth-grade pretest compared to ending sixth-grade posttest Orleans-Hanna Algebra Prognosis Test scores for sixth-grade boys meeting measured test score criteria for challenge math placement (pretest $M = 23.20$, $SD = 4.89$; posttest $M = 38.07$, $SD = 6.65$; $t(14) = 7.13$, $p < .001$ (one-tailed), $d = 1.867$), sixth-grade girls meeting measured test score criteria for challenge math placement (pretest $M = 21.20$, $SD = 4.81$; posttest $M = 36.33$, $SD = 9.96$; $t(14) = 9.87$, $p < .001$ (one-tailed), $d = 2.686$), sixth-grade boys not meeting measured test score criteria for challenge math placement (pretest $M = 18.60$, $SD = 4.91$; posttest $M = 34.80$, $SD = 10.04$; $t(14) = 6.86$, $p < .001$ (one-tailed), $d = 2.010$), and sixth-grade girls not meeting measured test score criteria for challenge math placement (pretest $M = 20.87$, $SD = 4.31$; posttest $M = 35.93$, $SD = 6.40$; $t(14) = 7.94$, $p < .001$ (one-tailed), $d = 2.099$).

Research Question #4

Table 9 displays results of Analysis of Variance ending sixth-grade posttest Orleans-Hanna Algebra Prognosis Test scores for sixth-grade boys meeting measured test score criteria for challenge math placement, sixth-grade girls meeting measured test score criteria for challenge math placement, sixth-grade boys not meeting measured test score criteria for challenge math placement, and sixth-grade girls not meeting measured test score criteria for challenge math placement. The fourth hypothesis was tested using Analysis of Variance (ANOVA). Orleans-Hanna Algebra Prognosis Test posttest-

posttest ANOVA results comparisons for (A) Boys Tested In ($M = 38.07$, $SD = 6.65$); (B) Girls Tested In ($M = 36.33$, $SD = 6.96$); (C) Boys Placed In ($M = 34.80$, $SD = 10.04$); and (D) Girls Placed In ($M = 35.93$, $SD = 6.40$). As seen in Table 9, the null hypothesis was not rejected for the Orleans-Hanna Algebra Prognosis Test ANOVA results research question #4 comparisons.

The overall main effect of comparisons for sixth-grade boys meeting measured test score criteria for challenge math placement, sixth-grade girls meeting measured test score criteria for challenge math placement, sixth-grade boys not meeting measured test score criteria for challenge math placement, and sixth-grade girls not meeting measured test score criteria for challenge math placement was not statistically significant, ($F(3, 56) = 0.47$, $p = .70$). Because no significant main effect was found *post hoc*, contrast analyses were not conducted.

Research Question #5

Table 10 displays first sixth-grade pretest challenge math test score compared to last sixth-grade posttest challenge math test score for sixth-grade boys meeting measured test score criteria for challenge math placement, sixth-grade girls meeting measured test score criteria for challenge math placement, sixth-grade boys not meeting measured test score criteria for challenge math placement, and sixth-grade girls not meeting measured test score criteria for challenge math placement. The third pretest-posttest hypothesis was tested using the dependent t test. As seen in Table 10, null hypotheses for test score improvement over time were rejected for the first sixth-grade pretest challenge math test score compared to last sixth-grade posttest challenge math test score for sixth-grade boys meeting measured test score criteria for challenge math placement: pretest $M = 94.27$, SD

= 7.90; posttest $M = 88.87$, $SD = 9.48$; $t(14) = -2.50$, $p = .01$ (one-tailed), $d = -0.654$ and rejected for sixth-grade boys not meeting measured test score criteria for challenge math placement: pretest $M = 92.73$, $SD = 7.57$; posttest $M = 88.53$, $SD = 9.20$; $t(14) = -1.72$, $p = .05$ (one-tailed), $d = -0.450$. Also as seen in Table 10, null hypotheses for test score improvement over time were not rejected for the first sixth-grade pretest challenge math test scores compared to last sixth-grade posttest challenge math test scores for sixth-grade girls meeting measured test score criteria for challenge math placement: pretest $M = 93.68$, $SD = 6.79$; posttest $M = 91.20$, $SD = 6.81$; $t(14) = -0.94$, $p = .18$ (one-tailed), $d = -0.243$ and not rejected for test score reduction over time for sixth-grade girls not meeting measured test score criteria for challenge math placement: pretest $M = 92.17$, $SD = 4.91$; posttest $M = 90.07$, $SD = 11.17$; $t(14) = -0.82$, $p = .21$ (one-tailed), $d = -0.251$.

Research Question #6

Table 11 displays results of Analysis of Variance last sixth-grade posttest challenge math test score for sixth-grade boys meeting measured test score criteria for challenge math placement, sixth-grade girls meeting measured test score criteria for challenge math placement, sixth-grade boys not meeting measured test score criteria for challenge math placement, and sixth-grade girls not meeting measured test score criteria for challenge math placement. The sixth hypothesis was tested using Analysis of Variance (ANOVA). The last sixth-grade challenge math test posttest-posttest ANOVA results comparisons for (A) Boys Tested In ($M = 88.87$, $SD = 9.48$); (B) Girls Tested In ($M = 91.20$, $SD = 6.81$); (C) Boys Placed In ($M = 88.53$, $SD = 9.20$); and (D) Girls Placed In ($M = 90.07$, $SD = 11.17$). As seen in Table 11, the null hypothesis was not

rejected for the Orleans-Hanna Algebra Prognosis Test ANOVA results research question #6 comparisons.

The overall main effect of comparisons for sixth-grade boys meeting measured test score criteria for challenge math placement, sixth-grade girls meeting measured test score criteria for challenge math placement, sixth-grade boys not meeting measured test score criteria for challenge math placement, and sixth-grade girls not meeting measured test score criteria for challenge math placement was not statistically significant, ($F(3, 56) = 0.26, p = .86$). Because no significant main effect was found *post hoc*, contrast analyses were not conducted.

Research Question #7

Table 12 displays first trimester sixth-grade pretest challenge math course grade score compared to last trimester sixth-grade posttest challenge math course grade score for sixth-grade boys meeting measured test score criteria for challenge math placement, sixth-grade girls meeting measured test score criteria for challenge math placement, sixth-grade boys not meeting measured test score criteria for challenge math placement, and sixth-grade girls not meeting measured test score criteria for challenge math placement. The last pretest-posttest hypothesis was tested using the dependent *t* test. As seen in Table 12, null hypotheses for test score improvement over time were rejected for the first trimester sixth-grade pretest challenge math course grade score compared to last trimester sixth-grade posttest challenge math course grade score for sixth-grade boys meeting measured test score criteria for challenge math placement: pretest $M = 94.07, SD = 4.68$; posttest $M = 92.25, SD = 4.40$; $t(14) = -3.22, p = .003$ (one-tailed), $d = -0.840$ and rejected for sixth-grade boys not meeting measured test score criteria for challenge math

placement: pretest $M = 93.25$, $SD = 5.41$; posttest $M = 91.13$, $SD = 5.12$; $t(14) = -1.80$, $p = .05$ (one-tailed), $d = -0.466$. Also as seen in Table 12, null hypotheses for test score improvement over time were not rejected for the first trimester sixth-grade pretest challenge math course grade score compared to last trimester sixth-grade posttest challenge math course grade score for sixth-grade girls meeting measured test score criteria for challenge math placement: pretest $M = 93.63$, $SD = 3.18$; posttest $M = 93.75$, $SD = 4.52$; $t(14) = 0.13$, $p = .45$ (one-tailed), $d = 0.035$ and not rejected for test score reduction over time for sixth-grade girls not meeting measured test score criteria for challenge math placement: pretest $M = 93.31$, $SD = 2.11$; posttest $M = 93.54$, $SD = 3.11$; $t(14) = 0.32$, $p = .38$ (one-tailed), $d = 0.033$.

Research Question #8

Table 13 displays results of Analysis of Variance last trimester sixth-grade posttest challenge math course grade score for sixth-grade boys meeting measured test score criteria for challenge math placement, sixth-grade girls meeting measured test score criteria for challenge math placement, sixth-grade boys not meeting measured test score criteria for challenge math placement, and sixth-grade girls not meeting measured test score criteria for challenge math placement. The last hypothesis was tested using Analysis of Variance (ANOVA). The last trimester sixth-grade posttest challenge math course grade score posttest-posttest ANOVA results comparisons for (A) Boys Tested In ($M = 92.25$, $SD = 4.40$); (B) Girls Tested In ($M = 93.75$, $SD = 4.52$); (C) Boys Placed In ($M = 91.13$, $SD = 5.12$); and (D) Girls Placed In ($M = 93.54$, $SD = 3.11$). As seen in Table 13, the null hypothesis was not rejected for the last trimester sixth-grade posttest challenge math course grade ANOVA results research question #8 comparisons.

The overall main effect of comparisons for sixth-grade boys meeting measured test score criteria for challenge math placement, sixth-grade girls meeting measured test score criteria for challenge math placement, sixth-grade boys not meeting measured test score criteria for challenge math placement, and sixth-grade girls not meeting measured test score criteria for challenge math placement was not statistically significant, ($F(3, 56) = 1.18, p = .32$). Because no significant main effect was found *post hoc*, contrast analyses were not conducted.

Table 1

Demographic Information of Individual Sixth-Grade Boys Meeting Measured Test Score Criteria for Challenge Math Placement

Student Number	Gender	Ethnicity	Free or Reduced Price Lunch Program	Special Education
1.	Male	Caucasian	No	No
2.	Male	Caucasian	No	No
3.	Male	Caucasian	No	No
4.	Male	Caucasian	No	Yes
5.	Male	Caucasian	No	No
6.	Male	Caucasian	No	No
7.	Male	Caucasian	Yes	No
8.	Male	Caucasian	No	No
9.	Male	Caucasian	No	No
10.	Male	Caucasian	No	No
11.	Male	Caucasian	No	No
12.	Male	Caucasian	No	No
13.	Male	Caucasian	No	No
14.	Male	Caucasian	No	No
15.	Male	Caucasian	No	No

Note. All students were in attendance in the research school district fifth-grade through sixth-grade.

Table 2

Demographic Information of Individual Sixth-Grade Girls Meeting Measured Test Score Criteria for Challenge Math Placement

Student Number	Gender	Ethnicity	Free or Reduced Price Lunch Program	Special Education
1.	Female	Caucasian	No	No
2.	Female	Caucasian	No	No
3.	Female	Caucasian	No	No
4.	Female	Caucasian	No	No
5.	Female	Caucasian	No	No
6.	Female	Caucasian	No	No
7.	Female	Caucasian	No	No
8.	Female	Caucasian	No	No
9.	Female	Caucasian	No	No
10.	Female	Caucasian	No	No
11.	Female	Caucasian	No	No
12.	Female	Caucasian	No	No
13.	Female	Caucasian	No	No
14.	Female	Caucasian	No	No
15.	Female	Caucasian	No	No

Note. All students were in attendance in the research school district fifth-grade through sixth-grade.

Table 3

Demographic Information of Individual Sixth-Grade Boys Not Meeting Measured Test Score Criteria for Challenge Math Placement but Receiving Challenge Math Placement Based on Fifth-Grade Teachers' Recommendations

Student Number	Gender	Ethnicity	Free or Reduced Price Lunch Program	Special Education
1.	Male	Asian	No	No
2.	Male	Caucasian	No	No
3.	Male	Caucasian	No	No
4.	Male	Caucasian	No	No
5.	Male	Caucasian	No	No
6.	Male	Caucasian	No	No
7.	Male	Caucasian	No	No
8.	Male	Caucasian	No	No
9.	Male	Caucasian	No	Yes
10.	Male	Caucasian	No	No
11.	Male	Caucasian	No	No
12.	Male	Caucasian	No	No
13.	Male	Caucasian	No	No
14.	Male	Caucasian	No	No
15.	Male	African-American	No	No

Note. All students were in attendance in the research school district fifth-grade through sixth-grade.

Table 4

Demographic Information of Individual Sixth-Grade Girls Not Meeting Measured Test Score Criteria for Challenge Math Placement but Receiving Challenge Math Placement Based on Fifth-Grade Teachers' Recommendations

Student Number	Gender	Ethnicity	Free or Reduced Price Lunch Program	Special Education
1.	Female	Caucasian	No	No
2.	Female	Caucasian	No	No
3.	Female	Caucasian	No	No
4.	Female	Caucasian	No	No
5.	Female	Caucasian	No	No
6.	Female	Caucasian	No	No
7.	Female	Caucasian	No	No
8.	Female	Caucasian	No	No
9.	Female	Caucasian	No	No
10.	Female	Caucasian	No	No
11.	Female	Caucasian	No	No
12.	Female	Caucasian	No	No
13.	Female	Caucasian	No	No
14.	Female	Caucasian	No	No
15.	Female	Caucasian	No	No

Note. All students were in attendance in the research school district fifth-grade through sixth-grade.

Table 5

End of Fifth-Grade Pretest Math Essential Learner Outcome Scores Converted to Standard Scores Compared to Ending Sixth-Grade Posttest Math Essential Learner Outcome Scores Converted to Standard Scores for Sixth-Grade Boys Meeting Measured Test Score Criteria for Challenge Math Placement, Sixth-Grade Girls Meeting Measured Test Score Criteria for Challenge Math Placement, Sixth-Grade Boys Not Meeting Measured Test Score Criteria for Challenge Math Placement, and Sixth-Grade Girls Not Meeting Measured Test Score Criteria for Challenge Math Placement

Source	Standard Scores						
	Pretest		Posttest		<i>d</i>	<i>t</i>	<i>p</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
A	120.00	(2.54)	121.47	(2.85)	0.415	1.59	.07 [†]
B	120.07	(4.32)	121.87	(2.17)	0.500	1.73	.05*
C	119.00	(4.52)	118.80	(4.35)	-0.038	-0.15	.44 [†]
D	117.80	(3.28)	119.73	(3.13)	0.503	1.95	.04*

Note. A = Boys Tested In; B = Girls Tested In; C = Boys Placed In; and D = Girls Placed In.

[†]*ns.* **p* ≤ .05.

Table 6

Results of Analysis of Variance Ending Sixth-Grade Posttest Math Essential Learner Outcomes Scores Converted to Standard Scores for Sixth-Grade Boys Meeting Measured Test Score Criteria for Challenge Math Placement, Sixth-Grade Girls Meeting Measured Test Score Criteria for Challenge Math Placement, Sixth-Grade Boys Not Meeting Measured Test Score Criteria for Challenge Math Placement, and Sixth-Grade Girls Not Meeting Measured Test Score Criteria for Challenge Math Placement

Source of Variation	Sum of Squares	Mean Square	<i>df</i>	<i>F</i>	<i>p</i>
Between Groups	94.13	31.38	3	3.03	.04* ^a
Within Groups	580.80	10.37	56		

Essential Learner Outcome Scores	Mean (<i>SD</i>)
\bar{A}	121.47 (2.85)
\bar{B}	121.87 (2.17)
\bar{C}	118.80 (4.35)
\bar{D}	119.73 (3.13)

Note. A = Boys Tested In; B = Girls Tested In; C = Boys Placed In; and D = Girls Placed In.

^aSee Table 7 for *post hoc* contrast analysis results.

[†]*ns.* **p* < .05.

Table 7

Post Hoc Contrast Analysis Independent t Test Results for Ending Sixth-Grade Posttest Math Essential Learner Outcomes for Sixth-Grade Boys Meeting Measured Test Score Criteria for Challenge Math Placement, Sixth-Grade Girls Meeting Measured Test Score Criteria for Challenge Math Placement, Sixth-Grade Boys Not Meeting Measured Test Score Criteria for Challenge Math Placement, and Sixth-Grade Girls Not Meeting Measured Test Score Criteria for Challenge Math Placement

Source	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>d</i>	<i>t</i>	<i>p</i>
\bar{A} vs. \bar{B}	121.47 (2.85)		121.87 (2.17)		-0.387	-0.43	.33 [†]
\bar{A} vs. \bar{C}	121.47 (2.85)		118.80 (4.35)		1.517	1.99	.03*
\bar{A} vs. \bar{D}	121.47 (2.85)		119.73 (3.13)		1.302	1.59	.06 [†]
\bar{B} vs. \bar{C}	121.87 (2.17)		118.80 (4.35)		2.036	2.45	.01**
\bar{B} vs. \bar{D}	121.87 (2.17)		119.73 (3.13)		1.917	2.17	.02*
\bar{C} vs. \bar{D}	118.80 (4.35)		119.73 (3.13)		-0.504	-0.68	.25 [†]

Note. A = Boys Tested In; B = Girls Tested In; C = Boys Placed In; and D = Girls Placed In.

[†]*ns.* **p* < .05. ***p* = .01.

Table 8

End of Fifth-Grade Pretest Orleans-Hanna Algebra Prognosis Test Scores Compared to Ending Sixth-Grade Posttest Orleans-Hanna Algebra Prognosis Test Scores for Sixth-Grade Boys Meeting Measured Test Score Criteria for Challenge Math Placement, Sixth-Grade Girls Meeting Measured Test Score Criteria for Challenge Math Placement, Sixth-Grade Boys Not Meeting Measured Test Score Criteria for Challenge Math Placement, and Sixth-Grade Girls Not Meeting Measured Test Score Criteria for Challenge Math Placement

Source	Pretest		Posttest		<i>d</i>	<i>t</i>	<i>p</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
A	23.20 (4.89)		38.07 (6.65)		1.867	7.13	.001***
B	21.20 (4.81)		36.33 (9.96)		2.686	9.87	.001***
C	18.60 (4.91)		34.80 (10.04)		2.010	6.86	.001***
D	20.87 (4.31)		35.93 (6.40)		2.099	7.94	.001***

Note. A = Boys Tested In; B = Girls Tested In; C = Boys Placed In; and D = Girls Placed In.

[†]*ns.* ****p* < .001.

Table 9

Results of Analysis of Variance Ending Sixth-Grade Posttest Orleans-Hanna Algebra Prognosis Test for Sixth-Grade Boys Meeting Measured Test Score Criteria for Challenge Math Placement, Sixth-Grade Girls Meeting Measured Test Score Criteria for Challenge Math Placement, Sixth-Grade Boys Not Meeting Measured Test Score Criteria for Challenge Math Placement, and Sixth-Grade Girls Not Meeting Measured Test Score Criteria for Challenge Math Placement

Source of Variation	Sum of Squares	Mean Square	<i>df</i>	<i>F</i>	<i>p</i>
Between Groups	82.58	27.53	3	0.47	.70 [†]
Within Groups	3279.60	58.56	56		

Orleans-Hanna Scores	Mean (<i>SD</i>)
\bar{A}	38.07 (6.65)
\bar{B}	36.33 (6.96)
\bar{C}	34.80 (10.04)
\bar{D}	35.93 (6.40)

Note. A = Boys Tested In; B = Girls Tested In; C = Boys Placed In; and D = Girls Placed In.

[†]*ns.* No *post hoc* results calculated or displayed.

Table 10

First Sixth-Grade Pretest Challenge Math Test Compared to Last Sixth-Grade Posttest Challenge Math Test for Sixth-Grade Boys Meeting Measured Test Score Criteria for Challenge Math Placement, Sixth-Grade Girls Meeting Measured Test Score Criteria for Challenge Math Placement, Sixth-Grade Boys Not Meeting Measured Test Score Criteria for Challenge Math Placement, and Sixth-Grade Girls Not Meeting Measured Test Score Criteria for Challenge Math Placement

Source	Pretest		Posttest		<i>d</i>	<i>t</i>	<i>p</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
A	94.27 (7.90)		88.87 (9.48)		-0.654	-2.50	.01**
B	93.68 (6.79)		91.20 (6.81)		-0.243	-0.94	.18 [†]
C	92.73 (7.57)		88.53 (9.20)		-0.450	-1.72	.05*
D	92.17 (4.91)		90.07 (11.17)		-0.251	-0.82	.21 [†]

Note. A = Boys Tested In; B = Girls Tested In; C = Boys Placed In; and D = Girls Placed In.

[†]*ns.* **p* = .05. ***p* = .01.

Table 11

Results of Analysis of Variance Last Sixth-Grade Posttest Challenge Math Test for Sixth-Grade Boys Meeting Measured Test Score Criteria for Challenge Math Placement, Sixth-Grade Girls Meeting Measured Test Score Criteria for Challenge Math Placement, Sixth-Grade Boys Not Meeting Measured Test Score Criteria for Challenge Math Placement, and Sixth-Grade Girls Not Meeting Measured Test Score Criteria for Challenge Math Placement

Source of Variation	Sum of Squares	Mean Square	<i>df</i>	<i>F</i>	<i>p</i>
Between Groups	66.53	22.18	3	0.26	.86 [†]
Within Groups	4838.80	86.41	56		

Last Challenge Math Test Score	Mean (<i>SD</i>)
\bar{A}	88.87(9.48)
\bar{B}	91.20 (6.81)
\bar{C}	88.53 (9.20)
\bar{D}	90.07 (11.17)

Note. A = Boys Tested In; B = Girls Tested In; C = Boys Placed In; and D = Girls Placed In.

[†]*ns.* No *post hoc* results calculated or displayed.

Table 12

First Trimester Sixth-Grade Pretest Challenge Math Course Grade Score Compared to Last Trimester Sixth-Grade Posttest Challenge Math Course Grade Score for Sixth-Grade Boys Meeting Measured Test Score Criteria for Challenge Math Placement, Sixth-Grade Girls Meeting Measured Test Score Criteria for Challenge Math Placement, Sixth-Grade Boys Not Meeting Measured Test Score Criteria for Challenge Math Placement, and Sixth-Grade Girls Not Meeting Measured Test Score Criteria for Challenge Math Placement

Source	Pretest		Posttest		<i>d</i>	<i>t</i>	<i>p</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
A	94.07 (4.68)		92.25 (4.40)		-0.840	-3.22	.003**
B	93.63 (3.18)		93.75 (4.52)		0.035	0.13	.45 [†]
C	93.25 (5.41)		91.13 (5.12)		-0.466	-1.80	.05*
D	93.31 (2.11)		93.54 (3.11)		0.033	0.32	.38 [†]

Note. A = Boys Tested In; B = Girls Tested In; C = Boys Placed In; and D = Girls Placed In.

[†]*ns.* **p* = .05. ***p* < .01.

Table 13

Results of Analysis of Variance Last Sixth-Grade Posttest Challenge Math Course Grade Score for Sixth-Grade Boys Meeting Measured Test Score Criteria for Challenge Math Placement, Sixth-Grade Girls Meeting Measured Test Score Criteria for Challenge Math Placement, Sixth-Grade Boys Not Meeting Measured Test Score Criteria for Challenge Math Placement, and Sixth-Grade Girls Not Meeting Measured Test Score Criteria for Challenge Math Placement

Source of Variation	Sum of Squares	Mean Square	<i>df</i>	<i>F</i>	<i>p</i>
Between Groups	67.21	22.40	3	1.18	.32 [†]
Within Groups	1058.83	18.91	56		

Last Challenge Math Course Grade	Mean (<i>SD</i>)
\bar{A}	92.25(4.40)
\bar{B}	93.75 (4.52)
\bar{C}	91.13(5.12)
\bar{D}	93.54 (3.11)

Note. A = Boys Tested In; B = Girls Tested In; C = Boys Placed In; and D = Girls Placed In.

[†]*ns.* No *post hoc* results calculated or displayed.

CHAPTER FIVE

Conclusions and Discussion

The following conclusions may be drawn from the study for each of the eight research questions.

Research Question #1 Conclusion

Overall, pretest-posttest results indicated end of fifth-grade pretest Math Essential Learner Outcome scores compared to ending sixth-grade posttest Math Essential Learner Outcome scores for sixth-grade boys meeting measured test score criteria for challenge math placement, sixth-grade girls meeting measured test score criteria for challenge math placement, sixth-grade boys not meeting measured test score criteria for challenge math placement, and sixth-grade girls not meeting measured test score criteria for challenge math placement were statistically significantly different in the direction of higher posttest mean Math Essential Learner Outcome scores for Girls Tested In and Girls Placed In challenge math and were not statistically significantly different in the direction of higher posttest mean Math Essential Learner Outcome score for Boys Tested In and in the direction of lower posttest mean Math Essential Learner Outcome score for Boys Placed In challenge math. Comparing students' posttest Math Essential Learner Outcome scores with district Essential Learner Outcome nomenclature puts their performance in perspective. For Boys Tested In a posttest standard score of 121.47 converted back to a Math Essential Learner Outcome score of 54 is congruent with a competency level research school district nomenclature of *Beyond Proficient*. For Girls Tested In a posttest standard score of 121.87 converted back to a Math Essential Learner Outcome score of 54 is congruent with a competency level research school district nomenclature of *Beyond*

Proficient. For Boys Placed In a posttest standard score of 118.80 converted back to a Math Essential Learner Outcome score of 51 is congruent with a competency level research school district nomenclature of *Proficient*. For Girls Placed In a posttest standard score of 119.73 converted back to a Math Essential Learner Outcome score of 52 is congruent with a competency level research school district nomenclature of *Proficient*. Finally, the Boys Tested In posttest standard score of 121.47 (+1.47), the Girls Tested In posttest standard score of 121.87 (+1.80), the Boys Placed In posttest standard score of 118.80 (-0.20), and the Girls Placed In posttest standard score of 119.73 (+1.93) represents a pattern of math improvement except for Boys Placed In.

Research Question #2 Conclusion

Overall, posttest-posttest results of analysis of variance ending sixth-grade posttest math Essential Learner Outcomes scores converted to standard scores for sixth-grade boys meeting measured test score criteria for challenge math placement, sixth-grade girls meeting measured test score criteria for challenge math placement, sixth-grade boys not meeting measured test score criteria for challenge math placement, and sixth-grade girls not meeting measured test score criteria for challenge math placement was significantly different. *Post hoc* contrast analysis results indicated that (A) Boys Tested In and (B) Girls Tested In math Essential Learner Outcomes scores converted to standard scores provided the greatest statistically significant variance where (A) Boys Tested In compared to (C) Boys Placed In, (B) Girls Tested In compared to (C) Boys Placed In, and (B) Girls Tested In compared to (D) Girls Placed In suggesting a pattern that students tested in to challenge math will be successful without regard to gender. Finally, girls

tested in to challenge math classes may be expected to outperform all other peers tested in or placed in challenge math classes.

Research Question #3 Conclusion

Overall, pretest-posttest end of fifth-grade pretest Orleans-Hanna Algebra Prognosis Test scores compared to ending sixth-grade posttest Orleans-Hanna Algebra Prognosis Test scores were statistically different in the direction of test score improvement for sixth-grade boys meeting measured test score criteria for challenge math placement, were statistically different in the direction of test score improvement for sixth-grade girls meeting measured test score criteria for challenge math placement, were statistically different in the direction of test score improvement for sixth-grade boys not meeting measured test score criteria for challenge math placement, and were statistically different in the direction of test score improvement for sixth-grade girls not meeting measured test score criteria for challenge math placement. Comparing students' posttest Orleans-Hanna Algebra Prognosis Test scores with test nomenclature puts their performance in perspective where all student groups (A) Boys Tested In, (B) Girls Tested In, (C) Boys Placed In, and (D) Girls Placed In performed at an end of sixth-grade level to warrant clear placement into seventh-grade pre-algebra classes. Finally, the Boys Tested In posttest Orleans-Hanna Algebra Prognosis Test score of 38.07 (+14.87), the Girls Tested In posttest Orleans-Hanna Algebra Prognosis Test score of 36.33 (+15.13), the Boys Placed In posttest Orleans-Hanna Algebra Prognosis Test score of 34.80 (+16.20), and the Girls Placed In posttest Orleans-Hanna Algebra Prognosis Test score of 35.93 (+15.06) represents a pattern of math test score improvement over time for all students Boys and Girls, Tested In and Placed In.

Research Question #4 Conclusion

Overall, posttest-posttest results of analysis of variance ending sixth-grade posttest Orleans-Hanna Algebra Prognosis Test scores for sixth-grade boys meeting measured test score criteria for challenge math placement, sixth-grade girls meeting measured test score criteria for challenge math placement, sixth-grade boys not meeting measured test score criteria for challenge math placement, and sixth-grade girls not meeting measured test score criteria for challenge math placement was not significantly different. No *Post hoc* contrast analysis was performed as no variance was found between (A) Boys Tested In, (B) Girls Tested In, (C) Boys Placed In, and (D) Girls Placed In.

Research Question #5 Conclusion

Overall, pretest-posttest start of sixth-grade pretest challenge math test score compared to last sixth-grade posttest challenge math test score were statistically different in the direction of test score deterioration for sixth-grade boys meeting measured test score criteria for challenge math placement, were not statistically different in the direction of test score deterioration for sixth-grade girls meeting measured test score criteria for challenge math placement, were statistically different in the direction of test score deterioration for sixth-grade boys not meeting measured test score criteria for challenge math placement, and were not statistically different in the direction of test score deterioration for sixth-grade girls not meeting measured test score criteria for challenge math placement. Comparing students' posttest challenge math test scores with the research districts grade nomenclature puts their performance in perspective where (A) Boys Tested In, scored 88.87 which equals the equivalent of a grade of a "B", (B) Girls

Tested In, scored 91.20 which equals the equivalent of a grade of a “B”, (C) Boys Placed In, scored an 88.53 which equals the equivalent of a grade of a “B”, and (D) Girls Placed In, scored a 90.07 which also is the equivalent of a grade of a “B”. The research schools grade scale is as follows; 100 to 93 is the equivalent of an “A”, 92 to 84 is the equivalent of a “B”, 83 to 77 is the equivalent of a “C”, 76 to 69 is the equivalent of a “D”, and 68 or below is considered an “F”. Finally, the Boys Tested In last sixth-grade posttest challenge math test score of 88.87 (-5.40), the Girls Tested In posttest last sixth-grade posttest challenge math test score of 91.20 (-2.48), the Boys Placed In posttest last sixth-grade posttest challenge math test score of 88.53 (-4.20), and the Girls Placed In posttest last sixth-grade posttest challenge math test score of 90.07 (-2.10) represents a pattern of math test score decline over time for all students Boys and Girls, Tested In and Placed In. However, the girls’ posttest math test scores both (B) Tested In and (D) Placed In did not decrease significantly while the boys posttest math scores both (A) Tested In and (C) Placed In significantly decreased over time.

Research Question #6 Conclusion

Overall, posttest-posttest results of analysis of variance last sixth-grade posttest challenge math test score for sixth-grade boys meeting measured test score criteria for challenge math placement, sixth-grade girls meeting measured test score criteria for challenge math placement, sixth-grade boys not meeting measured test score criteria for challenge math placement, and sixth-grade girls not meeting measured test score criteria for challenge math placement was not significantly different. No *Post hoc* contrast analysis was performed as no variance was found between (A) Boys Tested In, (B) Girls Tested In, (C) Boys Placed In, and (D) Girls Placed In.

Research Question #7 Conclusion

Overall, pretest-posttest first trimester sixth-grade pretest challenge math course grade compared to last trimester sixth-grade posttest challenge math course grade were statistically different in the direction of grade score decline for sixth-grade boys meeting measured test score criteria for challenge math placement, were not statistically different in the direction of grade score improvement for sixth-grade girls meeting measured test score criteria for challenge math placement, were statistically different in the direction of grade score decline for sixth-grade boys not meeting measured test score criteria for challenge math placement, and were not statistically different in the direction of grade score improvement for sixth-grade girls not meeting measured test score criteria for challenge math placement. Comparing students' last trimester sixth-grade posttest challenge math course grade with the research districts grade nomenclature puts their performance in perspective where (A) Boys Tested In, scored 92.25 which equals the equivalent of a grade of a "B", (B) Girls Tested In, scored 93.75 which equals the equivalent of a grade of a "A", (C) Boys Placed In, scored an 91.13 which equals the equivalent of a grade of a "B", and (D) Girls Placed In, scored a 93.54 which is the equivalent of a grade of a "A". Again the research schools grade scale is as follows; 100 to 93 is the equivalent of an "A", 92 to 84 is the equivalent of a "B", 83 to 77 is the equivalent of a "C", 76 to 69 is the equivalent of a "D", and 68 or below is considered an "F". Finally, the Boys Tested In last trimester sixth-grade posttest challenge math course grade of 92.25 (-1.82), the Girls Tested In posttest last trimester sixth-grade posttest challenge math course grade of 93.75 (+0.12), the Boys Placed In posttest last trimester sixth-grade posttest challenge math course grade of 91.13 (-2.12), and the Girls Placed In

posttest last trimester sixth-grade posttest challenge math course grade of 93.54 (+0.23) represents a pattern of math grade score decline over time for all Boys, (A) Tested In and (C) Placed In. However, the girls' posttest math grade scores both (B) Tested In and (D) Placed In made small non-significant increases in their grade scores over time.

Research Question #8 Conclusion

Overall, posttest-posttest results of analysis of variance last trimester sixth-grade posttest challenge math course grade for sixth-grade boys meeting measured test score criteria for challenge math placement, sixth-grade girls meeting measured test score criteria for challenge math placement, sixth-grade boys not meeting measured test score criteria for challenge math placement, and sixth-grade girls not meeting measured test score criteria for challenge math placement was not significantly different. No *Post hoc* contrast analysis was performed as no variance was found between (A) Boys Tested In, (B) Girls Tested In, (C) Boys Placed In, and (D) Girls Placed In.

Discussion

Challenge math students, whether *Tested In or Placed In* will be successful in performing at high levels on math Essential Learner Outcomes and Orleans-Hanna Algebra Prognosis Test during the later part of the sixth-grade challenge math course. All groups increased at high levels in regards to the Orleans-Hanna Algebra Prognosis Test and all groups with the exception of (C) Boys Placed In performed at an increased level on the sixth-grade math Essential Learner Outcome than they did on the fifth-grade math Essential Learner Outcome. While this group of (C) Boys Placed In did not improve at the same level as the other groups, they still performed at a *Proficient* level by the research school district standards. In the *post hoc* comparison of the math Essential Learner Outcome scores it was interesting to note that students that were Tested

In outperformed their Placed In peers equally with regard to gender but that (B) Girls Tested In outperformed all other groups. Because the end of the year test is assessing new more recently introduced advanced concepts compared with the review of previous knowledge assessed at the beginning of the school year, it was not surprising to see that all students, regardless of gender or placement condition would score lower on the last test of the year in challenge math vs. the first test of the year. Furthermore, the math curriculum of the research school is organized to start the year with review and it gradually begins to increase with new concepts being introduced as the year progresses. While all students scored lower on the final test of the year compared to the first test it was interesting to note that boys, whether Tested In or Placed In scored significantly lower than girls who were Tested In or Placed In on these tests. This trend also continued when comparing the end of the last trimester course grade versus the first trimester course grade where Boys Tested In or Placed In had significantly lower last trimester course grades than their first trimester course grades. Girls both Tested In and Placed In earned better grades during the last trimester compared to the first trimester. Although the girls' improvement was not significant over time from pretest to posttest, the boys decrease was significant and that could be cause for concern. However, while boys, either Tested In or Placed In, had tests scores and final grade averages that were lower than the girls, they still performed within a solid "B" average range.

Implications for practice. Throughout all levels of school (elementary, middle, and high), girls earn higher grades than boys in all major subjects, including math and science (American Association of University Women Educational Foundation [AAUWEF], 1998; Duckworth & Seligman, 2006; N. S. Cole, 1997; Pomerantz, Altermatt, & Saxon, 2002). Overall, girls are thought to be more self-disciplined than boys and thus perform better in the classroom on assignments and tests (Duckworth &

Seligman, 2006). It seems that girls use learning strategies such as preparing for tests, seeking help, and persisting even when things get challenging and boys are more focused on outperforming each other and engaging in disruptive endeavors (University of Illinois at Urbana-Champaign, 2006). Understanding the implications of these studies is important for shaping instructional improvement efforts in the classroom to assist the research schools male students. Staff development should be offered to all middle level teachers on the best ways to teach both boys and girls in order to help both genders achieve at higher levels.

The practice used by the research school in testing and then placing students based on the results of these tests, which may include teacher recommendation, appears to be working effectively based on the results of this study. Since the time of this study the research school district has added one more test to the placement process to better inform teachers, administrators, and parents of the most appropriate math placement option for their students. Further studies should be performed on this newer placement process, similar to the design of this study, to see if the students are continuing to be placed appropriately in challenge math.

Implications for policy. Students that attended the research school and were participants in this study were mostly from higher socio-economic (SES) homes with college-educated parents who set high educational expectations for their children. These students have education role models in front of them each day, they see what education can provide for them and they are raised in what has been referred to as a *concerted cultivation* manner that implies focus on the importance of learning, education, achievement, and service to others based on learning success (Lareau, 2003). While the aforementioned should be the family ideal for all children this is not

the case for increasing numbers of children born into poverty who's parents have not themselves not successfully completed their education. Currently, the research school district is a member of a two county, 11 school district learning community required by law to provide education to students from families of less economic advantage. Studies show that students from families with fewer economic advantages perform less well than their peers from more socio-economic advantaged homes (Baharudin & Luster, 1998; Jeynes, 2002; Eamon, 2005; Majoribanks, 1996; Hochschild, 2003; McNeal, 2001; Seyfried, 1998). Because the research school district will be enrolling increased numbers of students from lower socio-economic homes to comply with the economic diversity mandate of the legislation it will be important that the research school make every effort to place these students appropriately in either math 6 or challenge math based on test results and teacher recommendation in consultation with the students parents.

Implications for further research. Students that take challenge math in sixth-grade are on a math track for placement in pre-algebra in seventh-grade and then placement in algebra in eighth-grade. While all groups in this study performed well during the sixth-grade year taking challenge math, it is not known how these students perform through the remainder of the math track, both middle school and high school. The premise of this study is that students are being pushed into higher-level math courses before they are ready; therefore, additional research must be conducted to follow challenge math students in a longitudinal study to track progress in later math courses. It would also be important to follow those students that do not meet the requirements for placement in challenge math based on test results but are placed in challenge math at the insistence of the child's parents. Because the importance of math cannot be overstated for all boys and girls alike who seek to complete advanced education leading to careers of service to others it is imperative that all schools provide math instruction as a priority

for all students regardless of their gender or current level of math ability. Finally, we assert that a well-designed rigorous math curriculum, committed, caring, and skilled teachers, and motivated students trump parsimonious placement criteria for successful admission to challenge math coursework.

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