A CASE STUDY OF A “DOUBLE-DOSE” MATHEMATICS INTERVENTION

A thesis presented
by
Michelle Dahlsten Kratofil

to
The School of Education

In partial fulfillment of the requirements for the degree of
Doctor of Education

in the field of
Education

College of Professional Studies
Northeastern University
Boston, Massachusetts
November 2013
Abstract

The purpose of this case study was to discover and describe the components of a “double-dose” math intervention that resulted in increased mathematics achievement for high school Algebra I intervention participants in an effort to inform local decisions regarding program improvements and to provide insight to other educators investigating mathematics interventions. Students participating in this “double-dose” intervention were assigned to two math classes. The first math class was a regular math class comprised of heterogeneously ability grouped students. Students from the first class who needed extra support populated the second daily math class. This homogeneous group of students was involved in learning experiences in which concepts were pre-taught and re-taught while addressing identified foundational gaps in math skills and developing perseverance and problem-solving skills. The data for this study were collected via student and parent surveys, instructor and administrator interviews, observations and analysis of documents. These qualitative data were supplemented by quantitative data of treatment and comparison groups acquired from state and local assessments in an effort to provide a more complete description of the intervention. This study was informed by Vygotsky’s Sociocultural Theory and zone of proximal development. The results of the study indicated that the intervention had a statistically significant impact on student achievement while the qualitative data indicated improved affective qualities such as confidence and attitude toward mathematics. In addition, triangulation of all data sources showed five critical elements for the design and implementation of similar interventions: extending and focusing the learning time, using varied instructional strategies, basing
instruction on student need, building relationships and refining the selection of intervention participants.

*Keywords:* low-achieving math students, struggling math students, math interventions, extended learning time
ACKNOWLEDGEMENTS

An undertaking such as this requires a lot of time, dedication and sacrifice on the part of the researcher. It also, however, requires the same commitment by the researcher’s family. I am so grateful to my husband, Dave, and our sons for their unwavering support and constant encouragement. I could not have done this without them.

I also acknowledge my advisor, Dr. Kelly Conn, for sharing her expertise and providing excellent guidance throughout the research and writing process. It was a blessing to be assigned to her and to benefit from her knowledge. In addition, I thank Dr. Jane Lohmann and Dr. George Curry, my committee members, for their valuable time and input.

Lastly, I thank the Math Lab instructors who work tirelessly to make a difference in the lives of our students. I am humbled and inspired by them.
# TABLE OF CONTENTS

**CHAPTER I. INTRODUCTION**

A. Purpose of the Study .................................................. 10  
B. Statement of the Problem ............................................. 10  
C. Significance of the Research Problem .............................. 14  
D. Research Questions .................................................... 17  
E. Theoretical Framework ................................................ 18  
F. Research Design ......................................................... 20  
G. Limitations ............................................................... 20  

**CHAPTER II. LITERATURE REVIEW** ........................................ 21  
A. Low-Achieving Mathematics Students .............................. 21  
B. Effective Mathematics Instruction ................................... 30  
C. Effective Mathematics Interventions ............................... 36  

**CHAPTER III. RESEARCH DESIGN** ....................................... 43  
A. Methodology ............................................................ 43  
B. Research Design ....................................................... 44  
C. Research Tradition .................................................... 44  
D. Participants ............................................................. 45  
E. Recruitment and Access ............................................. 46  
F. Data Collection ......................................................... 47  
G. Data Storage ............................................................ 50  
H. Data Analysis ........................................................... 51  
I. Trustworthiness ......................................................... 52  

**CHAPTER IV. THE FINDINGS** ............................................. 54  
A. Introduction ............................................................ 54  
B. Design and Implementation of the Math Lab Intervention ......... 54  
   1. Findings for Research Question 1, Sub-question 1 ............. 55  
   2. Findings for Research Question 1, Sub-question 2 ............. 57  
      a. Planned Implementation ....................................... 58  
         i. Student Selection ....................................... 58  
         ii. Instructional Focus .................................... 60  
         iii. Requisite Resources .................................... 61  
      b. Actual Implementation ....................................... 62  
         i. Extended Learning Time ................................ 63  
         ii. Focus of Instruction ................................... 63  
         iii. Instructional Structures ................................ 69  
         iv. Delivery of Instruction ................................. 76  
         v. Safe Learning Environment ............................... 80  
         vi. Selection of Students ................................... 85  
         vii. Conclusion .............................................. 86  
C. Effect of Math Lab Intervention on Academic Achievement .... 86
1. Impact on Algebra I Grades .................................................. 87
2. Impact on Overall Academic Achievement .............................. 89
3. Impact on Algebra I End-of-Course Exam Performance ............... 91
4. Impact on Individual Growth in Mathematics ............................... 93

D. Effect of Math Lab Intervention on Student Affect ...................... 98
   1. Findings for Research Question 3, Sub-question 1 ....................... 98
   2. Findings for Research Question 3, Sub-question 2 ....................... 99
   3. Findings for Research Question 3, Sub-questions 3 and 4 ............. 100
   4. Conclusion .................................................................. 101

CHAPTER V. CONCLUSIONS ...................................................... 103
A. Introduction .................................................................. 103

B. Discussion of Design and Implementation Findings .................. 103
   1. Extending and Focusing the Learning Time ...................... 104
   2. Using Varied Instructional Strategies .............................. 105
   3. Basing Instruction on Student Need ............................... 106
   4. Building Relationships ............................................... 107
   5. Selecting the Right Student ......................................... 109

C. Discussion of Student Achievement and Student Affect Findings .... 112
   1. Impact on Student Achievement ..................................... 112
   2. Impact on Student Affect ............................................. 113
      a. How Students Experienced Math Lab ..................... 114
      b. How Parents Perceived Math Lab ......................... 114
      c. How Teachers Perceived Math Lab ..................... 114
      d. How Administrators Perceived Math Lab ............. 115
      e. Summary of Responses ....................................... 115

D. Recommendations for Educational Practice ........................... 115

E. Plan for Dissemination .................................................... 116

F. Areas for Future Research .............................................. 117

REFERENCES ................................................................. 118

APPENDICES ................................................................... 131
A. Consent Forms ............................................................ 132
   1. Administrator Consent Form ..................................... 133
   2. Instructor Consent Form .......................................... 135
   3. Parent/Student Consent Forms Cover Letter ...................... 137
   4. Parent Consent Form .............................................. 138
   5. Student Consent Form ............................................. 140

B. Survey and Interview Protocols ......................................... 143
   1. Administrator Interview Protocol .............................. 144
   2. Instructor Interview Protocol .................................... 145
   3. Parent Survey Protocol ............................................. 146
   4. Student Survey Protocol ............................................. 147
C. Observation Tools........................................................................................................148
   1. Seating Chart: Movement, Interaction and/or Behavior Charts........149
   2. Selective Scripting..........................................................................................150
D. Math Lab Letter........................................................................................................151
E. Learning Preferences Self-Assessments..........................................................152
   1. The Modality Preferences Instrument.......................................................153
   2. The Theory of Multiple Intelligences Self-Assessment......................154
   3. Triarchic Theory of Intelligences-Robert Sternberg.........................155
   4. Interaction Inventory......................................................................................156
LIST OF TABLES

Table 1. Research Questions and Corresponding Data Sources……………………48
Table 2. Focus of Instruction: Frequency of Responses and Observations…………64
Table 3. Instructional Structures: Frequency of Responses…………………………69
Table 4. Percentage of Class Time Students are Engaged in Each Instructional Structure…………………………………………………………………………………70
Table 5. One-to-One Assistance: Frequency of Observations………………………71
Table 6. Comparison between Treatment Groups and Comparison Groups Algebra I Grades…………………………………………………………………………………88
Table 7. Comparison of Means of Algebra I Grades……………………………………89
Table 8. Comparison between Treatment Groups and Comparison Groups Grade Point Averages………………………………………………………………………90
Table 9. Comparison of Means of Overall Grade Point Average………………………91
Table 10. Comparison between Treatment Groups and Comparison Groups Algebra I End-of-Course Scale Scores……………………………………………………92
Table 11. Comparison of Means of Algebra I End-of-Course Scale Scores…………93
Table 12. Comparison of Grade 8 and Algebra I MAP Achievement Levels for 2011-2012 Algebra I Students………………………………………………………94
Table 13. Comparison of Means of Grade 8 and Algebra I MAP Assessment Achievement Levels for 2011-2012 Algebra I Students……………………………………95
Table 14. Comparison of Grade 8 and Algebra I MAP Assessment Achievement Levels for 2012-2013 Algebra I Students………………………………………………96
Table 15. Comparison of Means of Grade 8 and Algebra I MAP Assessment

Achievement Levels for 2012-2013 Algebra I Students
Chapter 1: Introduction

The United States prides itself on having an edge in creativity and innovation. But how long can we maintain this edge in an environment where a commitment born of sheer national will can bring a developing nation into economic prominence? If scientific and engineering jobs are likely to be outsourced, should we abandon the goal of a high-quality mathematics education for every student? On the contrary. If we are looking toward a global future, we must redouble our efforts to equip our citizens with a working knowledge of mathematics…. (Seeley, 2009)

Purpose of the Study

The purpose of this case study was to discover and describe the components of the math intervention that resulted in increased mathematics achievement for high school Algebra I intervention participants in an effort to inform local decisions regarding program improvements and to provide insight to other educators investigating mathematics interventions.

Statement of the Problem

During the 2011-2012 school year, a suburban, Midwestern school district implemented a math intervention called Math Lab for students with a history of failure in mathematics who were enrolled in grades six through eight and in Algebra I. The students selected for the intervention had been unable to master grade-level mathematics concepts and skills, as measured by state and local assessments, despite exhibiting positive attitudes and significant effort. Intervention participants were assigned to a heterogeneously ability-grouped math class on one day and assigned to a homogeneously
ability-grouped math class on the opposite day. This approach, referred to as “double-dosing”, placed students in heterogeneous classrooms for regular math instruction and in a homogeneously grouped math class for additional instruction and support (Nomi & Allensworth, 2009; Piper, Marchand-Martella, & Martella, 2009). Intervention participants appeared to have benefited from interactions with more advanced peers (Chiu et al., 2008), exposure to rigorous curricula (Reed, 2008; Schmidt & Cogan, 2009; Tennison, 2007), and the development of critical thinking skills (Reed, 2008) in the heterogeneously grouped math class. In the homogeneously grouped math class, students benefited from re-teaching difficult concepts, pre-teaching upcoming concepts and focused tutorials on deficiencies in foundational mathematics.

The administration and teachers believed that the time and resource intensive intervention would result in increased achievement on the Missouri Assessment Program (MAP) mathematics assessment. Analysis of the 2012 MAP data showed that a total of fifteen out of fifty-three students participating in the intervention earned a proficient or advanced score on the MAP mathematics assessment. Further breakdown of the data showed that four of thirty middle school students earned a proficient or higher score while eleven of twenty-three high school Algebra I students earned a proficient or advanced designation on the assessment.

School districts across the country have dedicated significant resources in the past ten years to increasing student achievement in mathematics to meet the demands of the No Child Left Behind Act (NCLB) of 2001. Despite this emphasis, students in the United States are performing at lower levels in mathematics than their international peers (Dillon, 2010; Robelen, 2011) and are making only modest gains in overall math
proficiency (Aud, et. al., 2010). While several studies, summarized in the subsequent section, have examined the achievement gains of students participating in similar “double-dose” mathematics interventions (Ketterlin-Geller, Chard & Fien, 2008; Nomi & Allensworth, 2009; Piper et al., 2009), none have described the context and components of an effective “double-dose” program. This study attempted to add to the body of knowledge by providing such detail.

Although specific components of “double-dose” interventions may vary from context to context, common components include the assignment of low-achieving students to a regular mathematics class in which students are engaged in the general math curriculum with mixed-ability peers. In addition to the regular mathematics class, students are concurrently enrolled in an additional math class or tutoring program that provides individualized support and additional instructional time to promote mastery of the general curriculum. The objective of a “double-dose” intervention is to provide appropriate scaffolding to accelerate learning in order to help low-achieving students “catch up” to their peers. The summaries that follow highlight current research in “double-dose” mathematics interventions.

The quasi-experimental study conducted by Leanne Ketterlin-Geller, David Chard and Hank Fien (2008), sought to determine the effects of two mathematics interventions for upper-elementary aged students. Qualifying students were assigned to one of three groups – (a) a “double-dose” intervention group, which provided extended time, practice and assistance with the regular curriculum; (b) an intervention group, which utilized a purchased mathematics intervention program; or (c) the control group, which received no intervention. The researchers concluded that both interventions resulted in improved
math achievement as measured by local assessments when compared to the control group. In addition, the “double-dose” intervention resulted in improved mastery of grade-level content as measured by the state mathematics assessment.

The quasi-experimental study by Takako Nomi and Elaine Allensworth (2009) used four years of student achievement data and course grades to evaluate the effectiveness of a “double-dose” algebra policy implemented by the Chicago Public School system in 2003. In an attempt to decrease the failure rate in Algebra I, Chicago Public Schools mandated that any student scoring below the 50th percentile on the state mathematics assessment be enrolled in a “double-dose” algebra support class. Analysis of four years of data revealed that the policy did not have any effect on Algebra I failure rates, but the policy did have a significantly positive effect on student understanding of algebra skills and concepts as evidenced by increased achievement on the state mathematics assessment.

Lisa Piper, Nancy Marchand-Martella, and Ronald Martella (2009) conducted action research involving eight middle school students to examine the effectiveness of a short-term “double-dose” intervention. The researchers selected the eight participants based on performance on the state math assessment, local common assessments and classroom assessments. The participants received 25 minutes per week of the “double-dose” intervention for a total of four weeks. The intervention time was used to provide additional help on the current unit of instruction. Data were collected via unit pre-tests and post-tests. The results showed that, after the intervention, the study participants demonstrated the same achievement on classroom quizzes as their peers who did not participate in the intervention.
The studies highlighted above are typical of the studies conducted on “double-dose” mathematics interventions. These studies are generally experimental in nature and rely on quantitative data. This study delved beyond the quantitative data to explore the qualitative features that make such interventions successful. By describing the context of the intervention from the perspectives of administrators, instructors, parents, students and participant observer, a more complete understanding of “double-dose” interventions has been offered that may prove beneficial to others implementing similar interventions.

The findings of this study will benefit school district personnel, such as curriculum directors, principals, interventionists, and classroom teachers, who are responsible for designing and implementing academic interventions. In addition, the findings have benefited the researcher by providing direction to further refine and improve the Math Lab intervention at the middle school and high school levels in the district in which the study took place.

**Significance of Research Problem**

The issue of mathematics achievement has been a persistent issue in the district in which this study takes place. Despite a relatively low historical poverty level of less than 16%, student achievement in mathematics as demonstrated on state assessments showed 50-60% proficiency since 2006 with very little growth (Missouri Department of Elementary and Secondary Education, 2012). On the ACT college entrance exam, student scores on the mathematics subtest showed a trend of slight improvement but fluctuated significantly from year to year. In 2011, the district’s sub-score average in mathematics was 20.6, which was lower than the state average of 21.0, lower than the national average of 21.1 and lower than several neighboring districts with higher poverty
rates (Missouri Department of Elementary and Secondary Education, 2012). In addition, data from the Missouri Department of Higher Education (2011) revealed that up to 45% of graduates between 2007 and 2010 required remedial mathematics courses as college freshmen.

In her qualitative analysis of the mission statements of New Jersey public schools, Robertson (2000) found six recurring themes including “statements promising students would reach their maximum capacity to learn” and “statements insuring the best possible education shall be provided for all students” (p. 89). The district in which this study took place has a similar mission for its students. In the area of mathematics, however, the data indicated that the district is not adequately meeting these objectives or preparing students for post-secondary opportunities.

Addressing the issue of mathematics achievement also meets a growing need in the United States. Thomas Friedman (2005) maintained that the shrinking of our global community via access to technology has increased competition in business. To remain globally competitive, students need a solid foundation in science, technology, engineering and mathematics (STEM) related fields. According to Friedman, “the American education system from kindergarten through twelfth grade just is not stimulating enough young people to want to go into science, math and engineering” (2005, p. 270). As a result, the United States is not producing the number of business and industrial leaders needed to maintain an advantage over international competition (Friedman, 2005; Leal, 2012). Furthermore, American companies have begun to invest in research divisions overseas because the intellectual capital they require is not readily available in the United States (Friedman, 2005).
President Barack Obama, who asserted that the ability of the United States to compete in the global economy depends on STEM education, has echoed Friedman’s call (Robelen, 2010). Murphy (2012) cited the fact that more than two million STEM-related jobs in the United States went unfilled, even as the national unemployment rate stood at 8%, as evidence that STEM reform in education must be addressed. Furthermore, “the U.S. Department of Labor projects that 15 of the 20 fastest-growing occupations over the next ten years will require significant mathematics or science preparation. The agency projects growth in STEM jobs to be three times greater than that of non-STEM jobs” (Leal, 2012, Demand for STEM section, para. 7).

Despite the unprecedented emphasis on mathematics resulting from the implementation of NCLB, mathematics performance on the Program for International Student Assessment (PISA) showed students in the United States lagging behind their international peers (Dillon, 2010). A recent analysis of PISA data indicated that approximately ten percent of students in the United States scored in the top two tiers of the PISA math assessment, placing the United States twenty-fifth out of the thirty-four participating countries (Robelen, 2011). Dillon (2010) noted that students in the United States were out-performed by thirty countries. The 2007 Trends in Mathematics and Science Study showed improvement in overall scores but significant gaps between the scores of top performing students in the United States and those of higher ranked countries (Gonzales et al., 2009). Mark S. Schneider, former commissioner of the National Center for Education Statistics and current vice-president of the American Institutes of Research, maintained that the lack of top performers in mathematics on
international assessments is a disturbing reality as the demands of our global economy require competence in STEM areas (Robelen, 2011).

While Schmoker (2011) argued that higher-level math proficiency is only required in a small proportion of occupations, ACT, the non-profit formerly known as American College Testing, maintained that the mathematics skills required to enter the first-year of post-secondary education is equivalent to the skills needed for a high school graduate to secure an entry-level job that has potential for growth, potential for personal advancement and income sufficient to support a family of four above the poverty line (ACT, 2006). Consequently, all students need a solid foundation in mathematics regardless of post-secondary aspirations.

**Research Questions**

In an effort to address these national concerns, to inform local decisions regarding the Math Lab intervention, and to provide insight to other educators investigating mathematics interventions, the following research questions were developed.

Central Research Question 1: What is the process by which the Math Lab intervention in a suburban Midwest high school was designed and implemented?

Sub-question 1: What were the critical elements of the Math Lab intervention?

Sub-question 2: How was the Math Lab intervention implemented?

Central Research Question 2: What were the local and state achievement scores in mathematics for students who participated in the Math Lab intervention and how did the math achievement scores of participants compare to the math achievement scores of non-participants of similar demographics and ability?
Central Research Question 3: How do key stakeholders perceive the Math Lab intervention and the potential impact of Math Lab on student success?

Sub-question 1: How do students experience Math Lab?

Sub-question 2: How do parents perceive Math Lab?

Sub-question 3: How do teacher perceive Math Lab?

Sub-question 4: How do administrators perceive Math Lab?

Theoretical Framework

The purpose of this descriptive case study was to discover and describe the components of the “double-dose” intervention that resulted in increased mathematics achievement for the high school Algebra I intervention participants. Through this intervention, teachers assessed the ability of level of students to develop individual learning plans designed to fill foundational gaps in mathematical understanding. At the same time, the teacher provided support to master the grade-level content. Consequently, Vygotsky’s zone of proximal development provided an appropriate perspective by which to examine the literature, design the study and analyze the data.

As a sociocultural theorist, Vygotsky asserted that social interaction is an integral element of the learning process. Regardless of the content or skill, whether spontaneous or scientific, learning begins with an interaction between the novice and a more experienced other (John-Steiner & Mahn, 1996; Kozulin, 2003; Miller, 2011). As this social interaction is repeated and refined, the novice becomes able to demonstrate the content or skill independently, at which time the new knowledge has been internalized and learning has occurred (Kozulin, 2003; Miller, 2011). In the case of the “double-dose” math intervention, the more experienced other is the classroom
teacher/interventionist who uses small group instruction, individual instruction and computer-assisted instruction to facilitate the internalization of new mathematic content and skills.

According to Vygotsky, such internalization occurs as the learner moves through the zone of proximal development (Miller, 2011). The zone of proximal development is defined as the distance between actual development - the level of independent problem solving - and potential development - the level of assisted problem solving (Miller, 2011). Because learning is not about acquiring a specific set of knowledge but rather a process of mediating change in understanding, Vygotsky maintained that learning is a collaborative event involving a novice and an experienced mediator (John-Steiner & Mahn, 1996; Miller, 2011; Tudge & Winterhoff, 1993). The mediator facilitates the process of understanding by assessing the level of independent problem solving of the novice and developing a collaborative learning environment which targets content and skills beyond the novice’s current independent problem solving ability (Miller, 2011; Tudge & Winterhoff, 1993). The mediator helps the novice progress through the zone of proximal development by scaffolding or adjusting the level of support as the novice progresses toward independent mastery (Miller, 2011). Effective scaffolding bridges the novice’s current knowledge with new knowledge via “prompts, clues, modeling, explanation, leading questions, discussion, joint participation, encouragement, and control of the child’s attention” (Miller, 2011, p. 175). The result of such interactions is co-construction of new knowledge between the two learners.

The central tenet of the Math Lab intervention was to meet students at the level of their academic ability and scaffold instruction to accelerate their understanding to that of
their grade-level peers. Using Vygotsky’s zone of proximal development as a theoretical lens was most appropriate and was consistent with the theoretical foundations of similar research on “double-dose” mathematics interventions.

**Research Design**

Due to the descriptive nature of this study, the researcher selected a qualitative design to complement the quantitative studies generated by other scholars. The goal of this study was to understand the components of the Math Lab intervention that contributed to student success and to provide a complete description of the context and process so that others may replicate the intervention. As noted by Stake (1995), qualitative research is best suited to situations in which the researcher seeks to understand the complexities of a relationship as well as construct, rather than discover knowledge (p. 37). As such, a qualitative approach was most appropriate for this study.

**Limitations**

While not the focus of the study, the quantitative data analysis was based on a comparison group matched by gender, socioeconomic status, past history in mathematics, and current mathematics teacher. Student motivation was not a factor by which the researcher was able to compose the comparison group, but it was a significant factor in the selection of participants for the Math Lab intervention.

As Director of Curriculum, Assessment and Staff Development for the school district in which the study took place, the researcher directed the research behind the development of the Math Lab intervention and was been actively involved in the program’s design and implementation. Consequently, the researcher has a vested interest in the success of the program.
Chapter 2: Literature Review

Although several studies investigating the effectiveness of “double-dose” mathematics interventions are included in the review of the literature, it is imperative to examine the literature from a broader perspective to develop a thorough understanding of the problem of practice. The review of the literature will begin by examining the research on causes of low achievement in mathematics for regular education students. The second component of the literature review will examine effective instructional practices in mathematics as well as effective mathematics interventions; the latter section will include “double-dose” mathematics interventions.

Low-Achieving Mathematics Students

This section of the literature review will synthesize the research on causes of low achievement in mathematics including cognitive and environmental factors. The existing research on cognitive causes of persistent low achievement in mathematics for students of average intelligence indicate that, in the areas of number sense and basic arithmetic, low achieving students may never catch up with their typical-achieving peers (Geary, 2011). The areas of most concern for low-achieving students are related to the visuospatial reasoning component of working memory and the inhibition component of working memory (Geary, 2011; Gersten & Clarke, 2007b; Holmes & Adams, 2006; Marzano, 2004; McREL, 2010). The visuospatial information processing affects one’s ability to “translate word problems into mathematical equations” (Geary, 2011, p. 257) which inhibits one’s ability to filter out unnecessary information. The second cognitive factor that may result in persistent low achievement in mathematics is processing speed. Geary
(2011) noted that slow processing speed is most likely attributable to slow retrieval of basic math facts or to attention issues rather than an actual deficit in processing speed.

A review of the literature reveals many sources that identify characteristics of students who struggle with mathematics. The typical low-achieving mathematics student is characterized as one who lacks confidence (Allsopp, Kyger, & Ingram, n.d.; Burns, 2007), expects failure (Allsopp, et al., n.d.; Burns, 2007), cannot make connections between existing and new knowledge (Allsopp, et al.), and lacks metacognitive abilities (Allsopp, et al.). Gersten and Clarke (2007b) described struggling math students as slow in fact retrieval, unable to filter irrelevant information, unable to visualize mathematical concepts, and limited in deriving meaning from symbols. Geary (2009) added that struggling students do not understand the concepts underlying basic arithmetic and use ineffective strategies. Although characteristics of low-achieving mathematics students are easy to find, the causes of low-achievement prove to be much more elusive.

As noted by Louie, Brodesky, Brett, Yang and Tan (2008), the body of knowledge regarding low-achievement in mathematics is just developing. In contrast to low-achievement in reading, there are no consistent diagnostic tools or standard definitions for learning disabilities in mathematics. In addition, low-achievement in mathematics is not unique to students diagnosed with learning disabilities (Geary, 2011; Louie et al., 2008). Geary (2011) maintained that approximately 10% of school-age children will be identified as low-achieving in mathematics, which he defines as scoring between the eleventh and twenty-fifth percentiles on standardized mathematics achievement tests for a minimum of two years consecutively. Geary (2011) noted that “among researchers in this field, a consensus is emerging with respect to the utility of
distinguishing between children with [math learning disabilities] and their low achievement peers” (p. 251).

In his review entitled *Consequences, Characteristics, and Causes of Mathematical Learning Disabilities and Persistent Low Achievement in Mathematics*, Geary (2011) used his own research and the existing literature to evaluate the mathematical competencies of number sense and arithmetic as well as the cognitive domains of intelligence, working memory and processing speed to determine whether there was a connection between specific mathematical deficiencies and cognitive processes. His findings show that intelligence was not a factor as the low-achieving students in his study were by definition of average intelligence. In addition, deficiencies in processing speed were ruled out as the slow speed of fact retrieval typical of low-achieving math students negatively influences processing speed. Instead, the research indicated that specific components of working memory were most likely the cause of persistent low-achievement in mathematics (Geary, 2009; Geary, 2011).

Using data from the Missouri Longitudinal Study of Mathematical Development and Disability, Geary (2011) tracked student achievement in fluently “identifying and combining quantities associated with sets of objects and Arabic numerals” (p. 253). He found that low-achieving mathematics students lagged at least one year behind their typical achieving peers with the gap in these number sense skills widening as the students progressed through the grade-levels. Data representing student understanding of number magnitude revealed that low-achieving students in the lower grades showed a lack of understanding between smaller and greater quantities. That misunderstanding, however, was corrected by fourth grade at which time low-achieving students performed this task
with the same accuracy as their typical-achieving peers. As noted by Geary (2011), the visuospatial component of working memory may contribute to this deficiency in some students as the “approximate representational systems for magnitude are believed to be located” in this area of the brain (p. 257). Research from Marzano (2004) supported the importance of visualization and non-linguistic representations to committing information to memory.

When working arithmetic problems, low-achieving students commit more procedural mistakes than their typical-achieving peers do. These errors include mistakes in basic math facts and in mathematical processes, such as properly aligning digits in a subtraction problem (Gersten & Clarke, 2007b). In the case of errors in mathematical processes, low-achieving students eventually learn the correct processes but do so several years after their typical-achieving classmates (Geary, 2011). Errors in basic math facts, however, are more tenacious. A review of the existing research led Geary (2011) to conclude that deficiencies in basic math fact retrieval is most likely due to an inability to exclude irrelevant information from “entering working memory during the process of fact retrieval” (p. 255). Gersten and Clarke (2007b) concurred with this conclusion. McREL (2010) asserted that memory deficits contribute to difficulties with multi-step tasks, such as long division, in which students omit crucial steps. Geary notes that most persistently low-achieving mathematics students score at average levels on assessment of the central executive, which controls working memory. However, these assessments generally focus on task switching rather than on inhibition so more study is needed in this area.

Although the research indicated that persistently low-achieving mathematics students may have working memory deficiencies, Geary (2011) cautioned that these are
minimal deficiencies as compared to the extensive working memory deficits of students with learning disabilities in mathematics. As such, interventions for low-achieving students should focus on building capacity in “processing of numbers, learning of arithmetic procedures, and in memorizing basic arithmetic facts” (p. 259).

The environmental factors that affect performance in mathematics will be limited to those that fall within the categories of curriculum and instruction. Although there are other external factors that influence a student’s ability to learn and achieve, such as socio-economic status and parental involvement, these factors are outside of a school system’s locus of control (Louie et al., 2008; Lubienski, 2007; Meece, Wigfield & Eccles, 1990). Many times these factors become a scapegoat for educators and an excuse to take no steps toward remediation. For this reason, the literature review will be limited to environmental factors over which school systems have influence – curriculum and instruction.

Curriculum and instruction causes of low achievement in mathematics in the United States are multi-faceted. One facet that is highlighted when comparing the achievement of students in the United States to students in other countries is the need to balance conceptual understanding and algorithmic processes in mathematics instruction (Ball, Lubienski, & Mewborn, 2001; McREL, 2010; Radu, 2002; Stigler & Hiebert, 2004; Stigler & Hiebert, 1999). Research has shown that teachers in the United States emphasize process and algorithms at the expense of conceptual understanding, which contributes to aversion and low performance in mathematics (Ball et al., 2001; Buchler, 2009; Stigler & Hiebert, 2004; Stigler & Hiebert, 1999). Furthermore, mathematics instructors are reluctant to present students with challenging problems and let them
persevere through solving the problems on their own, a practice which prohibits the student from taking ownership of his own learning (Buchler, 2009; Stigler & Hiebert, 2004; Stigler & Hiebert, 1999; Stodolsky, 1985).

Central to the debate about mathematics curriculum and instruction in the United States is the notion of balancing conceptual understanding and algorithmic processes (Allsopp et al., n.d.; McREL, 2010; Stigler & Hiebert, 2004; Radu, 2002). As stated by Ball, Lubienski and Mewborn, “too often the curriculum and teaching methods used in school inundate students with skills and procedures without allowing them to develop an appreciation for the power of mathematics as a system of human thought” (2001, p. 435). McREL (2010) recommended equal emphasis on conceptual understanding and fluency in basic skills noting that one does not necessarily have to precede the other. Seeley (2009) concurred that a balanced math program emphasizes both conceptual understanding and skill development but added that using math to “solve a wide range of problems in various contexts by reasoning, thinking, and applying the mathematics” is equally important (p. 71). Radu argued that reducing the discussion of effective mathematics curriculum and instruction to a dichotomy between skills and concepts oversimplifies the issue and “brings no advantages in respect to teaching” (2002, p. 95).

Similarly, Stigler and Hiebert (2004) asserted that the true power of conceptual understanding was not found in the mathematical problem presented but in the manner in which students interacted with the problem. In their analysis of the 1999 TIMSS videos of mathematics instruction, the researchers found that 17% of math problems from the United States focused on conceptual understanding - 4% more than Hong Kong, one of the highest performing countries. Further analysis revealed, however, that in every
instance that a concept oriented problem was presented in the United States, the teacher
turned the higher-level problem into a procedure-based problem denying the students the
opportunity to deeply explore and apply the concepts addressed. In contrast, teachers in
Hong Kong preserved the integrity of conceptual understanding questions 46% of the
time. The opportunity for “constructive struggling” is essential for developing
mathematical understanding (Seeley, 2009, p. 89).

Allsopp, Kyger and Ingram (n.d.) maintained that students who struggle with
mathematics encounter even less opportunity to build conceptual understanding. Because
the mathematics curriculum in the United States covers so many topics (Allsopp et. al.,
n.d.; National Center for Education Statistics, 1999; Seeley, 2009), teachers must keep a
brisk pace as they work through the curriculum, leaving students who need more time to
master concepts to rely on procedural accuracy at the expense of concept mastery. As
noted by Allsopp et al. (n.d.), “teaching understanding of the math processes as well as
teaching the algorithms for computing solutions is critical for students with math learning
problems” (p. 2).

In addition to emphasizing procedures over concepts, Allsopp et al. (n.d.) noted
that the spiraling curriculum common in the United States poses additional challenges for
struggling mathematics students. Within the spiraling curriculum, students are
introduced to a variety of topics one year and revisit the same topics at greater depth in
subsequent years. Despite the appropriateness of this approach for the majority of
students, low-achieving mathematics students are not given enough time to practice and
truly master each topic before moving on to the next. When that topic is addressed the
following year, the anticipated foundation is only partially acquired (Allsopp et al., n.d.; Seeley, 2009).

Stigler and Hiebert (2004) cautioned that scrutinizing curriculum and instruction practices alone will not adequately address the deficiencies of mathematics in the United States. In addition, the cultural routines of teaching must be targeted. “The cultural activity of teaching – the ways in which the teacher and students interact about the subject – can be more powerful than the curriculum materials that teachers use” (Stigler & Hiebert, 2004, p. 5). Specifically, the researchers advocated the implementation of lesson study, a focused, collaborative problem-solving process (Stigler & Hiebert, 1999). Lesson study is an eight-step process that begins with the selection of a learning target on which the teaching team wishes to focus (Lewis, 2002; Stigler & Hiebert, 1999). Once the learning target has been chosen, the teaching team collaborates to develop a lesson to meet the target. One teacher implements the team-designed lesson while the rest of the team observes. Based upon observation data, the lesson is revised and taught in another classroom. The lesson is again observed by the team and revised based upon team feedback. The final step in the process is to share the process and findings orally or in writing. According to Stigler and Hiebert (1999), the power of lesson study is that it focuses on continuous improvement of student learning within the context of improved teaching. Teachers lead the way in sustained, collaborative professional development. In addition, lesson study has proven to bring about systemic improvements in schools (Lewis, 2002).

Another facet of the curriculum and instruction effects on mathematics achievement involves restricted access to the curriculum through scheduling practices,
specifically ability grouping. Research indicates that homogeneous between class ability grouping has virtually no impact on academic achievement (Chiu et al., 2008; Reed, 2008; Westchester Institute, 2002) with the exception of students placed in the highest groups who are offered a substantially different curriculum than their low and average ability peers (Burris, Hubert, & Levin, 2006; Gamoran, 1992; Kulik, 1993; Westchester Institute, 2002). Despite these findings, homogeneous, between class ability grouping continues to be a common practice in secondary schools, especially in mathematics (Reed, 2008; Schmidt & Cogan, 2009; Tennison, 2007; Westchester Institute, 2002).

Academic tracks, which began in the mid-nineteenth century in the United States, have historically been classified as academic, general and vocational (Chiu et al., 2008). In recent years, many secondary schools have removed general and vocational courses from their course offerings in an attempt to promote college-preparatory programs for all students (Reed, 2008). The result has been a revised ability grouping system that includes “honors, advanced placement and on-level classes” (Chiu et al., 2008, p. 125).

The negative effects of ability grouping are well documented in the literature. Students in lower tracks do not have equal access to curriculum (Schmidt & Cogan, 2009; Tennison, 2007), nor are they encouraged to develop critical thinking skills related to mathematics (Reed, 2008). Students in lower tracks are denied the opportunity for “upward comparisons” via interactions with academically advanced peers, which negatively affects the lower tracked students’ beliefs about aptitude in mathematics (Chiu et al., 2008, p. 131). In addition, research indicates that students in lower track mathematics are likely to continue falling behind their upper track peers which
widens the performance gap between the groups (Gamoran, 1992) becoming the root cause of persistent low achievement (Burris et al., 2006).

The research on persistent low achievement in mathematics suggests that students with average intelligence are hindered by curriculum and instruction practices that do not support the development of conceptual understanding and critical thinking (Ball et al., 2001; Buchler, 2009; Stigler & Hiebert, 2004; Stigler & Hiebert, 1999). While the research on causes of mathematics deficiencies continues to evolve, current research indicates that students with cognitive deficits are most likely to have slight deficits in working memory (Geary, 2011). Regardless of the reason for persistent low-achievement, effective mathematics instruction is critical to developing the mathematics competency required by today’s global economy (Ball et al., 2001; Buchler, 2009; Fuchs & Fuchs, 2001; Geary, 2011; Stigler & Hiebert, 2004; Stigler & Hiebert, 1999).

Effective Mathematics Instruction

Meeting the needs of all mathematics learners, especially struggling learners, requires the use of a variety of pedagogical methods (McREL, 2010). Ball et al. (2001) maintained that effective instruction is the key to improved mathematics achievement. To be successful in mathematics, students must be taught the strategies that are most effective in quantitative studies (Buchler, 2009; McREL, 2010). Buchler (2009) cautioned that, without explicit quantitative strategy instruction, students attempt to transfer strategies that are effective in non-quantitative studies, which leads to low-achievement and increased math aversion.

As noted in What We Know About Mathematics Teaching and Learning by McREL (2010), the basis of effective instruction is a standards-based curriculum with
measurable learning targets that are clearly articulated across grade levels. McREL cautioned that standards must be grounded in research but should also be “internationally benchmarked, aligned with college and workforce expectations, and made rigorous in both content and skills” (2010, p. 52). These standards are not a seemingly endless list of topics to be addressed at each grade level, but rather purposefully grouped learning targets centered around the “big ideas” of “numbers and operations, algebra, geometry, measurement, and data analysis and probability” (McREL, 2010, p. 54). According to Jensen and Nickelsen (2008), purposefully grouping learning targets enables the brain to detect patterns in the content, which facilitates learning.

Once a sound curriculum is in place, the focus can shift to effective pedagogy. Sound pedagogy in mathematics includes strategies that (a) access prior knowledge, (b) require verbal or written processing of procedures and concepts, (c) incorporate a variety of instructional strategies and (d) integrate social interaction and cooperation (McREL, 2010). In addition, students must engage in active learning grounded in real-world application; students must “do” math (Henningsen & Stein, 1997; Hyde, 2007). “Real life is a rich source of mathematics problems. Learning is highly interactive as students explore problems, formulate ideas, and check those ideas with peers and with their teacher through discussion and collaboration” (McREL, 2010, p. 66).

Jensen and Nickelsen (2008) identified “priming and activating prior knowledge” as the first instructional step in promoting in-depth learning of academic content (p. 74). Establishing connections to prior learning benefits students by improving the chance of remembering the new information, peaking interest, providing effective scaffolding, and immediately clearing up misconceptions (Jensen & Nickelsen, 2008). Instructional
strategies that activate and build prior knowledge include previewing materials, questioning and discussing, and making explicit connections (Jensen & Nickelsen, 2008; Marzano, Pickering & Pollack, 2001). “When students connect new learning to previously learned material, subsequent learning becomes easier and students are more apt to experience a sense of mathematical power” (McREL, 2010, p. 86).

In addition to activities designed to access prior knowledge or teach prerequisite content or skills, it is also vital to identify the relevance of the content to students’ lives (Jensen & Nickelsen, 2008; Willis, 2010). Hyde (2007) maintained that “making connections is… at the heart of doing mathematics” which includes connecting mathematics content to personal experiences and prior knowledge, to real-world situations, and to other mathematics content (p. 46). As noted by Seeley, rather than watching a teacher demonstrate mathematics, students must be engaged in “doing mathematics and solving challenging problems” (2009, p. 30).

Metacognition, “thinking about thinking”, includes connecting new learning to prior learning, selecting appropriate strategies to accomplish the learning task, and evaluating the effectiveness of strategies selected to adjust the approach if necessary (McREL, 2010, p. 96). Harvey and Goudvis (2000) described learners at four levels of metacognition:

1. “Tacit learners” who are not aware of their thought processes.
2. “Aware learners” who know when they are struggling or confused but do not know which strategies to use to repair the misunderstanding.
3. “Strategic learners” who use specific strategies while learning and problem-solving and know when and how to correct misunderstandings.
4. “Reflective learners” who use a variety of strategies flexibly while learning and adjust strategies as needed (p. 17).

According to Robb (2003), there are “three categories of metacognition: personal test-taking strengths; awareness of mind-wandering; and uses of learning strategies” (p. 125). In order for students to develop metacognition, the strategies that build metacognition must be modeled for students by their teachers (Robb, 2003).

Strategies that promote metacognition include discussions with peers, teachers and whole class (Chapin, O’Connor & Anderson, 2009; Kenney, Hancewicz & Heuer, 2005; McREL, 2010; Stigler & Hiebert, 1999; Wickett, 2000; Willis, 2010), and journaling about mathematical thinking and problem-solving (Jensen & Nickelsen, 2008; Kenney et al., 2005; McREL, 2010; Steen, 2007). Mathematics conversations and writing activities are critical to deepening mathematical understanding (Kenney et al., 2005) as these opportunities often reveal student misconceptions that can subsequently be corrected (Chapin et al., 2009). Such activities also provide opportunities for students to thoroughly articulate their thought processes (Chapin et al., 2009). These metacognitive activities result in improved reasoning and problem-solving skills, which leads to increased mathematical understanding (Chapin et al., 2009; McREL, 2010).

Effective mathematics instruction necessitates the presentation of concepts and skills in a variety of ways in order to meet the diverse needs of learners (McREL, 2010; Willis, 2010). The use of manipulatives (McREL, 2010; Monroe & Panchyshyn, 1995; Willis, 2010), think alouds (McREL, 2010; Monroe & Panchyshyn, 1995), as well as questioning and cueing strategies (Marzano et al., 2001; McREL, 2010; Stigler & Hiebert, 1999) promote conceptual understanding more effectively than the traditional
lecture-model-independent practice sequence of traditional mathematics instruction (Hyde, 2007; Stigler & Hiebert, 2004). Gersten and Clarke (2007a) and Fuchs and Fuchs (2001) maintained that presenting new content in three stages – concrete, representation and abstract – scaffolds instruction in such a way to move students to abstract mathematical thinking while building a solid conceptual foundation using manipulatives and non-verbal representations.

Willis (2010) maintained that differentiated instruction based on flexible grouping should be targeted at the learning needs of students 1) reasoning abstractly with the concept, 2) beginning to grasp the concept and 3) being introduced to the concept. In addition, students must be active participants in the learning activity to maximize understanding of concepts and skills (Jensen & Nickelsen, 2010; McREL, 2010; Monroe & Panchyshyn, 1995; Willis, 2010). According to McREL, “students who experience a range of activities from short whole-group instruction to extended periods when they are engaged in problem solving are more likely to enjoy learning” (2010, p. 92).

Gersten and Clarke (2007a) summarized recent studies of research-based strategies that have proven to be effective for low-achieving mathematics students. Of the six strategies highlighted in the review, four strategies were found to have moderate to large effect sizes for low-achieving students who did not qualify for special education services. The strategy with the largest effect size of .62 was peer-assisted learning in heterogeneous groups. Direct instruction in which the teacher models a problem-solving strategy for students to replicate in practice had an effect size of .58 for low-achieving math students. The last two strategies involved the use of formative assessments by
teachers and students. Analysis of formative data by students resulted in an effect size of 0.57 while use of formative data by the teacher resulted in an effect size of 0.51.

Inherent in the instructional strategies described in the preceding paragraphs is the importance of social interaction and cooperation in mathematics instruction (Burns, 2007; Gersten & Clarke, 2007a; Jensen & Nickelsen, 2010; McREL, 2010). As noted by Jensen and Nickelsen (2010), “cooperative learning…has been shown in numerous studies to promote higher achievement across all age levels, across subject areas, and on almost all tasks” (p. 40). Promoting interaction in mathematics instruction has the added benefit of improving attitudes toward math and increasing student motivation (McREL, 2010).

Lastly, effective mathematics instruction incorporates inquiry-based learning grounded in real-world application (Daggett, 2005; Henningsen & Stein, 1997; Hyde, 2007; McREL, 2010; Stigler & Hiebert, 2004). Daggett (2005) asserted that deep learning of content occurs when students must apply knowledge and skills to unknown real-world situations. “Incorporating more rigorous and relevant instruction...will yield immediate results in students’ enthusiasm to learn. When students are engaged in the learning process, real achievement takes place, and their chances to excel at what they do increase” (Dagget, 2005, p. 2).

When considering the development of mathematics interventions, the manner in which mathematics curricula are presented to all students must be the first element evaluated (Gersten et al., 2009). The goal of any school system should be developing learners who can adapt what they have learned to unknown situations (Daggett, 2005). In order to do so, however, a solid foundation of understanding must be laid from beginning
to end of classroom instruction in order to provide each student with his best chance at success. When students struggle despite implementation of effective mathematics instruction, specific interventions must be developed to address areas of deficiency (Gersten et al., 2009).

**Effective Mathematics Interventions**

According to the Evidence Based Intervention Network of the School of Psychology at the University of Missouri-Columbia (2011), the need for any academic intervention is attributable to one of five underlying reasons for low achievement.

1. The task is more difficult for the student.
2. The student needs more help with the task.
3. The student needs more time to build proficiency.
4. The student cannot generalize known content to new situations.
5. The student is not motivated to complete the task.

Once the underlying reason for low achievement has been determined, diagnostic assessment data must be analyzed to determine specific areas of weakness so that an intervention that will remediate that specific deficiency can be implemented (Betts, Hahn, & Zau, 2011; Milgram & Wu, 2005; National Council of Teachers of Mathematics, 2007). The specific alignment of the intervention to the individual need of the student is an essential component of mastery learning through the zone of proximal development as described by Vygotsky (Miller, 2011).

According to Fuchs and Fuchs (2001), the primary intervention must be the re-design of classroom instruction to maximize learning for low-achieving students in a way that preserves the learning for their average-achieving and high-achieving peers. Based
upon their research, Fuchs and Fuchs (2001) asserted that four principles are essential for this instruction transformation:

- Faster paced instruction incorporating a variety of instructional strategies and grouping structures, which leads to increased student engagement.
- Frequent use of motivational statements centered on the students’ abilities to meet high curricular expectations.
- Verbalization of mathematical problem-solving processes by students.
- Incorporation of concrete-representation-abstract strategies to move students to abstract mathematical thinking while building a foundation of conceptual understanding.

Even with such adjustments to whole-group instruction, interventions that are more intensive may be required. These interventions should be tailored to the individual student’s needs based upon diagnostic assessment data and delivered in one-to-one or small group settings. In addition, deficit skills should be taught and practiced in context not in isolation (Fuchs & Fuchs, 2001).

Milgram and Wu (2005) proposed an accelerated intervention program for students in fourth through seventh grade focused on 1) “place value and basic number skill”, 2) “fractions and decimals”, 3) “ratios, rates, percents and proportions”, and 4) mathematical processes (p. 3). Many opportunities for “doing” mathematics in school and at home are inherent in the success of this intervention (Milgram & Wu, 2005, p. 3).

Both of the intervention examples previously described as well as the five explanations for low achievement from the Evidence Based Intervention Network imply the need for extended time actively engaged in the learning process. In his seminal work
on the subject of extended learning time, John B. Carroll (1963) proposed that a student with an aptitude for learning, the willingness to learn and the ability to understand instruction could master a given learning task if provided quality instruction and sufficient learning time. In the decades following, additional research and studies have supported the claim that time on task has a positive impact on academic achievement (Bloom, 1974; Harnischfegar & Wiley, 1976; Odden, 2009).

Current research on extended learning includes studies on expanding the school day with after school programs as well as expanding the school year by reducing or re-allocating summer vacation (Aronson, Zimmerman, & Carlos, 1999; Farbman & Kaplan, 2005). Although the manner in which additional learning time can be obtained may vary, the result is the same – extended learning time is positively correlated with improved academic achievement (Aronson et al., 1999; Farbman & Kaplan, 2005).

Recent research on extended learning mathematics interventions includes studies of “double-dose” mathematics courses (Ketterlin-Geller et al., 2008; Odden, 2009; Nomi & Allensworth, 2009; Piper et al., 2009). In a “double-dose” intervention, low achieving students are assigned to a regular math class in which the standard curriculum is presented. In addition to the regular math class, these students are also enrolled in an additional math class designed to support the learning in the regular math class by pre-teaching, re-teaching or building basic math skills previously missed. Such a structure ensures that even the lowest achieving students are engaged in learning the same curriculum as their peers with additional instruction and additional time to maximize the opportunity for mastery (Ketterlin-Geller et al., 2008; Nomi & Allensworth, 2009; Piper et al., 2009).
The quasi-experimental study, conducted by Ketterlin-Geller et al. (2008), sought to determine the effects of two mathematics interventions for upper-elementary aged students. Qualifying students were assigned to one of three groups – (a) a “double-dose” intervention group, which provided extended time, practice and assistance with the regular curriculum; (b) an intervention group, which utilized a purchased mathematics intervention program; or (c) the control group, which received no intervention. The researchers concluded that both interventions resulted in improved math achievement as measured by local assessments when compared to the control group. In addition, the “double-dose” intervention resulted in improved mastery of grade-level content as measured by the state mathematics assessment.

The quasi-experimental study by Takako Nomi and Elaine Allensworth (2009) used four years of student achievement data and course grades to evaluate the effectiveness of a “double-dose” algebra policy implemented by the Chicago Public School system in 2003. In an attempt to decrease the failure rate in Algebra I, Chicago Public Schools mandated that any student scoring below the 50th percentile on the state mathematics assessment be enrolled in a “double-dose” algebra support class. Analysis of four years of data revealed that the policy did not have any effect on Algebra I failure rates, but the policy did have a significantly positive effect on student understanding of algebra skills and concepts as evidenced by increased achievement on the state mathematics assessment.

Lisa Piper et al. (2009) conducted action research involving eight middle school students to examine the effectiveness of a short-term “double-dose” intervention. The researchers selected the eight participants based on performance on the state math
assessment, local common assessments and classroom assessments. The participants received 25 minutes per week of the “double-dose” intervention for a total of four weeks. The intervention time was used to provide additional help on the current unit of instruction. Data were collected via unit pre-tests and post-tests. The results showed that, after the intervention, the study participants demonstrated the same achievement on classroom quizzes as their peers who did not participate in the intervention.

Aronson, Zimmerman and Carlos (1999) maintained that additional learning time alone is not an effective intervention. The time spent in an extended learning intervention must be devoted to active engagement in instructional activities. In a mixed methods study of remedial science and math programs, Dewalt and Rodwell (1988) found that an additional thirty minutes per day of extended learning only resulted in increased achievement if the content was presented in a different manner than in the regular classroom using hands-on or other active learning instructional strategies. In his synthesis of Algebra I interventions, Carl Vogel asserted that “how both double-block and standard Algebra I are taught is even more important than the curriculum” (2008, p. 40, emphasis in the original). Specifically, the traditional method of teacher demonstrates and student replicates is not effective in an intervention for struggling mathematics students. Likewise, Odden maintained that extended learning opportunities should not “just offer students more of the same” instruction (2009, p. 78). Instead, these interventions should be “staffed with teachers skilled in additional instructional approaches for reaching students who did not understand the material the first time they encountered it” (Odden, 2009, p. 78).
To provide specific recommendations to school personnel regarding the development of mathematics interventions, Gersten et al. (2009) conducted a review of quasi-experimental studies and experimental studies of mathematics interventions. The results of this review were synthesized in an Institute of Education Sciences Practice Guide on interventions for struggling math students. Although these recommendations are specific to use within a Response to Intervention model with elementary and middle school students, the recommendations are applicable to other intervention models and Algebra I students, who are typically in eighth or ninth grade.

The recommendations with strong levels of evidence include “explicit and systematic” interventions “providing models of proficient problem solving, verbalization of thought processes, guided practice, corrective feedback, and frequent cumulative review” and “instruction in solving word problems” (Gersten et al., 2009, p. 6). The recommendations with moderate levels of evidence include a focus on basic math fact fluency and student use of a variety of concrete and visual representations of mathematical concepts (Gersten et al., 2009).

While the research on mathematics interventions is not as extensive as in other subject areas, there is a growing body of literature from which to glean research-based recommendations (Balfanz, Legters & Jordan, 2004). These recommendations include identifying the underlying reasons for the deficiency and using assessment data to select specific interventions to move the student through the zone of proximal development to mastery of the learning target (Betts et al., 2011; Evidence Based Intervention Network, 2011; Milgram & Wu, 2005). In addition, interventions must ensure effective use of
extended learning time by actively engaging students in instructional activities (Aronson et al., 1999; Farbman & Kaplan, 2005; Gersten, et al., 2009).

The review of the literature provides a solid foundation for the proposed study by exploring the internal and external causes of low achievement in mathematics for students without disabilities. In addition, an analysis of effective mathematics instruction for all students as well as effective mathematics interventions for low-achieving students provides a context by which to develop, implement and evaluate a “double-dose” intervention.
Chapter 3: Research Design

Methodology

Building upon the existing research on mathematics interventions, specifically “double-dose” interventions, the intent of this study was to describe and explain the aspects of the Math Lab intervention that were promoting student success in mathematics. The following research questions became the basis for this exploration.

Central Research Question 1: What is the process by which the Math Lab intervention in a suburban Midwest high school was designed and implemented?

Sub-question 1: What were the critical elements of the Math Lab intervention?

Sub-question 2: How was the Math Lab intervention implemented?

Central Research Question 2: What were the local and state achievement scores in mathematics for students who participated in the Math Lab intervention and how did the math achievement scores of participants compare to the math achievement scores of non-participants of similar demographics and ability?

Central Research Question 3: How do key stakeholders perceive the Math Lab intervention and the potential impact of Math Lab on student success?

Sub-question 1: How do students experience Math Lab?

Sub-question 2: How do parents perceive Math Lab?

Sub-question 3: How do teacher perceive Math Lab?

Sub-question 4: How do administrators perceive Math Lab?

Cresswell (2007) offered several contexts in which a qualitative approach to inquiry is required, including to provide “a complex, detailed understanding of the issue” [emphasis in the original] or to convey “the contexts or settings in which participants in a
study address a problem or issue” (p. 40). Both conditions applied to this which provided an in-depth analysis of data collected from multiple resources in the natural setting to reveal the perspectives of the participants in the Math Lab intervention (Cresswell, 2007).

The paradigm that informed the study is constructivism. Guba and Lincoln (1994) assert that constructivism is characterized by the belief that reality is context and participant dependent and that a “consensus construction” can be reached through the interaction of the researcher and participants (p. 111).

Research Design

Due to the descriptive nature of this study, the researcher selected a qualitative design to complement the quantitative studies generated by other scholars. The goal of this study was to understand the components of the Math Lab intervention that contributed to student success and to provide a complete description of the context and process so that others may replicate the intervention. As noted by Stake (1995), qualitative research is best suited to situations in which the researcher seeks to understand the complexities of a relationship as well as construct, rather than discover knowledge (p. 37). As such, a qualitative approach was most appropriate for this study.

Research Tradition

The proposed study will describe the Math Lab intervention, which included two class sections with two different instructors from two different school years; as such, the study utilized a single case-study design with two embedded sub-cases (Yin, 2012).

Creswell (2007) described case study research as the “study of an issue explored through one or more cases within a bounded system” (p. 73) which should be used “when the inquirer… seeks to provide an in-depth understanding of the case” (p. 74). The
research questions that drove this study were written to provide a detailed description of the Math Lab intervention in an effort to add to the body of knowledge regarding mathematics interventions.

In the process of developing this study, the researcher relied on the works of Robert E. Stake (1995) and Robert K. Yin (2009; 2012) in the area of case study research specifically as well as the works of John W. Creswell (2007; 2009) and Joseph A. Maxwell (2005) in the area of qualitative research in general.

**Participants**

The population of the study consists of forty-four Algebra I students. Twenty-one of the participants were enrolled in the Math Lab intervention during the 2011-2012 school year. The remaining twenty-three students were enrolled in the Math Lab intervention during the 2012-2013 school year. The researcher used homogeneous sampling and convenience sampling strategies. The students selected for the intervention had been unable to master grade-level mathematics concepts and skills, as measured by state and local assessments, despite exhibiting positive attitudes and significant effort. Consequently, the participants were invited to participate in the intervention independent of the research study being proposed, which is consistent with convenience sampling (Creswell, 2007; Maxwell, 2005). However, the students’ underachievement in mathematics was a common characteristic important to the researcher and relevant to the research questions, which is characteristic of homogeneous sampling (Lund & Lund, 2010).

The district in which the study took place serves a population that is 95% white and 16% free and reduced lunch. The demographics of the potential study participants
reflected the overall demographics of the study with 95% white and 15.7% free and reduced lunch. None of the participants received special services in mathematics.

The sample size used in this study will prohibit the results to be generalized to other contexts (Light, Singer & Willett, 1990) nor is the study intended to be generalized. As noted by Creswell (2009), “the value of qualitative research lies in the particular description and themes developed in context of a specific site. Particularity rather than generalizability is the hallmark of qualitative research” (p. 193, emphasis in the original).

**Recruitment and Access**

As stated previously, the researcher was an administrator in the district in which the participants were enrolled. In this capacity, the researcher had access to longitudinal student data, was frequently in classrooms for observation, and was able to contact students, parents and staff in person or by e-mail. Administrator and instructor interviews were conducted face-to-face while student and parent interviews were conducted via an on-line survey, which was disseminated via e-mail accounts.

Prior to the study, the building administrator and Math Lab instructors had consented to participating in interviews. To recruit parent and student survey participants, parents of Math Lab participants were notified via mail and e-mail of the opportunity for their child and for themselves to participate in this study. A copy of the consent letter is included in Appendix A. Students were offered a $5 gift card to a local convenience store for taking the time to complete the survey. The researcher met with the students for whom consent had been given to explain the purpose of the study, the risks and incentives of participation, and the opportunity for the students to decline participation.
Because an incentive for participation was included, participants were not anonymous. To protect the confidentiality of participants, however, the Director of Technology in the district in which the study took place collected all student responses and generated a list of survey participants separate from the survey responses so that the incentive could be provided while ensuring participant anonymity.

**Data Collection**

Data was collected via interviews of administrators, instructors, parents and students and via physical artifacts. In addition, the researcher observed each Math Lab class a minimum of three times to collect observation data (Maxwell, 2005; Stake, 1995; Yin, 2009; Yin, 2012).

Focused interviews of administrators and instructors took place in the administrator’s office and researcher’s office respectively. All interviewees determined where their interviews would be conducted. Both instructors chose the researcher’s office due to convenience and minimized interruptions. Interviews were conducted with the researcher and instructors sitting side-by-side in an effort to establish a non-threatening environment. Yin (2009) described a focused interview as a short, open-ended, conversational interview based upon an established protocol. The protocols for the administrator and instructor interviews are included in the Appendix B. These interviews were conducted by the researcher, lasted approximately one hour and were recorded using Audacity so that the exact words of the participants could be captured to ensure that the thoughts and perspectives of the participants were conveyed as accurately as possible (Yin, 2012). The researcher also took notes during the interview process.
using the two-column notetaking strategy suggested by Creswell (2009). Table 1 shows how the research questions and sub-questions were addressed by the interview protocols.

Table 1.

*Research Questions and Corresponding Data Sources*

<table>
<thead>
<tr>
<th>Central Research Question</th>
<th>Sub-Question/Null Hypothesis</th>
<th>Data Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What is the process by which the Math Lab intervention at a suburban Midwest high school was designed and implemented?</td>
<td>1. What were the critical elements of the Math Lab intervention?</td>
<td>Archival documents; Administrator Interview Protocol question 2; Instructor Interview Protocol questions 2 and 3 Observation data; Administrator Interview Protocol questions 3 and 4; Instructor Interview Protocol question 4; Student Survey questions 3, 4, and 5; Parent Survey questions 3 and 4</td>
</tr>
<tr>
<td></td>
<td>2. How was Math Lab implemented?</td>
<td></td>
</tr>
<tr>
<td>2. What were the local and state math achievement scores for students who participated in the Math Lab intervention and how did the math achievement scores of participants compare to the math achievement scores of non-participants of similar demographics and ability?</td>
<td>1. The math achievement scores of Math Lab participants do not differ from the achievement scores of non-participants of similar demographics and ability.</td>
<td>2011, 2012 and 2013 MAP data; math grades; grade point averages</td>
</tr>
<tr>
<td>3. How do key stakeholders perceive the Math Lab intervention and the potential impact of Math Lab on student success?</td>
<td>1. How do students experience Math Lab?</td>
<td>Student Survey questions 1, 2 and 6; Observation data; Journal responses Parent Survey questions 2 and 5 Instructor Interview Protocol questions 4, 5 and 6; Observation data Administrator Interview Protocol questions 5, 6 and 7</td>
</tr>
<tr>
<td></td>
<td>2. How do parents perceive Math Lab?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. How do teachers perceive Math Lab?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. How do administrators perceive Math Lab?</td>
<td></td>
</tr>
</tbody>
</table>

Table 1
Data from parents and student participants were collected via surveys that were distributed through e-mail accounts and collected via Survey Monkey. The researcher collected and analyzed parent and student responses while maintaining sole access to this data. Table 1 shows how the research questions and sub-questions were addressed by the survey questions.

Students in the Math Lab intervention kept journals to capture their thoughts and feelings about specific math concepts and about their growth as a math student; the journals were collected and analyzed for additional data. Table 1 shows how the research questions were addressed by the journal responses.

As stated previously, this study was a single case-study design with two embedded sub-cases (Yin, 2012). Each Algebra I Math Lab met for 90 minutes every other day. The researcher observed each Math Lab for the entire 90 minute class period a minimum of three times for a total of six observations. As a participant-observer, the researcher had the benefit of knowledge of the internal processes and decision-making regarding the Math Lab intervention but had to guard against bias due to her involvement in the program (Yin, 2009). Observation data collected via selective scripting and movement, interaction, and behavior pattern charts provided objective data to incorporate into the study (New Teacher Center, 2006); examples of these data collection tools are included in Appendix C. The movement, interaction and behavior pattern chart was used to collect data on the types of learning activities and focus of the learning activities in which students were engaged. A chart of the seating arrangements was drawn on the chart at the beginning of each observation. In five minute intervals, the researcher recorded codes for each student based upon the activity in which he/she was engaged.
Codes were developed for whole group instruction, small group instruction, independent work, one-to-one assistance, computer-assisted instruction, peer-assisted instruction, and not engaged in instruction. Notes were added to indicate if the learning target with which the student was engaged represents pre-teaching, re-teaching or foundational skill development. The selective scripting tool was used to record comments made by students or teachers that were directly related to the research questions. See Table 1 for the manner in which observation data was used to address the research questions.

Archival documents articulating the research process that informed the Math Lab intervention development as well as the original plan for the structure of Math Lab was used to address Central Research Question 1, Sub-question 1.

Finally, all quantitative data were gathered via the district’s student information system and state assessment reports, both of which the researcher was able to access due to her role in the district.

Collecting data in the methods described above allowed the researcher to triangulate the data to maximize validity and to broaden understanding of the complexities of the Math Lab program (Maxwell, 2005).

Data Storage

The data collected for this study was stored securely in the researcher’s Dropbox account. All interviews were transcribed by the researcher. The student survey data was collected via Survey Monkey and was downloaded by the district’s Director of Technology into a spreadsheet. Interviews were recorded through Audacity and saved as sound files. All handwritten notes and observation charts were scanned and stored as
PDFs. Storage in Dropbox allowed the researcher to maintain participant confidentiality as well as ensure the data was not lost due to technology failure.

**Data Analysis**

The manner in which the qualitative data were captured depended on the data type. Survey data were downloaded from Survey Monkey into Microsoft Excel. Interview data were transcribed into Microsoft Word. Journal entries, archival documents and observation data were scanned as PDFs. The researcher then read the data to gain a general sense of the design and implementation of the Math Lab intervention and participant perspectives of the Math Lab intervention during first cycle coding. According to Saldana (2009), descriptive coding is appropriate for all types of qualitative research and with studies using various data sources. The defining characteristic of description coding is the assignment of words or phrases that succinctly capture the topic of the data (Saldana, 2009). Descriptive coding was used for the first cycle of coding.

During the second cycle of coding, the data were re-analyzed via pattern coding. Patterns discerned from the data were categorized into major themes to develop a detailed understanding of the implementation of Math Lab and the perceptions of stakeholders regarding Math Lab (Saldana, 2009).

The quantitative data was represented by measures of central tendency and standard deviation (Minium, Clarke, & Coladarci, 1999). Although this study did not attempt to discern causation, a t-test of independent samples was used to compare the achievement of the Math Lab participants with the achievement of students of similar
demographics and abilities that did not participate in the Math Lab intervention (Minium et al., 1999).

These qualitative and quantitative findings became the basis for a detailed description of the development and implementation of the Math Lab intervention, the perspectives of the Math Lab participants and the potential impact of the Math Lab intervention on student achievement. The final step in the data analysis was to make meaning of the data to add to the body of knowledge regarding mathematics interventions (Creswell, 2009).

**Trustworthiness**

As a participant-observer in this study, the researcher was biased regarding the Math Lab intervention. The researcher initiated the research behind this intervention, oversaw the intervention’s implementation, selected the instructors and developed the criteria for the selection of student participants.

To mitigate the bias held by the researcher, several strategies were employed. First, multiple data sources from all stakeholders were used to triangulate the data in an effort to provide the most precise description of the Math Lab intervention while minimizing the voice and perspective of the participant-observer (Yin, 2012). As noted by Gay, Mills and Airasian, the practice of triangulation allows the researcher to develop a "more complete picture of what is being studied and to cross-check information" (2006, p. 405).

In addition, the researcher as participant-observer spent nine hours in observations in an effort to develop trust with the students and to "overcome distortions" that may have resulted from having a visitor in the classroom (Gay, Mills & Airasian, 2006, p.
Fraenkel and Wallen (2009) maintained that ensuring the consistency of data collection through repeated observations is a key factor in ensuring reliability. Lastly, the process of "member checking" was used (Stake, 1995, p. 115). Once interviews were transposed and an initial draft was written, the researcher asked the instructors of the Math Lab intervention and the building administrator to review the documents and provide feedback regarding the accuracy of the data. The instructors and administrator were also given the opportunity to suggest alternate interpretations which were taken into consideration by the researcher in the re-writing process (Fraenkel & Wallen, 2009; Gay, et al., 2006; Stake, 1995).
Chapter 4: The Findings

Introduction

In this chapter, the researcher uses the words of administrators, teachers, parents and students captured through interviews, surveys, journal entries, archival documents and observations to weave the tapestry that is the Math Lab story. By addressing each of the research questions on which the study was based, this chapter provides an explanation of the history of the Math Lab intervention, descriptions of the planned implementation and actual implementation of the Math Lab intervention, and depictions of the impact of Math Lab participation on student achievement and on student affect.

Design and Implementation of the Math Lab Intervention

Central research question 1: What is the process by which the Math Lab intervention in a suburban Midwest high school was designed and implemented?

Sub-question 1: What were the critical elements of the Math Lab intervention?

Sub-question 2: How was the Math Lab intervention implemented?

The first central research question inquired as to the process by which the Math Lab intervention was designed and implemented. As stated previously, the issue of mathematics achievement is a persistent issue in the district in which this study took place. Despite a relatively low historical poverty level of less than 16%, student achievement in mathematics as demonstrated on state assessments (Missouri Department of Elementary and Secondary Education, 2012), the ACT college entrance exam, and remedial placement in post-secondary placements (Missouri Department of Higher Education, 2011) had created concern amongst district administration, faculty and the community.
Findings for research question 1, sub-question 1. In response to this concern, district faculty conducted research on best practices in mathematics instruction focusing specifically on elementary instructional delivery and grouping practices at the middle school level. While reviewing the literature on grouping practices, the research committee discovered the studies on “double-dose” mathematics interventions conducted by Leanne Ketterlin-Geller et al. (2008), Takako Nomi and Elaine Allensworth (2009), and Lisa Piper et al. (2009). In addition, one of the faculty on the research committee had previously worked in a district which offered such a “double-dose” intervention to students with a history of struggling in mathematics. The results of this “double-dose” research coupled with the staff member’s experience with a similar intervention piqued the interest of building and district administration to consider developing a “double-dose” intervention for struggling middle school and Algebra I students. As described by one of the high school Math Lab teachers,

we were just seeing a lot of student who were struggling with… retention. Those were the type of kids that were our ‘bubble kids’ that… had the ability to move from Basic to Proficient but just didn’t have the support. So, we were looking for a way to address… those students specifically.

The high school principal described the formation of Math Lab in a more global manner as a reaction to “students that were failing Algebra I… and were most likely ill-prepared for Algebra II and Geometry that caused them to struggle to meet graduation requirements….” The common characteristic of many of the students who struggled to meet graduation requirements in mathematics was a lack of “basic foundational support”
for subsequent learning. In response, the principal explained that Math Lab was conceived to “scaffold and support and accommodate kids who really struggled”.

Four teachers – one sixth grade, one seventh grade, one eighth grade and one Algebra I – were asked to accompany administrators on a site visit to a nearby district that had been implementing a “double-dose” intervention for several years. The second high school Math Lab teacher did not participate in the site visit because that teacher was not hired until the following summer. The site visit included observing a middle school intervention classroom and a high school intervention classroom as well as collaborating with the district mathematics coordinator over implementation details.

At the time of the site visit, this district had been offering this “double-dose” intervention for five years and, due to the program’s success, had expanded it to all high schools and all middle schools in the district. The district served 17,524 students with 18.2% qualifying for free and reduced lunch services. The student population was 79.8% white, 13.1% African-American, 4.3% Hispanic and 2.4% Asian. Although the neighboring district differs considerably in size and population served, the site visit team gleaned several key elements of the Math Lab intervention to borrow from the neighboring district’s intervention model including:

- class sizes limited to 15 at the high school level and limited to 10 at the middle school level,
- emphasis placed on building positive student-student and student-teacher relationships,
- instruction focused on pre-teaching, re-teaching and addressing foundational math skill deficits, and
• computers and hand-held devices used for foundational math skill instruction to allow the instructor to facilitate small group instruction.

The site visit also provided insight into what Math Lab should not be. As noted by the high school Math Lab instructor,

I liked his approach from the relationship side where he would get to know them very well but it didn’t seem like he would be supporting them mathematically. These are students that typically need… a different approach to a math class.

Instead of structuring the Math Lab in a traditional math class format of the teacher explains and demonstrates and then the students practice, the high school Math Lab teacher felt that “a Math Lab candidate would be more successful” with the incorporation of “more hands-on learning” rather than “‘monkey see, monkey do’” approach of a traditional math class as “having three hours of math between two straight days… would be rough for anyone”. Although this sentiment was primarily based upon this teacher’s experience in working with struggling math students, the importance of presenting course content in a different way than the students experienced in the regular class is supported in the research on effective mathematics interventions (Aronson et al., 1999; Dewalt & Rodwell, 1988; Odden, 2009).

**Findings for research question 1 sub-question 2.** After the site visit, district and building administration determined that current staffing would allow for the development of five Math Lab classrooms. There would be one Math Lab intervention per grade level in grades six through eight at the middle school and two Math Lab interventions for Algebra I at the high school. Once the Math Lab teachers were selected, teachers and administrators met to plan the structure of the Math Lab intervention and to identify
resources needed for successful implementation. Although Math Lab was implemented at the middle school level, the focus of this study is on the high school Math Lab only. Consequently, the remainder of this chapter will describe the high school Math Lab implementation exclusively.

**Planned implementation.** The planning of the first year of Math Lab implementation, which was scheduled for the 2011-2012 school year, centered on the process for selecting students, the focus of Math Lab instruction, and the resources required for successful implementation. At this point in the planning process, the teachers were very uneasy about the implementation. Specifically, they were concerned that students would be resentful about giving up an elective of their choice to be in the class and that this resentment would manifest itself in defiance and other behavior problems. As one teacher put it, “what happens if the students are deadbeats”? The first planning meeting was designed to address most of these concerns.

**Student selection.** The first step in the process was to identify the students who would likely respond to the Math Lab intervention. The Evidence Based Intervention Network of the School of Psychology at the University of Missouri-Columbia (2011) cites the following reasons for low achievement: the student finds the task difficult, the student needs more help, the student needs more time, the student cannot generalize known to unknown, or the student is not motivated. For the purposes of selecting students for the Math Lab intervention, students who fit the first three reasons but did not fit the latter two were the target. The “right kid” for Math Lab is motivated and able to apply existing knowledge to new situations even though he/she may have difficulty with
a particular task or need additional help or extended learning time in order to master that task.

Determining specific criteria to identify these students was not well informed by the research, however, and the administration and teachers had to develop the measures by which to invite Math Lab participants. For the first year, the team determined that teachers from the previous grade level would make recommendations for inclusion based upon

1. a history of low performance on standardized assessments,
2. a history of struggling with mathematics concepts and skills despite significant effort to understand and master these concepts and skills,
3. a demonstrated need for intensive support in mathematics, and
4. a positive attitude about learning and school.

Missouri Assessment Program data were evaluated to determine the history of performance on standardized assessments. The remaining three factors were based entirely upon teacher feedback.

One Math Lab teacher described the “right kid” as “one that has the ability level to understand it but just needs…a different approach to how they’re taught”. The high school principal maintained that these are kids with relatively average or above motivation that were still not getting it…. So we were very specific about the profile of the child that we felt was going to benefit from it. This was not viewed as a catch-all, repair-all kind of a program.
Math Lab classes at the high school Math Labs were limited to fifteen participants. Once students were identified, each schedule was modified by eliminating one elective course which was replaced by Math Lab. If necessary, the student’s math class was also changed so that each student had the same teacher for Algebra I and Math Lab, which was a non-negotiable component for the Math Lab teachers. The teachers believed that having the same instructor for both classes would eliminate communication gaps between teachers and would simplify planning for the Math Lab intervention. Finally, letters were mailed home to parents explaining the purpose of the intervention and informing them to contact the building principal or the district office if they wished to opt-out of the intervention (see Appendix D).

Instructional focus. The Math Lab instructors determined, based upon the research conducted and the observations from the site visit the previous spring, that instruction would focus on re-teaching mathematical concepts and skills from the regular math class with which Math Lab students were struggling, pre-teaching upcoming mathematical concepts and skills to build prior knowledge and confidence, and “filling gaps” in foundational math skills, such as addition, subtraction, multiplication and division of whole numbers and fractions, that were impeding the success of Math Lab students. This would be accomplished through varied instructional strategies such as hands-on learning, small group instruction, computer-assisted instruction, and peer-assisted instruction. In addition, the teachers were committed to building strong student-student relationships and student-teacher relationships through teambuilding, which would be a central focus for the first few weeks of school.
Several resources were provided for teachers to address the instructional needs identified. First, the research on effective mathematics instruction asserted that writing in mathematics is a critical step in conceptual understanding (Baxter, Woodward & Olson, 2005; Kenney et al., 2005; McREL, 2010; Russell, n.d.). The teachers had determined that they would have each student keep a journal in which he/she would respond to questions, reflect on learning, and explain mathematical thinking. According to Russell (n.d.), with journaling math no longer becomes a task where by the individual simply follows the steps…. When a math journal entry is required as a follow up to the specific learning goal, one actually has to think about what was done and what was required to solve the specific math…problem (para. 1).

In addition, several student self-assessments were provided to teachers through which they could gather additional information about the learning preferences of their students. The origin of these self-assessments are unknown, but copies are included in Appendix E.

To help the teachers with the team-building aspect, teambuilding structures were introduced and explored (Kagan, 1994). As previously identified, peer-assisted instruction was an integral component of the intended Math Lab instructional design. The Math Lab instructors agreed that committing significant time to teambuilding at the beginning of the school year would be essential to create the trustful, learning community required for peer-assisted learning.

Requisite resources. The most significant resource required for the Math Lab intervention was a bank of 5-7 computers in each Math Lab classroom. In order to
accommodate this need, the same classroom was used for the Math Lab interventions. During the Math Lab block, the two teachers at the high school traded classrooms.

To make the computer-assisted instruction meaningful for students, the teachers researched computer-based math programs which would provide diagnostic assessments to determine foundational math skill deficiencies so that targeted lessons could be assigned to meet the individual needs of each student. The high school selected Math XL for School by Pearson. Math XL for School can be used for self-paced enrichment or remediation according to individual needs. For the purposes of Math Lab, Math XL for School features content organized into learning modules. Once students show mastery of a particular module, he/she will graduate to the next module assigned based upon the diagnostic assessment. Teachers may also prescribe specific lessons if necessary (Speckler, 2011). The only other resources required were notebooks to be used as journals. The Math Lab instructors used resources already available to them for daily Math Lab lessons.

*Actual implementation.* As one would expect, the actual implementation of the Math Lab intervention varied from the original plan for implementation. Specifically, the need for considerations beyond the selection of students, the focus of instruction and attainment of resources became more and more evident as the implementation progressed. The data provided in this section of the chapter are derived from parent and student surveys, administrator and instructor interviews, observation data collected by the researcher and journal entries of students. The data provide an in-depth description of the actual implementation of the Math Lab intervention as it evolved over a two-year period.
Extended learning time. As this chapter will show, the Math Lab implementation was multi-faceted with many features designed to meet the unique needs of the Math Lab students. One such aspect is simply the fact that students had more time within the school day to practice and master the concepts and skills being taught in the regular Algebra I curriculum. One student stated that “Math Lab was a great educational class… and if you have two math classes it increases your math ability”. Parents also commented that the “extra instruction” and “extra time” helped their children become more “successful in math”.

As stated previously, the high school in which the Math Lab intervention was implemented uses a block schedule in which students have one set of four classes on A days and another set of four classes on B days. Each Math Lab student was assigned to a regular Algebra I class on one of those days and also assigned to a Math Lab on the other day resulting in twice as much time in a math class as well as having a math class every day rather than every other day. Establishing such a schedule was the first step in the Math Lab intervention implementation.

Focus of instruction. As anticipated in the planning stages of the Math Lab intervention, pre-teaching concepts and skills, re-teaching concepts and skills and addressing foundation skill deficits is a major focus of the instructional time in Math Lab. In addition, the data show perseverance and problem-solving were critical elements as well. Table 2 shows the frequency with which each component was referenced through student and parent surveys, in principal and teacher interviews, and during classroom observations.
Table 2

Focus of Instruction: Frequency of Responses and Observations

<table>
<thead>
<tr>
<th>Instructional Focus</th>
<th>Student</th>
<th>Parent</th>
<th>Teacher</th>
<th>Principal</th>
<th>Observation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-teaching</td>
<td>8</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Re-teaching</td>
<td>8</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Foundational skills</td>
<td>12</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Perseverance/Problem Solving</td>
<td>1</td>
<td>1</td>
<td>6</td>
<td>0</td>
<td>6</td>
</tr>
</tbody>
</table>

How the instructional focus was chosen was dependent upon the individual needs of the Math Lab students. True to sociocultural theory and the zone of proximal development, the theoretical foundations of this study, the instructor assessed the current ability level of the students and designed scaffolded, collaborative instructional support to move the student toward independent mastery (Miller, 2011; Tudge & Winterhoff, 1993).

In regards to pre-teaching concepts and skills, one student responded that “it gives me an extra boost so I can have a background of what we are learning”. Another described the pre-teaching exercises as “mini lessons for the next class”. The pre-teaching component of Math Lab enabled a third student to provide assistance to others. “It gave me a chance to get ahead on what we would be doing in [Algebra] class the next day, and it made it so I could help those students who didn’t understand what we were doing”.

According to the Math Lab instructors, approximately one-third of class time is devoted to pre-teaching upcoming concepts and skills. In addition to the obvious benefit of having more time to master the material, one instructor also credits the pre-teaching
activities for boosting the confidence of the Math Lab students enabling them to interact more effectively with their peers in the Algebra classroom.

When I pre-teach them and they know the material before the kids that they think are the ‘smart kids’, it allows them to say ‘OK, well, I’m really not that dumb’. I think that helps them be successful more than anything else.

When compared to pre-teaching activities, re-teaching activities were mentioned in equal number by students and in equal number by teachers. It was, however, the instructional focus most often observed by the researcher during classroom visits. That may have been due, in part, to the time of the year in which the observations took place. All six observations took place just a few weeks before state end-of-course testing began. Consequently, the Math Lab teachers were providing extra review for students to help them prepare for these assessments.

The Math Lab instructors claimed that approximately one-third of the instructional time in Math Lab was devoted to re-teaching activities. According to one Math Lab teacher, a benefit of having extended time to re-teach concepts was the opportunity to “go deeper” with the content and skills than they could in the regular Algebra I class as evidenced by the following statement. “I know some of the students think they are in there because they’re not capable, but I think I push them sometimes harder than I do my regular Algebra classes in some topics just because we can dig deeper”.

Students also noted the depth with which math concepts were studied in Math Lab as compared to the regular Algebra class. One student shared that “it goes into way more detail about what we’re learning and [my teacher] breaks down the problems until
we get what we are doing”. Another student shared that he “learned more things about
Algebra with both classes than just learning it in Algebra [class]”.

In addition, students commented on the importance of extra time or additional
help with troublesome concepts. As shared by one student,
sometimes just learning it in class isn’t enough, and I need to go over it again and
need the extra help. But I don’t have to worry because the next day I will have
Math Lab and it will help me a lot.

Another student remarked that Math Lab “helped clarify the math I’m still a little
confused on. Just another day of practice really, and it’s well worth it”. That sentiment
was echoed by a third student who credited Math Lab with improved grades in math. “I
had better grades because [my teacher] would help with the homework…assigned and
review the lesson we just learned”. One student, who had initially expressed resentment
about having to forego an elective course to participate in the Math Lab intervention,
shared the following about the benefit of re-teaching and extra help: “[Math Lab] has
helped me a lot. Sometimes just learning it in class isn’t enough, and I need to go over it
again and need the extra help”.

Although students and parents seemed to be unaware that one of the objectives of
the Math Lab intervention was to repair foundational math skill deficits, the instructors
and principal maintained that this was a critical component of the program. In addition,
student work on foundational skills was observed in four of the six observations. Such
foundational skill repair was primarily accomplished through computer-assisted
instruction via Math XL for School or on-line mathematics games. One instructor
described the critical nature of the foundational skill repair as follows:
A lot of these students just struggle with basic operations with positive and negative numbers… with integers. There are things like adding and subtracting positive and negative numbers, fractions, some of those skills that are just difficult and they make Algebra more difficult…. If they struggle with just adding and subtracting positive and negative numbers, then they’re stuck.

Working on the computers was mentioned by 11 student respondents as a typical component of Math Lab. When mentioned, however, students referenced “taking math quizzes” or “math practice” as the objective of the computer-assisted instruction not working on basic math skills. In addition, handheld electronic devices called Math Sharks were used the first year of the Math Lab intervention. On the Sharks, students practiced basic operations with integers and fractions. Students disliked working on the Math Sharks so much that the high school Math Labs stopped using them mid-year and sent them to the middle school teachers. The majority of the negative comments received from students via the survey were centered on using the Math Sharks or on using Math XL for School on the computers, which received one negative comment and five negative comments respectively.

Although not in the original plan for the Math Lab intervention implementation, the data revealed that perseverance and problem-solving was the fourth intentional instructional focus of Math Lab instructors. One Math Lab instructor summarized the lack of perseverance as “they don’t like to think through [the problems]. They just want the right answer”. The other instructor commented that
they’re not used to struggling through math. They’re used to “I don’t get it – OK, move on”. So getting them to say “OK, I don’t get this. What can I do to figure it out”? is something that is a challenge but after a while they start getting it.

According to the Math Lab instructors, becoming more adept at persevering leads to improved problem-solving, which is a skill that helps struggling students in multiple content areas. In math, problem-solving is often taught through word problems.

[My students] don’t like… any problem solving that I give them. So, sometimes that just makes me do more because I think that is an area that they struggle with, and it’s not math concepts. A lot of times, it’s them really decoding what they are being asked to do.

One parent commented that her child benefited from “learning ways to problem solve”.

In addition, one student illustrated his teacher’s promotion of perseverance by stating “[my teacher] was always there to help us. [My teacher] never let us give up”.

During classroom observations, the researcher overheard several conversations in which the teacher could have provided immediate direction and clarification to a student but, instead, used questioning strategies or prompting to promote critical thinking and perseverance on the student’s part. For example, a student struggling with a problem initiated the following exchange between himself and the teacher.

“Would it be positive zero or negative zero”?

The teacher responded, “You tell me. Can zero be positive or negative”?

The student replied with another question to which the teacher answered, “what do you think? Talk to me about that”.

The student explained his answer and the teacher replied, “you’re good”.

*Instructional structures.* In addition to common instructional emphasis, there were also commonalities in the structures used to deliver instruction. For the purposes of this study, instructional structures is defined as the grouping structures used to facilitate the delivery of the focus of instruction. Table 3 shows the frequency with which each component was referenced through student and parent surveys and in principal and teacher interviews.

**Table 3**

*Instructional Structures: Frequency of Responses*

<table>
<thead>
<tr>
<th>Instructional Structures</th>
<th>Student</th>
<th>Parent</th>
<th>Teacher</th>
<th>Principal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 to 1 assistance</td>
<td>6</td>
<td>2</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Small group</td>
<td>5</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Computer-assisted</td>
<td>11</td>
<td>0</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Peer-assisted</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

In addition to data collected through surveys and interviews, data were also obtained via observations. The researcher observed each Math Lab intervention three times for a total of nine hours of observations. During each observation, data regarding instructional structure were collected at five minute intervals. At the conclusion of each observation, the total percentage of time spent on each instructional structure was calculated. Table 4 shows the percentage of time in which various instructional structures were utilized during classroom observations.
Table 4

<table>
<thead>
<tr>
<th>Instructional Structures</th>
<th>Obs. #1</th>
<th>Obs. #2</th>
<th>Obs. #3</th>
<th>Obs. #4</th>
<th>Obs. #5</th>
<th>Obs. #6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 to 1 assistance</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Small group</td>
<td>27%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Computer-assisted</td>
<td>25%</td>
<td>4%</td>
<td>0%</td>
<td>0%</td>
<td>22%</td>
<td>0%</td>
</tr>
<tr>
<td>Peer-assisted</td>
<td>2%</td>
<td>39%</td>
<td>66%</td>
<td>0%</td>
<td>20%</td>
<td>19%</td>
</tr>
<tr>
<td>Whole group</td>
<td>5%</td>
<td>6%</td>
<td>0%</td>
<td>34%</td>
<td>17%</td>
<td>6%</td>
</tr>
<tr>
<td>Independent work</td>
<td>24%</td>
<td>37%</td>
<td>22%</td>
<td>61%</td>
<td>36%</td>
<td>64%</td>
</tr>
<tr>
<td>Not Engaged in Instruction</td>
<td>17%</td>
<td>14%</td>
<td>22%</td>
<td>5%</td>
<td>5%</td>
<td>11%</td>
</tr>
</tbody>
</table>

For the purposes of this study, the definitions of the observed instructional structures are as follows:

- One-to-one assistance – instructional interaction between the instructor and one student
- Small group instruction – instructional interaction between the instructor and a group of three to five students
- Computer-assisted instruction – instruction facilitated by an on-line or software program
- Peer-assisted instruction – instructional interaction between two or more students
- Whole group instruction – instructional interaction between the instructor and the entire class
• Independent work – student working on their own to complete assignment or task

• Not engaged in instruction – students may have been finished with work, disengaged from the task, or engaged in work for another course

Although not mentioned at all as an instructional structure by the teachers, students and parents mentioned one-to-one assistance several times in survey response to the question “what, if anything, was most helpful about Math Lab”? One student commented that “I find it helpful sitting down with my teacher and having her just help me”. Another stated that “it has helped a lot because… I get to sit down with my teacher one-on-one and ask questions”. One parent shared that “there was always time for one on one work with the teacher if needed”.

The principal mentioned observing one-to-one assistance while visiting the Math Lab classroom. The researcher also observed one-to-one assistance and recorded the frequency with which the Math Lab instructors provided individual students with support while engaged in peer-assisted learning, computer-assisted learning or independent work in Table 5. One-to-one assistance was not observed during whole group instruction or small group instruction.

Table 5

<table>
<thead>
<tr>
<th>Instructional Structures</th>
<th>Obs. #1</th>
<th>Obs. #2</th>
<th>Obs. #3</th>
<th>Obs. #4</th>
<th>Obs. #5</th>
<th>Obs. #6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher assistance</td>
<td>3</td>
<td>6</td>
<td>24</td>
<td>23</td>
<td>16</td>
<td>9</td>
</tr>
<tr>
<td>Peer assistance</td>
<td>2</td>
<td>3</td>
<td>15</td>
<td>5</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>
In addition to one-to-one assistance provided by the teacher, students also received one to-one support from peers as noted in Table 5. Furthermore, student comments revealed that the teachers had set expectations regarding how peer support should be provided. Specifically, students were to provide hints, prompts or suggestions to help the struggling student figure out how to work the problem herself. The peer providing support was supposed to provide a strategy not an answer as corroborated by one student who commented to a peer asking for assistance, “I wasn’t going to tell you the answer. I wanted you to figure it out”. After asking a peer for help with a particular problem, another student teasingly stated, “she’s showing me how to work it not teaching me how to do it!” During a different observation, a student who was frustrated with her partner stated, “he is the worst partner ever! I asked him how to do it and he said ‘like this’” and motioned that her partner simply handed her his completed assignment.

According to the instructors, small group instruction was an essential component of the Math Lab structure. Once student needs were ascertained through a short, formative assessment, students would often be grouped to rotate through stations for the remainder of the class period. One Math Lab instructor shared that in approximately 75% of class periods, small group instruction was utilized to some extent. That was not confirmed by observation data, but, as previously stated, the majority of observations occurred during the weeks prior to state assessment administration and the focus of instruction was mainly on review which was conducted whole group followed by independent work or conducted via peer-assisted instruction.

According to one Math Lab instructor, students were given a formative assessment at the beginning of the class period. Then,
depending on how they do on that, I group them either by ability level or I inter-mix their abilities. It just depends on what we’re doing that day. I try to have three different activities planned that highlights their strengths and also addresses their weaknesses. Typically, I take the lower group first [for small group instruction] so they can have some background before they actually start moving [through the rotation].

Instructors and the principal disclosed that a typical approach to small group instruction would be for students to work problems on dry-erase, white boards while interacting with the instructor which allowed for immediate feedback and corrective action by the students. This structure was observed by the researcher during classroom visits as well.

Computer-assisted instruction was also a consistently used instructional structure. As stated previously, the primary purpose of using the on-line and software programs was to address the varied foundational skill deficits of the Math Lab students. Computer-assisted instruction also allowed the teachers to utilize small grouping structures to provide more targeted instruction for additional practice or re-teaching of Algebra I concepts from the regular Algebra curriculum.

In response to the prompt “Describe a typical day in Math Lab. What kind of activities did you engage in”?, eleven students mentioned working on the computers as a typical Math Lab experience. In response to this question, one student commented, “we often go on computers and did the online quizzes and lessons”. This response is indicative of the other comments provided regarding computer-assisted instruction. In
general, students did not seem to understand that they were using the computer programs to fill gaps in their foundational math skills.

In addition, no student mentioned computer-assisted instruction of any type as the most helpful aspect of Math Lab. Five students, however, identified the computer-assisted instruction as the least helpful aspect of Math Lab. One student shared, “what I found least helpful were the computer lessons because most of the time it wasn’t even about what we were learning. It was just a review on all types of math and it got boring”.

Grouping of students in partners was mentioned in surveys and interviews by students, teachers and the building administrator. In addition, it was observed in practice during five of six observations. During one observation, peer-assisted instruction was the prevailing instructional structure used. It is important to note that the expectation for peer-assisted instruction went beyond merely working side-by-side as partners. The expectation was that the student partners would help each other learn.

When selecting partners for peer-assisted instruction, teachers were purposeful in their choices. One instructor commented that

I choose who their partners are going to be and it’s not always the best kid with the one that struggles the most. Sometimes it’s the top two kids and then the next two kids. Sometimes, I put my stronger students with some of my students that are having more difficulty and try to let [the stronger student] kind of coach [the struggling student] along the way a little bit.

The other Math Lab instructor remarked that “a lot of the activities we do are with a partner. Their seating chart is made with a purpose so that their table partners are
people that they can do activities with”. This instructor uses a specific peer-assisted learning activity to practice perseverance as well as math skills.

Some of the activities that we do, one of them has to be the voice and one of them has to be the pencil and then they switch. So, it doesn’t matter who the stronger person is. They sometimes have to keep their mouths shut and let that other person struggle through it too.

Students also mentioned the use of peer-assisted instruction though the survey. One student remarked that “we usually get put into groups to use each other to learn”. At least one student found the peer-assisted grouping structures empowering. In response to the question “what, if anything, did you find most helpful about Math Lab”?, this student commented that “it made it so that I could help those students who didn’t understand what we were doing”.

Whole group instruction was not specifically mentioned in the surveys or interviews but was observed by the researcher during classroom visits. On most visits, whole group instruction consisted of explaining the tasks for the day after which other grouping structures were used for the remainder of the class. On one occasion, whole group instruction was used to review the quadratic formula. Students watched a YouTube video that they had seen previously during which they recorded facts that they knew about the formula. After the video, the instructor led students through a review of the formula.

Although only mentioned by one student in the survey, independent work was commonly observed during classroom visits. In all but one observation, the lesson began with independent work, most commonly in the form of an assessment to determine
grouping structures and to determine what skills needed more practice or re-teaching.

Independent work was also common as a culminating activity before the bell rang or before moving on to another concept within the same class period. Journaling and working on math problems were customary activities for independent work.

During independent work, students were supported by the instructor as well as by peers if they were having difficulty with the task. Instructors circulated constantly to provide formative feedback. In addition, students asked neighboring students for help. The instructors encouraged such peer interaction with comments like “don’t take her word for it. Work it out together”.

As shown in Table 4, there were times during the observations that students were not engaged in the math task assigned. This occurred when students completed the task and were waiting on their peers to finish before moving on to another task or topic. During these times, students were generally not idle nor disruptive. Instead, they engaged in such tasks as organizing their work, checking their grades through the on-line student information system, seeking help from other teachers, studying for an upcoming test or completing homework for another class.

Delivery of instruction. As noted by one of the Math Lab instructors, the Math Lab intervention is a “cannot look like a math class or smell like a math class but must still actually be one”. By this, the instructor meant that the extended learning time of Math Lab would be wasted if the same instructional strategies seen in a typical math class were utilized. Instead, a variety of instructional strategies were used to help students master the concepts behind the skills.
As mentioned in the preceding section when describing independent work, formative assessments were used by both instructors to determine the instructional focus of each Math Lab class. According to the Math Lab instructors, reliance on formative assessments to drive instruction was vital in order to move students through the zone of proximal development to grade level mastery. As described by one Math Lab instructor, you never know what the issues are going to be that day. They may have seemed like they got it yesterday in Algebra and I may not have a big re-teaching session planned, and then they walk in and I do one or two quick things I was going to do and [yesterday’s learning is] gone.

Often, the formative assessments reveal that there are a variety of needs that must be addressed during one lesson. One Math Lab instructor explained his process for determining how to group students for mini-lessons like this:

I probably ask them two or three or four questions and have them try to solve them, and then I analyze their mistakes. What steps are they actually doing incorrectly? Do they understand it? Is there a clear disconnect? I use a combination of these little informal assessments just to say “OK, I’m going to categorize you and try to address that today”. Usually it works out pretty well that there’s two or three people that are making the same mistake so I can group them together to address [the mistake].

Students also commented on the use and purpose of formative assessments. One student shared that his teacher “writes down questions for us to answer and then our teacher puts us into groups [based] on how well we know the material”. Another student
commented that “we usually start off with five problems we’re doing at the time in Algebra. Then we get in groups based on how well we do on the questions”.

In addition to formative assessments, one Math Lab instructor relied on journal entries to help assess student needs. In the instructor’s words, “the journals that I have are invaluable for me to plan what I need to”.

The importance of being flexible with instruction in order to move students from their current ability level through the zone of proximal development to mastery was described by one instructor in this manner:

You can’t have a canned curriculum. You can’t have lesson plans. All that stuff gets thrown out the window. You pretty much have to go day-by-day of what the students remember, and, with that flexibility, I’m able to not only pre-teach but I can also re-teach in different groups. That has to be a critical aspect of anybody that would even think about using this intervention.

Once the focus of instruction was determined through the use of formative assessments, the delivery model of that instruction was determined. Students, parents, teachers and the building administrator commented on the variety of strategies used in the Math Lab intervention. In addition, several strategies were observed by the researcher during classroom visits.

During most class periods, students were engaged in a variety of instructional strategies by moving through stations. One station was to work on the computers on Math XL for School. The other two stations generally involved working in small groups with the teacher and working with peers or independently on practice problems.
In small group work, students, teachers and the principal commented on using dry-erase, white boards. This strategy was also observed by the researcher during a classroom visit. Students were given a problem to work on the white board. Using the white boards made detecting mistakes easier for the instructor and also made correcting the mistake easier for the students. In addition, “if it’s something that lends itself to… [a strategy] that’s hands-on, then I can utilize something that is hands-on in the lesson. The hands-on approach was a lot more beneficial for them so they were able to get it”.

Students noted that many times these “mini-lessons” were pre-teaching activities to prepare them for upcoming content.

Peer-assisted or student work generally consisted of working specific problems. The problems may have been the same for each student or differentiated based upon individual need. During one observation, the instructor used the formative assessment given at the beginning of class to assign problems to each student that matched the level of rigor each student could handle independently. The more difficult problems were then worked in a small group setting or with support from a peer or the instructor.

Math games were mentioned by instructors, students, and parents. In addition, math games were observed by the researcher. Math games were played independently and with partners. In at least one Math Lab class, students could earn prizes or “math money” to purchase prizes for correct answers in the game. In response to the question “what, if anything, did your son/daughter find most helpful about the activities done in Math Lab”?, one parent remarked that the “math games and math money helped make learning fun”. One student responded that
before test days we play games. We have played Whammy, which is you’re in a
group with two others and the teacher gives you a problem. If you get it right,
you get to roll the dice and you win prizes. We have played Bingo with questions
that are like questions that are on the test, and you can earn candy.

The researcher observed a game of Whammy during a classroom visit. Students worked
interdependently with partners to solve the problems assigned. The game was structured
so that all students had a chance to win prizes so no one got discouraged if another team
was consistently faster or more accurate. If the team did not get the answer right the first
time, they could re-work the problem and still earn a prize.

The means of delivering instruction was also informed by learning-style
assessments given at the beginning of the year. Math Lab teachers administered several
learning-style inventories in order to ascertain preferred learning modalities such as
visual, auditory or tactile/kinesthetic. This information was referred to throughout the
year to tailor learning activities to students’ preferences.

Safe learning environment. From the inception of the Math Lab intervention, the
instructors instinctively knew that building a sense of community in the classroom would
be essential to encourage these students with a history of failure in mathematics to be
risk-takers in Math Lab. The codes “community”, “relationships”, “safe environment”,
and “go-to teacher”, which have been synthesized to establishing a “safe learning
environment”, were the most common codes from the teacher interviews. According to
one Math Lab instructor, there would be no hope for a successful intervention without
establishing a trusting, safe learning environment.
I feel like these are the kids that typically fall through the cracks. They’re good kids. They’re not trouble-makers. They want to do well. They just need that extra intervention, that extra support in order to achieve something. So, these are the kids that would sit there and not say anything and not ask for help. They don’t have that relationship because they’re not the ones that are going to talk to their teacher.

To ensure that the Math Lab students felt a connection to their teacher and ultimately to the other students in the intervention, the instructors devoted two weeks at the beginning of the school year to teambuilding activities. According to Spencer Kagan, “teambuilding creates enthusiasm, trust and mutual support which, in the long run, lead to more efficient academic work” (1994, p. 8:1). Regarding the time devoted to teambuilding, one Math Lab teacher echoed Kagan’s assertion, “that’s what I do the first few weeks is establish that relationship and it takes forever and it seems like I’m doing nothing, but it does pay off come this time of year”.

Some of the teambuilding activities were formal, such as those recommended by Kagan (1994). Other teambuilding activities were more informal and tailored specifically to the students in the Math Lab intervention. For example, one Math Lab instructor described using TodaysMeet.com to set up an anonymous discussion board for students. The instructor asked them to respond to their grade level’s reputation as shared by the class from the year before. The previous year’s Math Lab described them as “pretty rough”. The instructor read the unflattering comments from the previous year’s class word for word and asked the students to share what they thought and felt about the comments. The instructor used this exercise to teach the students how to have a
respectful conversation. “[They] need to be able to disagree with each other appropriately”. The instructor commented that “just asking them questions and having them respond honestly with anonymous names allows them to talk freely to each other without having to worry about people judging them”. The instructor maintained that providing structured opportunities to have controversial conversations allowed students to experience communicating openly and honestly without judgment from peers.

According to the teacher, there is an academic benefit to being able to communicate in this manner. “Establishing that in the first two weeks is huge and helps me. They don’t like being wrong and they’re wrong a lot. If they’re comfortable being wrong around each other it makes it a lot smoother…in class”. The students need to be willing to “open up and answer questions without being fearful of making a mistake”.

The other Math Lab instructor concurred with that sentiment. According to this teacher, at the beginning of the year, we do… a lot of teambuilding and group building” so that student understand that it’s OK to make mistakes. It’s OK to be wrong. It’s OK to try something. It’s OK to share your thoughts because even if your thoughts are completely wrong, it might spark something in someone else or even in [yourself] that leads you in the right direction.

As students worked through the teambuilding exercises, they built relationships with their teacher and with each other. Both Math Lab instructors noticed the bonds that developed between the Math Lab students. One instructor shared being “shocked” that, despite the fact that many of the students had attended school together since kindergarten, a majority of the students in Math Lab did not even know each other. The instructor
commented that “by the end of the year, some of the things that they had written were ‘I’m friends with people that I never thought I’d be friends with’. Even that aspect alone is a… success to me.”

The other instructor remarked that “they are [working] with everybody at some point and they just have to be OK. I notice in Algebra class that is who they tend toward. That’s who they feel comfortable with, those others who are in Math Lab”. Both instructors maintained that the sense of community and the sense of collaboration between Math Lab students enabled them to delve deeper into learning the math concepts and skills. When asked what impact their relationships with each other have on their academic success, one instructor responded that “they’re more likely to have collaborative conversations which leads to the actual deeper learning”.

During observations, the researcher witnessed an interchange between two students that exemplified the depth of the student-student relationship and showed a sincere mutual responsibility for success. Two students were working through a problem together. One student was trying to explain his reasoning to the other who was struggling to understand the explanation. The student leading the conversation called the teacher over for further guidance. Once the teacher intervened, the student who was having trouble with his classmate’s explanation turned to his classmate and said, “Oh, I see. I’m sorry, man. You were right”. The classmate responded, “I just wanted it explained better than I did. I want you to ace that test”.

In addition to the student-student relationships, one Math Lab instructor emphasized the critical nature of the teacher-student relationship. According to the teacher,
building that relationship so that I’m comfortable with them and I know what classes they’re in and working on whatever issues that they have in those classes shows…that there’s an adult who cares about them. There’s a teacher that cares about them and wants them to be successful”.

This instructor maintained that building positive teacher-student relationships was an absolute necessity for success in Math Lab. “Without the basis of that relationship, none of it is possible. Students that I struggle building relationships with typically… don’t get a whole lot out of Math Lab”.

The same teacher shared that students need a “go-to teacher that they can talk about everything with”. A teacher who monitors their grades, provides encouragement and helps in all subject areas. This component of the teacher-student relationship was observed by the researcher during classroom visits. On more than one occasion, the instructor referenced students’ grades in other classes and enquired as to missing assignments or upcoming tests.

In addition, student journal entries showed communication between teacher and student regarding current grades and academic goals in all content areas. In one such entry, the students were required to list their current grades for each class and record the number of missing assignments in each class. One student commented “I’m so proud of my grades! 😊” to which the teacher wrote in reply “you should be – I’m happy for you!”. Another student listed, to “study more” as a strategy for improving his grades. The teacher responded with a prompt, “how do you plan to study – note cards, review guides, etc?” In the same student’s journal was a note from the teacher asking what had
happened with a particular assignment that made my Music Appreciation grade drop considerably.

Through purposeful development of trust, mutual responsibility, and respect between students and teacher, the Math Lab teachers strove to create an environment in which students feel comfortable enough with each other to take academic risks.

*Selection of students.* The interviews with teachers and with the building principal revealed the aspiration to identify and invite the “right kid” into the Math Lab intervention. Some of the characteristics that teachers and administrators identified were students that “genuinely want to succeed”, students that do not have chronic “absence issues”, students who “missed some things along the way” and “have gaps in their learning”, students that “are going to give it their best shot” and students that are “just on the edge of being successful and not being successful”. Identifying students with good attendance and students with foundational math skill deficits is an easy task. Identifying the “bubble kids” who are right on the line of being successful on state assessments is also relatively straightforward. Identifying the student who will “give it their best shot” is considerably more difficult.

For the two years of the intervention, student selection has been determined by past performance in mathematics based upon course grades and state assessment results. In addition, eighth grade teachers have provided insight into the motivation for success of the Math Lab candidates. Teacher comments indicated that the proper metric has yet to be developed. According to one Math Lab instructor, “it’s still a work in progress how we’re selecting students”. This teacher explained that a student who needs too much one-on-one assistance is not a good Math Lab candidate as the Math Lab students must be
able to work independently and with peers for the intervention to be successful. “So, students like that aren’t going to benefit but they’re still put in Math Lab and I think part of the issue is, we don’t want to give up on a student”.

Conclusion. The actual implementation of the Math Lab intervention revealed that there are more facets that must be addressed to maximize the effectiveness of the intervention than was addressed by the original plan. For example, the site visits and research did not provide direction on the critical nature of relationship building between students and teacher. Nor did the site visits and research reveal the importance of basing the focus of instruction and the delivery of instruction on a formative assessment given that day. Finally, colleagues and scholars did not provide criteria for selecting the best candidate for this intervention. These critical lessons have been learned through trial and error during the two years of the Math Lab intervention implementation.

Effect of Math Lab Intervention on Academic Achievement

Central Research Question 2: What were the local and state achievement scores in mathematics for students who participated in the Math Lab intervention and how did the math achievement scores of participants compare to the math achievement scores of non-participants of similar demographics and ability?

One of the main catalysts for the development of the Math Lab implementation was to increase student achievement in mathematics to better prepare students for subsequent high school courses, post-secondary opportunities and the global workplace. The second central research question was designed to provide insight into the impact of Math Lab participation on achievement in mathematics.
From this central research question, a null hypothesis that the achievement of the two groups would not differ was developed. To test this hypothesis, comparison groups, comprised of students with similar academic histories and demographics who did not participate in the intervention, were established and Algebra I grades, overall grade point averages, and state assessment scores were compared using measures of central tendency and independent t-tests. In addition, measures of central tendency and dependent t-tests were used to compare the growth in achievement from grade eight to grade nine as measured by state mathematics assessments of the treatment groups and the comparison groups. The size of the population in this study is too small to generalize any findings to the larger population nor was the sampling strategy designed to make inferences. These statistics were calculated simply to provide a more complete description of the Math Lab intervention.

**Impact on Algebra I grades.** Through the survey, seven students and one parent conveyed that participating in Math Lab had resulted in improved grades in math. To investigate this claim further, the Algebra I grades for the treatment groups and comparison groups are compared in Table 6 and Table 7. For the purposes of quantifying the data, letter grades were converted to the corresponding grade point for each semester grade. The average of the semester grade points was used in this statistical analysis.
Table 6

*Comparison between Treatment Groups and Comparison Groups Algebra I Grades*

<table>
<thead>
<tr>
<th></th>
<th>2011-2012 Algebra I Students</th>
<th>2012-2013 Algebra I Students</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Treatment</td>
<td>Comparison</td>
</tr>
<tr>
<td><strong>n</strong></td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td>2.665</td>
<td>2.143</td>
</tr>
<tr>
<td><strong>Median</strong></td>
<td>2.675</td>
<td>2.15</td>
</tr>
<tr>
<td><strong>Mode</strong></td>
<td>2.85</td>
<td>2.15</td>
</tr>
<tr>
<td><strong>Range</strong></td>
<td>2.0</td>
<td>3.50</td>
</tr>
<tr>
<td><strong>Minimum</strong></td>
<td>1.85</td>
<td>.35</td>
</tr>
<tr>
<td><strong>Maximum</strong></td>
<td>3.85</td>
<td>3.85</td>
</tr>
<tr>
<td><strong>Sum</strong></td>
<td>53.3</td>
<td>42.85</td>
</tr>
</tbody>
</table>

Since the treatment groups and comparison groups were independent but matched populations, independent t-tests with two-tailed distribution and two-sample equal variance were calculated and the resulting probability is recorded in Table 7 (Minium et al., 1999). Microsoft Excel was used to calculate the *p*-values. An alpha value of 0.05 was used for all statistical tests (Minium et al., 1999).
Table 7

Comparison of Means of Algebra I Grades

<table>
<thead>
<tr>
<th>Groups</th>
<th>Mean</th>
<th>SD</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011-2012 Algebra I Students</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>2.665</td>
<td>0.532</td>
<td>0.0463</td>
</tr>
<tr>
<td>Comparison</td>
<td>2.142</td>
<td>0.969</td>
<td></td>
</tr>
<tr>
<td>2012-2013 Algebra I Students</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>2.509</td>
<td>0.943</td>
<td>0.0179</td>
</tr>
<tr>
<td>Comparison</td>
<td>1.75</td>
<td>1.054</td>
<td></td>
</tr>
</tbody>
</table>

The p-values from the independent t-tests from both years of the intervention are less than 0.05 which indicates the difference in achievement in relation to Algebra I grades of the treatment groups is statistically significant than the achievement in relation to Algebra I grades of the comparison group.

Impact on overall academic achievement. While parents and students commented on the perceived influence on math performance, the Math Lab instructors and the building administrator mentioned three times and one time respectively that the skills learned in Math Lab would help the participants become better students overall. To explore this assertion, the grade point averages from the year in which the treatment group participated in Math Lab were compared with the grade point averages of the comparison group from the same year (Table 8).
Table 8

Comparison between Treatment Groups and Comparison Groups Grade Point Averages

<table>
<thead>
<tr>
<th></th>
<th>2011-2012 Algebra I Students</th>
<th>2012-2013 Algebra I Students</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Treatment</td>
<td>Comparison</td>
</tr>
<tr>
<td>n</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Mean</td>
<td>2.519</td>
<td>2.349</td>
</tr>
<tr>
<td>Median</td>
<td>2.48</td>
<td>2.46</td>
</tr>
<tr>
<td>Mode</td>
<td>2.67</td>
<td>2.77</td>
</tr>
<tr>
<td>Range</td>
<td>1.47</td>
<td>2.78</td>
</tr>
<tr>
<td>Minimum</td>
<td>1.93</td>
<td>.6</td>
</tr>
<tr>
<td>Maximum</td>
<td>3.4</td>
<td>3.38</td>
</tr>
<tr>
<td>Sum</td>
<td>50.38</td>
<td>46.98</td>
</tr>
</tbody>
</table>

Again, the treatment groups and comparison groups were independent but matched populations. Consequently, independent t-tests with two-tailed distribution and two-sample equal variance were calculated and the resulting probability is recorded in Table 9 (Minium et al., 1999).
Table 9

**Comparison of Means of Overall Grade Point Average**

<table>
<thead>
<tr>
<th>Groups</th>
<th>Mean</th>
<th>SD</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011-2012 Algebra I Students</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>2.519</td>
<td>0.344</td>
<td>0.339</td>
</tr>
<tr>
<td>Comparison</td>
<td>2.349</td>
<td>0.684</td>
<td></td>
</tr>
<tr>
<td>2012-2013 Algebra I Students</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>2.766</td>
<td>0.61</td>
<td>0.243</td>
</tr>
<tr>
<td>Comparison</td>
<td>2.54</td>
<td>0.623</td>
<td></td>
</tr>
</tbody>
</table>

The p-values from the independent t-tests from both years of the intervention are greater than 0.05 which indicates the difference in achievement as defined by overall grade point average is not statistically significant.

**Impact on Algebra I End-of-Course Exam Performance.** Annual performance on the MAP Algebra I End-of-Course exam is one data point used in the evaluation of the curricular and instructional programs in the district in which this study occurred. When asked to describe the critical elements of the planning and implementation of the Math Lab intervention, one Math Lab instructor commented that the intervention was designed to help “our ‘bubble kids’ that we’d want to move from Basic to Proficient” on the MAP mathematics assessment. In 2011-2012, 50% of the Math Lab students scored proficient or better on the Algebra I MAP End-of-Course assessment as compared to 32% of the comparison group. In 2012-2013, 43% of the Math Lab students scored proficient or better on the assessment while 30% of the comparison group performed at that level. To
ascertain whether participation in the Math Lab intervention influenced achievement on the MAP Algebra I End-of-Course assessment, the scale scores of the treatment groups and comparison groups are compared in Table 10.

Table 10

*Comparison between Treatment Groups and Comparison Groups Algebra I End-of-Course Scale Scores*

<table>
<thead>
<tr>
<th></th>
<th>2011-2012 Algebra I Students</th>
<th>2012-2013 Algebra I Students</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Treatment</td>
<td>Comparison</td>
</tr>
<tr>
<td>n</td>
<td>23</td>
<td>22</td>
</tr>
<tr>
<td>Mean</td>
<td>200.261</td>
<td>195.273</td>
</tr>
<tr>
<td>Median</td>
<td>198</td>
<td>195</td>
</tr>
<tr>
<td>Mode</td>
<td>198, 203</td>
<td>190, 195</td>
</tr>
<tr>
<td>Range</td>
<td>37</td>
<td>42</td>
</tr>
<tr>
<td>Minimum</td>
<td>182</td>
<td>173</td>
</tr>
<tr>
<td>Maximum</td>
<td>219</td>
<td>215</td>
</tr>
<tr>
<td>Sum</td>
<td>4606</td>
<td>4296</td>
</tr>
</tbody>
</table>

As in the previous statistical analyses, the treatment groups and comparison groups were independent but matched populations. As a result, independent t-tests with two-tailed distribution and two-sample equal variance were calculated and the resulting probability is recorded in Table 11 (Minium et al., 1999).
Table 11

Comparison of Means of Algebra I End-of-Course Scale Scores

<table>
<thead>
<tr>
<th>Groups</th>
<th>Mean</th>
<th>SD</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011-2012 Algebra I Students</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>200.261</td>
<td>10.135</td>
<td>0.142</td>
</tr>
<tr>
<td>Comparison</td>
<td>195.273</td>
<td>11.698</td>
<td></td>
</tr>
<tr>
<td>2012-2013 Algebra I Students</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>195.696</td>
<td>12.996</td>
<td>0.686</td>
</tr>
<tr>
<td>Comparison</td>
<td>186.286</td>
<td>10.742</td>
<td></td>
</tr>
</tbody>
</table>

The $p$-values from the independent t-tests from both years of the intervention are greater than 0.05 which indicates the difference in achievement as defined by Algebra I End-of-Course scale scores is not statistically significant.

**Impact on individual growth in mathematics.** The theoretical foundation of this study was Vygotsky’s zone of proximal development which promotes meeting students at their current academic level and scaffolding instruction and support to move students forward in their practice until they are performing on grade level. This was also the purpose behind the Math Lab intervention. To provide insight into the individual growth of the students in the treatment groups and comparison groups, the achievement levels from the eighth grade mathematics MAP assessment were compared to the achievement levels of the Algebra I MAP assessment. This was a very weak comparison at best as the scale scores of the two assessments differ considerably so the comparison was made by quantifying the achievement levels assigned to the scale score bands. For
the purposes of this comparison, the Below Basic achievement level was assigned a score of 1, Basic was assigned a score of 2, Proficient was assigned a score of 3 and Advanced was assigned a score of 4. The data for the 2011-2012 treatment group and comparison group are recorded in Tables 12 and 13.

Table 12

_Comparison of Grade 8 and Algebra I MAP Achievement Levels for 2011-2012 Algebra I Students_

<table>
<thead>
<tr>
<th></th>
<th>Treatment</th>
<th></th>
<th>Comparison</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grade 8 MAP</td>
<td>Algebra I MAP</td>
<td>Grade 8 MAP</td>
<td>Algebra I MAP</td>
</tr>
<tr>
<td>n</td>
<td>21</td>
<td>21</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>Mean</td>
<td>2</td>
<td>2.714</td>
<td>2</td>
<td>2.429</td>
</tr>
<tr>
<td>Median</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Mode</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Range</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Minimum</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Maximum</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Sum</td>
<td>42</td>
<td>57</td>
<td>42</td>
<td>51</td>
</tr>
</tbody>
</table>

This statistical analysis was a within group comparison. As a result, paired, dependent t-tests with two-tailed distribution were calculated and the resulting probability is recorded in Table 13 (Minium et al., 1999).
Table 13

Comparison of Means of Grade 8 and Algebra I MAP Assessment Achievement Levels for 2011-2012 Algebra I Students

<table>
<thead>
<tr>
<th>Groups</th>
<th>Mean</th>
<th>SD</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011-2012 Treatment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade 8 MAP</td>
<td>2</td>
<td>0.309</td>
<td>0.0002</td>
</tr>
<tr>
<td>Algebra I MAP</td>
<td>2.714</td>
<td>0.565</td>
<td></td>
</tr>
<tr>
<td>2011-2012 Comparison</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade 8 MAP</td>
<td>2</td>
<td>0</td>
<td>0.005</td>
</tr>
<tr>
<td>Algebra I MAP</td>
<td>2.429</td>
<td>0.705</td>
<td></td>
</tr>
</tbody>
</table>

Table 13

The p-values from the dependent t-tests for both the treatment group and the comparison group in 2011-2012 are less than 0.05 which indicates the growth in achievement as measured by the grade eight mathematics MAP assessment and the Algebra I MAP assessment is statistically significant.

The corresponding data comparing the achievement levels on the grade eight mathematics assessment and the Algebra I MAP assessment for the 2012-2013 treatment group and comparison group are recorded in Tables 14 and 15.
Table 14

Comparison of Grade 8 and Algebra I MAP Assessment Achievement Levels for 2012-2013 Algebra I Students

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Comparison</th>
<th>2012-2013</th>
<th>2013-2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 8 MAP</td>
<td>Algebra I MAP</td>
<td>Grade 8 MAP</td>
<td>Algebra I MAP</td>
</tr>
<tr>
<td>n</td>
<td>23</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>Mean</td>
<td>2.130</td>
<td>2.391</td>
<td>2.130</td>
</tr>
<tr>
<td>Median</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Mode</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Range</td>
<td>2</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Minimum</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Maximum</td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Sum</td>
<td>49</td>
<td>55</td>
<td>49</td>
</tr>
</tbody>
</table>

This statistical analysis was also a within group comparison. Consequently, paired, dependent t-tests with two-tailed distribution were calculated and the resulting probability is recorded in Table 15 (Minium et al., 1999).
Table 15

Comparison of Means of Grade 8 and Algebra I MAP Assessment Achievement Levels for 2012-2013 Algebra I Students

<table>
<thead>
<tr>
<th>Groups</th>
<th>Mean</th>
<th>SD</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011-2012 Treatment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade 8 MAP</td>
<td>2.130</td>
<td>0.536</td>
<td>0.030</td>
</tr>
<tr>
<td>Algebra I MAP</td>
<td>2.391</td>
<td>0.706</td>
<td></td>
</tr>
<tr>
<td>2011-2012 Comparison</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade 8 MAP</td>
<td>2.130</td>
<td>0.448</td>
<td>0.377</td>
</tr>
<tr>
<td>Algebra I MAP</td>
<td>2.261</td>
<td>1.529</td>
<td></td>
</tr>
</tbody>
</table>

The *p*-value from the dependent t-tests for the 2012-2013 treatment group is less than 0.05 which indicates the growth in achievement as measured by the grade eight mathematics MAP assessment and the Algebra I MAP assessment is statistically significant. However, the *p*-value for the 2012-2013 comparison group is greater than 0.05 which suggests that the growth in achievement for this group is not statistically significant.

In the student and parent surveys, study participants were asked to describe the students’ impressions of math before participating in the Math Lab intervention and to describe the students’ impressions of math after participating in the Math Lab intervention. The responses to these questions along with comments from Math Lab teachers and the building administrator provide insight into the effect of participating in Math Lab on student affect.
Effect of Math Lab Intervention on Student Affect

Central Research Question 3: How do key stakeholders perceive the Math Lab intervention and the potential impact of Math Lab on student success?

Sub-question 1: How do students experience Math Lab?

Sub-question 2: How do parents perceive Math Lab?

Sub-question 3: How do teacher perceive Math Lab?

Sub-question 4: How do administrators perceive Math Lab?

W. James Popham defined student affect as “the attitudes, interests, and values that students exhibit and acquire in school” (2009, p. 85). The instructors of the Math Lab intervention intended to impact all three components of affect as described by Popham, but, in particular, they strove to influence each student’s attitude about mathematics. The influence of student affect after participating in the Math Lab intervention is described in this section using the words of students, parents, instructors and the building administrator.

Findings for research question 3 sub-question 1. When the student survey respondents described their impressions of math prior to Math Lab participation, eleven of the fourteen participants described a negative impression of math. One student shared that she “tried really hard” but “didn’t like it at all”. Other responses included “I greatly despised math”, “I didn’t like it at all and thought it was very difficult to understand”, “it was pretty hard”, and “I hated it”. Two students expressed confidence in their math abilities by stating “I liked math - it was my best subject” and “I thought I was pretty good but I knew I wasn’t an expert “. 
After Math Lab participation, the student for whom math was “really hard” who “didn’t like it at all” responded that she “understands things more clearly”. The student who “greatly despised math” shared that “math is so much easier now” and “I actually like math now”. These comments are indicative of the rest of the student responses. Out of fourteen respondents, twelve had positive attitudes toward math after participating in the Math Lab intervention. One student who responded negatively after the Math Lab intervention admitted that it helped but that “I still don’t really care about math”. The other student with negative impressions stated that “I find math really easy at times but other times I don’t understand”.

Students expressed being better prepared for math and having a better understanding of math. In addition, student expressed an increase in confidence and a sense of ownership of their own learning. One student commented,

I just like this class a lot. People say it’s a “special” class, but we’re the ones getting better grades in math. So, this is a good class, my math skills have developed so much more here. I love it! It’s a shame we won’t have it next year, but I can take what I learned here and put it to next year’s work!

Another student remarked that he would also transfer the knowledge and skills learned in Math Lab to Geometry the following school year. Finally, another student shared that “Math Lab has given me the confidence boost I needed to learn and excel in math”.

**Findings for research question 3 sub-question 2.** Parent survey responses confirmed the positive influence on student affect shared by the students. Four of seven parents responded that their child had negative impressions of math prior to participating in Math Lab. Of the three that maintained their child liked math, two also stated that
their child “thought it was difficult” and that they “struggled with it and became frustrated”. In response to how student impressions changed after participating in the Math Lab intervention, all seven parents noted a positive change in affect. One parent commented that “my son’s self-confidence has improved a great deal when it comes to math”. Another parent shared that her child has “the self-confidence to work harder at math, knowing he can be successful. Study strategies, test prep and overall grades have improved too”. Overall, seven parents expressed that their child’s confidence had improved, three commented that their child liked math, four remarked that their child had a better understanding of math, and four predicted continued success in math and other subjects.

**Findings for central research question 3 sub-questions 3 and 4.** Due to the similar remarks provided by Math Lab instructors and the building administrator, their responses to sub-questions 3 and 4 will be addressed simultaneously in this section. Teachers and principals noted that the Math Lab experience helps students feel success and develop self-confidence. One teacher commented that “it’s more of a confidence issue than anything. These are students that have not felt confident in mathematics for a long time”. Instructional emphases such as pre-teaching and re-teaching contributed to the feeling of success and subsequent growth in confidence.

In addition, both instructors and the building administrator observed that participating in the Math Lab intervention encouraged and taught students to take ownership of their own learning. This proactive approach to learning was evidenced in self-advocacy and transfer of knowledge and skills. One instructor commented that
one of the things we struggle with is going from “the teacher needs to do this” to “what can I do in order to be successful in this class”? That honestly takes a good six to eight months but we’re now to the point where their questions aren’t “why does the teacher do it like this?” but instead it’s “OK, what can I do to adjust”?

Transfer of knowledge to other content areas included learning specific study skills and problem solving skills that are not specific to math. According to the Math Lab instructors, Math Lab students tend to struggle in multiple courses, especially math, communication arts, science, social studies and foreign language. Both instructors expressed hope that the skills developed in Math Lab would transfer to other subject areas. As noted by one instructor,

it seems to me like it’s less of a success in mathematics as a success in overall study skills. Things like learning organizational skills, learning different methods of studying, learning just how to be responsible for your own actions and not putting everything on the teacher rather than on yourself. I think those are the skills that have helped them be successful.

Similarly, the principal remarked, “I think if one becomes a better math student, one can become a better student in general. It has huge implications”.

**Conclusion**

The preceding narrative and statistical accounts of the implementation of the Math Lab intervention and of the resultant effects on student affect and achievement revealed a complex program with many components that potentially contributed to the successful implementation of the program. In the next chapter, these components, as revealed through the comments of study participants and observation data, will be
synthesized into conclusions for adjustments to the program and possible replication of
the program.
Chapter 5: Conclusions

Introduction

The purpose of this case study was to discover and describe the components of the math intervention that resulted in increased mathematics achievement for the high school Math Lab intervention participants in an effort to inform local decisions regarding program improvements and to provide insight to other educators investigating mathematics interventions. The preceding narrative of the Math Lab story conveys an overall positive reaction by study participants to the Math Lab intervention. In this section, participant responses will be synthesized into themes to guide program improvements for the Math Lab intervention and to provide direction for other educators designing and implementing similar programs.

Discussion of Design and Implementation Findings

Archival documents and interview responses illustrated that the preliminary design of the intervention and the actual implementation differed in that the actual implementation included more critical elements than originally planned. The academic research upon which the intervention was based called for a “double-dose” of mathematics instruction in which regular curriculum was supplemented by more targeted pre-teaching and re-teaching (Ketterlin-Geller et al., 2008; Odden, 2009; Nomi & Allensworth, 2009; Piper et al., 2009). Observations at a neighboring school district with a similar mathematics intervention contributed three additional components to the implementation plan:
1. class sizes limited to 15 at the high school level,
2. emphasis placed on building positive student-student and student-teacher relationships, and
3. computers and hand-held devices used for foundational math skill instruction to allow the instructor to facilitate small group instruction.

Through interviews, surveys, journal entries, archival documents and observations, students, parents, instructors and the administrator encapsulated the components of the Math Lab intervention that were the most impactful based upon their individual experiences. Triangulation of the data from all sources, revealed that there were five critical components of the Math Lab intervention that contributed to the successful implementation of the intervention: extending and focusing the learning time, using varied instructional strategies, basing instruction on student need, building relationships and refining the selection of intervention participants.

**Extending and focusing the learning time.** As noted in the research on effective interventions, additional time with the content and skills being learned is key to improving student achievement in the targeted area (Aronson et al., 1999; Farbman & Kaplan, 2005; Ketterlin-Geller et al., 2008; Odden, 2009; Nomi & Allensworth, 2009; Piper et al., 2009). Students and parents commented that having more time in math instruction resulted in better understanding of concepts and skills through additional help and one-to-one assistance from the teacher. In addition, students, teachers and the building principal indicated that the additional instruction time allowed for a deeper understanding of the concepts than would have been gained without the “double-dose” intervention.
How the extended the learning time was used was another critical element mentioned by students, instructors and the building principal. Specifically, students were engaged in activities to pre-teach upcoming concepts and skills, re-teach previous concepts and skills, and repair foundational skill deficits. Students, teachers and the building administrator also noted that persevering through problem-solving was emphasized and practiced. As noted by Chapin et al. (2009) and McREL (2010), improved reasoning and problem-solving are important components to increased mathematical understanding.

**Using varied instructional strategies.** Extended time by itself is not an effective intervention, however. As stated by one of the Math Lab instructors, Math Lab “cannot look like a math class or smell like a math class but must still actually be one”. In other words, it is not appropriate nor effective to rely on the same strategies used in the regular math class. This assertion is supported by the literature which maintains that effective interventions maximize the benefits of extended learning time by actively engaging students in instructional activities (Aronson et al., 1999; Daggett, 2005; Farbman & Kaplan, 2005; Gersten et al., 2009).

In the Math Lab intervention, the use of varied instructional strategies included multiple grouping structures as well as methods of delivering instruction. Students, parents, teachers and the building administrator referenced whole group, small group, peer-assisted, and one-to-one assistance as essential components to the Math Lab intervention. These grouping structures were also evident in practice during classroom observations. Such grouping structures and collaborative learning experiences are also supported by the research of Burns (2007), Gersten & Clarke (2007a), Jensen and
Nickelsen (2010) and McREL (2010). In addition, a variety of instructional delivery modes were also referenced and observed including computer software programs and online games, review or practice learning games, instructional videos, and practice problems worked on paper as well as white boards.

**Basing instruction on student need.** The strategies referenced in the previous section must not be viewed as a “recipe” for an effective mathematics intervention. After all, these are strategies that one commonly sees in mathematics classrooms. The effectiveness of the Math Lab intervention was due to the purposeful use of these strategies based on day-to-day student need (Betts et al., 2011; Fuchs & Fuchs, 2001; Milgram & Wu, 2005; National Council of Teachers of Mathematics, 2007).

Through student survey responses, teacher interview comments and observation data, it was apparent that on-the-spot formative assessments dictated daily instruction. Teachers commented that preparing daily plans was often futile as student performance would require adjustments to any pre-determined plans. As previously noted, one of the Math Lab instructors was adamant that an intervention such as this must be based on immediate student need and that the curriculum must be flexible.

The impact of using formative assessments as the basis for daily instruction supports the conclusions of Gersten and Clarke (2007a) who reported an effect size of .51 for teacher use of formative assessment data. In addition, the premise behind the use of formative assessments corroborates the theoretical foundation on which this study is based. Moving a student through the zone of proximal development necessitates an accurate assessment of the student’s current ability level. Only then can the teacher as
more experienced other scaffold instruction to the point of internalizing the new knowledge at which learning occurs.

These three elements – extending and focusing the learning time, using varied instructional strategies and basing instruction on student need – addressed the academic foundation that contributed to the success of the Math Lab intervention.

**Building relationships.** Equally important to the success of the Math Lab intervention was the development of a sense of community within the classroom. Student and parent survey responses, instructor interviews, observation data and journal entries revealed that a high level of trust had been established between students and with the instructors. One instructor maintained that an individual student’s success in the Math Lab intervention could be predicted based upon whether the instructor successfully bonded with that student.

One advantage to developing trusting relationships within the Math Lab community was the establishment of a safe learning environment in which students were willing to take risks when engaging with the content. Without the comfort of such a learning environment, the students would not have ventured out of their comfort zones to truly engage. One Math Lab instructor attributed student success in Math Lab to them “feeling safe”. As noted by both Math Lab instructors, understanding that making mistakes is an essential part of learning and feeling comfortable to risk making a mistake in front of peers impacted student behavior in the regular Algebra I classroom as well as in the Math Lab intervention. Risk-taking in Math Lab led to becoming a more confident math student in general.
Although building a trusting community within the classroom to promote a safe learning environment is implied in the literature review in the section on effective mathematics instruction which emphasizes the incorporation of collaborative learning structures, peer-assisted learning and learning discussions (Chapin et al., 2009; Kenney et al., 2005; McREL, 2010; Stigler & Hiebert, 1999; Wickett, 2000; Willis, 2010), the effect of building student-student and student-teacher relationships was not explored in the review of the literature. Consequently, research on the connection between positive teacher-student/student-student relationships and student achievement has been added to this section.

Robert J. Marzano (2007) asserted that “if the relationship between the teacher and the students is good, then everything else that occurs in the classroom seems to be enhanced” (p. 150). Mary Ellen Beaty-O’Ferrall, Alan Green and Fred Hanna (2010) maintained that academic achievement frequently declines during the adolescent years due to teacher-student relationships. In addition, positive teacher-student relationships is key to effective classroom management which establishes a context for high academic achievement.

In their meta-analysis of 148 research studies investigating the relationship between interpersonal relationships among peers and academic achievement, Cary J. Roseth, David W. Johnson, and Roger T. Johnson (2008) concluded that cooperative learning opportunities, positive peer interactions and higher academic achievement were inter-related. In addition, “the more positive the relationships were among early adolescents, the higher they tended to achieve” (Roseth, Johnson & Johnson, 2008, p. 239). As noted by Marzano et al., “cooperative learning has an effect size of .78 when
compared with instructional strategies in which students work on tasks individually” (2001, p. 87). Effective cooperative learning which includes “positive interdependence, face-to-face promotive interaction, individual and group accountability, interpersonal and small group skills, and group processing” (Marzano et al., 2001, p. 85-86) is difficult to achieve without the a sense of community developed through purposeful team building (Kagan, 1994).

The development of these relationships and the subsequent emergence of a true learning community created an environment where it was safe to take risks. This is a vital component of the Math Lab intervention. Without this sense of community, students would have been less likely to move through the zone of proximal development with the scaffolded help provided by their instructors. This environment also allowed the role of “experienced other” to expand beyond the instructor to peers. Students benefitted from filling the role of novice learner and the role of experienced other frequently in the Math Lab intervention, which maximized the impact of the scaffolded instruction provided.

**Refining the selection of intervention participants.** Of all of the critical elements of the Math Lab implementation, the selection of students who will most benefit from this type of intervention is the least established. The instructors and the building administrator maintained that, while the profile of the student who will most benefit from Math Lab participation becomes clearer with each year of the intervention, the system for identifying Math Lab students needs to be refined. Specifically, a method for assessing motivation and pinpointing students whose math skills are developed enough to accelerate learning to gain more than a year’s growth must be developed to maximize and
justify the investment of human resources and financial resources into the Math Lab intervention.

At the same time that the Math Lab intervention was designed and implemented, the district in which this study occurred also made adjustments to the core mathematics curriculum. As noted previously, students with persistently low mathematics achievement are often hindered by curriculum and instruction that emphasize memorization of algorithms over conceptual understanding and critical thinking (Ball et al., 2001; Buchler, 2009; Stigler & Hiebert, 2004; Stigler & Hiebert, 1999). Professional development and curriculum development have focused exclusively on refining the curriculum to maximize conceptual knowledge and critical thinking as well as developing instructional practices that have been proven to be effective vehicles for conceptual knowledge and critical thinking. As a result, all students including the Math Lab participants have benefitted from more sound pedagogy (Ball et al., 2001; Buchler, 2009; McREL, 2010).

In addition, as the Math Lab intervention has been implemented over the past two years, students who have needed a more intensive intervention than Math Lab can offer have participated in the Math Lab intervention. Typically, these students are in need of more one-on-one assistance. As previously described, part of the intervention’s success can be attributed to the use of varied instructional structures including small group instruction and peer-assisted instruction. Some students who have unsuccessfully participated in Math Lab have not had the requisite knowledge and skills to be work effectively in these structures.
While not intentionally designed as such, the Math Lab intervention has evolved to mirror the conclusions of research conducted by Erica S. Lembke, David Hampton, and Sarah J. Beyers (2012) whose recent study identified the critical elements of Response to Intervention in Mathematics. In their study, Lembke et al. described the three tiers of mathematics instruction. The first tier consists of the general curriculum based upon locally adopted standards which must be implemented with fidelity. When students are unable to maintain grade level achievement, tier two or tier three interventions must be considered.

Lembke et al. described students appropriate for tier two interventions as “students who fall below benchmark scores on universal screening” but who are typically not earning “the lowest scores” (2012, p. 267). Within tier two interventions, students receive instruction that is “explicit, systematic, and supplemental to the core curriculum” with opportunities for students to communicate about their learning and with frequent feedback from the instructor (Lembke et al., 2012, p. 267). The Math Lab intervention fits this description of a tier two intervention.

Tier three interventions are described as essential for students who fall significantly below grade level performance and who do not respond as expected to tier two interventions. Tier three interventions are similar to tier two interventions but are administered “one-on-one” and are more “intensive” (Lembke et al., 2012, p. 267). This depiction accurately describes many of the Math Lab students who have struggled to be successful in the small group and peer-assisted structures vital to Math Lab implementation. The work of Lembke et al. may provide further insight into criteria for selecting the most appropriate Math Lab participants.
When considering the five critical elements of the Math Lab intervention - extending and focusing the learning time, using varied instructional strategies, basing instruction on student need, building relationships and refining the selection of intervention participants – the last three seem to be what differentiate the Math Lab interventions from other mathematics interventions. Most interventions include extending time, focusing instruction and using a variety of instructional strategies. To replicate these principles alone would not have resulted in the improvement seen with the Math Lab participants. The uniqueness and effectiveness of this intervention is due to the response to immediate student need, the development of positive student-student and student-teacher relationships and the continual quest to hone the participant selection criteria.

**Discussion of Student Achievement and Student Affect Findings**

In addition to direction for the development and implementation of effective mathematics interventions, the responses of students, parents, teachers, and administrators as well as statistical analysis of assessment and academic achievement data provided a summary of the academic and affective impact of participation in the Math Lab intervention. These insights are provided in this section.

**Impact on student achievement.** From the central research questions, a null hypothesis that the achievement of the treatment and comparison groups would not differ was developed. To test this hypothesis, comparison groups were established and Algebra I grades, overall grade point averages, and state assessment scores were compared using measures of central tendency and independent t-tests. In addition, measures of central tendency and dependent t-tests were used to compare the growth in achievement from
grade eight to grade nine as measured by state mathematics assessments of the treatment
groups and the comparison groups. These statistics were calculated simply to provide a
more complete description of the Math Lab intervention.

In every comparison – comparison of Algebra I grades, comparison of overall
grade point averages, comparison of the Algebra I End-of-Course scale scores, and
comparison of changes in achievement levels between the grade eight and Algebra I
MAP assessments - the mean scores of the treatment groups showed greater improvement
than those of the comparison groups. Additionally, the achievement of the 2011-2012
and 2012-2013 treatment groups as measured by Algebra I grades and change in grade
eight and Algebra I MAP assessment achievement levels is statistically significant which
indicates that the null hypothesis is rejected for this study population.

The considerable growth from grade 8 to Algebra I in grade 9, as defined by
performance on the state mathematics assessment, supported the theoretical foundation
upon which the study was based. Moving a statistically significant number of students
from below-grade-level performance in grade 8 to on-grade-level performance the
following year reinforced Vygotsky’s claim that the teacher as experienced mediator can
work collaboratively with the novice to move him through the zone of proximal
development to grade-level mastery (Miller, 2011).

**Impact on student affect.** Along with the effect of Math Lab participation on
academic achievement, students, parents, teachers and the principal also remarked on
improvements in affect as well. As stated previously, the overall sentiment from all
stakeholders was positive. The specific aspects of the intervention that support that
sentiment are described in this section.
How students experienced Math Lab. The majority of Math Lab participants who submitted survey responses shared that their impressions of mathematics were negative prior to participating in the Math Lab intervention. After participating in the intervention, thirteen of the fourteen respondents expressed positive impressions of mathematics. Specifically, students noted that Math Lab helped them “understand [math] more” and that Math Lab helped them improve their grades. In addition, students commented that they were better prepared for class and that they felt more confident in their math abilities after the Math Lab intervention.

How parents perceived Math Lab. Parents also expressed positive reactions to having their children participate in the Math Lab intervention. Six of the seven parents who responded to the Math Lab survey commented that their student “was more confident” and “less intimidated” than before participating in Math Lab. One parent remarked that her son “would most likely be struggling with math today if it were not for the Math Lab. It was a complete success story in my opinion”.

How teachers perceived Math Lab. To the Math Lab instructors, the impact on attitude was as important as any impact on aptitude. Specifically, the instructors felt the students benefited from increased confidence and ownership of their learning. As noted in the literature, a common characteristic of low-achieving math students is lack of confidence (Allsopp et al., n.d.; Burns, 2007). Increasing confidence as a means to improving mathematics performance was a consistent theme from the instructor interviews. In addition, the instructors expressed hope that the study skills, organizational skills and problem-solving skills learned in Math Lab would “span a lot
further than a math class”. Clearly, a hidden objective of the Math Lab intervention was to help the participants grow as students not just as mathematicians.

**How administrators perceived Math Lab.** The building administrator expressed repeatedly that Math Lab provided opportunities for struggling students to feel success. Like the instructors, he expressed optimism that the Math Lab experience would influence student performance beyond the mathematics classroom.

**Summary of responses.** Instructors and the building administrator were asked “how do you think the Math Lab intervention could potentially impact student success”? Two of the three replied that the impact was not potential but rather that the impact had been realized. The responses of students and parents confirmed that assertion. While the Math Lab participants’ responses were characterized by improved performance and skills in mathematics, the parents, instructors and principal agreed that the benefit of participating in Math Lab was broader. These stakeholders concurred that the students grew in confidence, the potential impact of which extends beyond academics.

**Recommendations for Educational Practice**

The objective of this case study was to delve beyond the quantitative data to explore the qualitative features that make a “double-dose” mathematics intervention successful. By describing the context of the intervention from the perspectives of administrators, instructors, students and participant observer, a more complete understanding of “double-dose” interventions has been offered to complement existing research.

For the district in which this study took place, next steps should include developing a metric for selecting the students to participate in the Math Lab intervention.
As mentioned in chapter 4, students who are prime for this program are motivated and able to apply existing knowledge to new situations even though they may have difficulty with mathematical tasks or need additional help or extended learning time in order to show mastery. The district should research metrics for evaluating motivation and select one to aid in student selection. In addition, the district in which this study took place has Math Lab in three other grade levels. These programs are not seeing the same success that the high school program has seen. The results of this study should be used as guide for evaluating current practices in an effort to improve program implementation at all levels.

For districts striving to design and implement an effective mathematics intervention, this study revealed the critical elements of an intervention that is working within a specific context - extending and focusing the learning time, using varied instructional strategies, basing instruction on student need, building relationships and selecting the right student. The researcher hopes that other practitioners will find components of this implementation that will work within their unique contexts so that the benefit of this implementation is realized beyond the parameters of the suburban, Midwestern school district in which the study took place.

**Plan for Dissemination**

To further facilitate the dissemination of the findings of this study, the researcher intends to submit proposals to present at local and state mathematics conferences. In addition, the researcher intends to repurpose this doctoral thesis as a manuscript which will be submitted to academic journals in hopes of having it published for a wider audience.
Areas for Future Research

The research on “double-dose” interventions should not end with this study. Additional research should be conducted on a much wider scale to more accurately define the relationship between “double-dose” interventions and mathematics achievement. Future studies should also include special education students as well as middle-level and elementary-level students. In addition, this study was conducted in a school with very low minority representation. Future studies should explore the viability of such an intervention with a more diverse student body.
References


Retrieved from National Center for Education Statistics website:


achievement and peer relationships: The effects of cooperative, competitive and

http://math.about.com/od/mathlessonplans/a/MathJournals.htm

Sage Publications.

Leadership, 67*(3), 44-47.

Schmoker, M. (2011). *Focus: Elevating the essentials to radically improve student
learning*. Alexandria, VA: ASCD.


for the challenges ahead*. Retrieved from
http://math.about.com/od/mathlessonplans/a/MathJournals.htm

Publications.


APPENDICES
Appendix A
Northeastern University, College of Professional and Graduate Studies  
Dr. Kelly Conn, Principal Investigator and Michelle Kratofil, Student Investigator  
*A Case Study of a “Double-Dose” Mathematics Intervention*

### Informed Consent to Participate in a Research Study

We are inviting you to take part in a research study. This form will tell you about the study, but the researcher will explain it to you first. You may ask this person any questions that you have. When you are ready to make a decision, you may tell the researcher if you want to participate or not. You do not have to participate if you do not want to. If you decide to participate, the researcher will ask you to sign this statement and will give you a copy to keep.

#### Why am I being asked to take part in this research study?

You are being invited to participate in this study because you are the administrator of Smithville High School where the Algebra Math Lab intervention has been implemented.

#### Why is this research study being done?

The purpose of the study is to describe the implementation and stakeholder perceptions of the Algebra Math Lab intervention so that the Smithville School district, and others like it, can continue to adjust and improve such programs.

#### What will I be asked to do?

If you agree to participate, you will be interviewed to provide specific details about your perceptions of the Algebra Math Lab intervention. Prior to participating in the interview, the project will be explained in easy-to-understand terms and participation is voluntary.

#### Where will this take place and how much of my time will it take?

The interview will take place in a setting of your choice and will last approximately one hour.

#### Will there be any risk or discomfort to me?

There is no risk associated with participation in this study. Your decision whether or not to participate will not affect your employment or benefits in the Smithville School District.

#### Will I benefit by being in this research?

There is no direct benefit to you for participating in the study.

#### Who will see the information about me?

Only the researcher will have access to information you provide. At the conclusion of the study, all responses will be reported as group results only. This summary will be available to all interested participants. If you would like the summary of group results, simply indicate that preference on the attached consent form.
Administrator responses will be recorded using Audacity computer software. Individual responses will then be transcribed into a Microsoft Excel spreadsheet and maintained by the researcher. No names will be associated with responses. The spreadsheet will be stored in an on-line “dropbox” to which the researcher alone has access.

**Can I stop my participation in this study?**
Your participation in this research is completely voluntary. You do not have to participate if you do not want to. Even if you begin the study, you may quit at any time. If you do not participate or if you decide to quit, you will not lose any rights, benefits, or services that would otherwise be provided by the Smithville School District.

**Who can I contact if I have questions or problems?**
Should you have any questions or desire further information, please call or email Dr. Kelly Conn at 857-205-9585 or k.conn@neu.edu or Michelle Kratofil 816-532-0406 or kratofil.m@husky.neu.edu.

**Who can I contact about my rights as a participant?**
If you have any questions about your rights in this research, you may contact Nan C. Regina, Director, Human Subject Research Protection, 960 Renaissance Park, Northeastern University, Boston, MA 02115. Tel: 617.373.4588, Email: irb@neu.edu. You may call anonymously if you wish.

**Will it cost me anything to participate?**
There are no costs associated with participation in this study.

**I agree to take part in this research.**

---

**Signature of person agreeing to take part**

**Date**

---

**Printed name of person above**

---

**Signature of person who explained the study to the participant above and obtained consent**

**Date**

---

**Printed name of person above**

---

**Sign here if you would like a summary of results at the conclusion of the study**
Northeastern University, College of Professional and Graduate Studies
Dr. Kelly Conn, Principal Investigator and Michelle Kratofil, Student Investigator
A Case Study of a “Double-Dose” Mathematics Intervention

Informed Consent to Participate in a Research Study

We are inviting you to take part in a research study. This form will tell you about the study, but the researcher will explain it to you first. You may ask this person any questions that you have. When you are ready to make a decision, you may tell the researcher if you want to participate or not. You do not have to participate if you do not want to. If you decide to participate, the researcher will ask you to sign this statement and will give you a copy to keep.

Why am I being asked to take part in this research study?

You are being invited to participate in this study because you are an instructor of one of the Algebra Math Labs at Smithville High School.

Why is this research study being done?

The purpose of the study is to describe the implementation and stakeholder perceptions of the Algebra Math Lab intervention so that the Smithville School district, and others like it, can continue to adjust and improve such programs.

What will I be asked to do?

If you agree to participate, you will be interviewed to provide specific details about your perceptions of the Algebra Math Lab intervention. Prior to participating in the interview, the project will be explained in easy-to-understand terms and participation is voluntary.

Where will this take place and how much of my time will it take?

The interview will take place in a setting of your choice and will last approximately one hour.

Will there be any risk or discomfort to me?

There is no risk associated with participation in this study. Your decision whether or not to participate will not affect your employment or benefits in the Smithville School District.

Will I benefit by being in this research?

There is no direct benefit to you for participating in the study.

Who will see the information about me?

Only the researcher will have access to information you provide. At the conclusion of the study, all responses will be reported as group results only. This summary will be available to all interested participants. If you would like the summary of group results, simply indicate that preference on the attached consent form.
Instructor responses will be recorded using Audacity computer software. Individual responses will then be transcribed into a Microsoft Excel spreadsheet and maintained by the researcher. No names will be associated with responses. The spreadsheet will be stored in an on-line “dropbox” to which the researcher alone has access.

<table>
<thead>
<tr>
<th>Can I stop my participation in this study?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Your participation in this research is completely voluntary. You do not have to participate if you do not want to. Even if you begin the study, you may quit at any time. If you do not participate or if you decide to quit, you will not lose any rights, benefits, or services that would otherwise be provided by the Smithville School District.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Who can I contact if I have questions or problems?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Should you have any questions or desire further information, please call or email Dr. Kelly Conn at 857-205-9585 or <a href="mailto:k.conn@neu.edu">k.conn@neu.edu</a> or Michelle Kratofil 816-532-0406 or <a href="mailto:kratofil.m@husky.neu.edu">kratofil.m@husky.neu.edu</a>.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Who can I contact about my rights as a participant?</th>
</tr>
</thead>
<tbody>
<tr>
<td>If you have any questions about your rights in this research, you may contact Nan C. Regina, Director, Human Subject Research Protection, 960 Renaissance Park, Northeastern University, Boston, MA 02115. Tel: 617.373.4588, Email: <a href="mailto:irb@neu.edu">irb@neu.edu</a>. You may call anonymously if you wish.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Will it cost me anything to participate?</th>
</tr>
</thead>
<tbody>
<tr>
<td>There are no costs associated with participation in this study.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>I agree to take part in this research.</th>
</tr>
</thead>
</table>

Signature of person agreeing to take part  
Date

Printed name of person above

Signature of person who explained the study to the participant above and obtained consent  
Date

Printed name of person above

Sign here if you would like a summary of results at the conclusion of the study
March 17, 2013

Dear Parent or Guardian:

I am a doctoral student in the College of Professional Studies at Northeastern University and Director of Curriculum, Assessment and Staff Development for the Smithville School District. Dr. Kelly Conn of Northeastern University and I are conducting a research project on the Algebra I Math Lab class in which your child is/was enrolled. We request permission for your child and for you to participate in this study.

The purpose of this study is to discover and describe the components of the Math Lab intervention that resulted in increased mathematics achievement for the intervention participants in an effort to make improvements to the program and to provide insight to other educators investigating mathematics interventions.

For your student, the study consists of answering a brief survey that will be distributed via his/her Smithville School District e-mail account. Prior to distributing the survey, I will meet with the students to explain the project and answer questions. Your child will participate only if he or she is willing to do so. Only I will have access to information from your child.

For you, the parent, the study also consists of a brief survey that will be distributed via the e-mail address you have provided to the school district. Your participation is also voluntary and your responses will be confidential.

At the conclusion of the study, all responses will be reported as group results only. A summary of group results will be available to all interested parents and students. If you would like the summary of group results, simply indicate that preference on the attached consent forms.

Participation in this study is voluntary. Your decision whether to participate or to allow your child to participate will not affect the services normally provided to your child by the Smithville School District nor will it affect your child’s grade in any class.

Even if you give your permission for your child to participate, your child is free to refuse. If your child agrees to participate, he or she is free to end participation at any time. If your child participates in the study, he/she will be given a $5 Quik Trip gift card to compensate for the time spent responding to the survey.

Should you have any questions or desire further information, please call me or email me at 816-532-0406 or kratofil.m@husky.neu.edu. You may also contact my faculty advisor, Dr. Kelly Conn, at 857-205-9585 or k.conn@neu.edu. Please sign and return the student and parent consent forms if you would like to participate in this study. A stamped, return envelope is included for your convenience.

If you have any questions about your rights as a research subject, you may contact the Northeastern University office of Human Subject Research Protection at 617-373-4588 or by e-mail at n.regina@neu.edu.

Sincerely,

Michelle Kratofil
Northeastern University Doctoral Student
Informed Consent to Participate in a Research Study

We are inviting you to take part in a research study. This form will tell you about the study, but the researcher will explain it to you first. You may ask this person any questions that you have. When you are ready to make a decision, you may tell the researcher if you want to participate or not. You do not have to participate if you do not want to. If you decide to participate, the researcher will ask you to sign this statement and will give you a copy to keep.

Why am I being asked to take part in this research study?
You are being invited to participate in this study because your child was enrolled or is currently enrolled in the Algebra Math Lab at Smithville High School.

Why is this research study being done?
The purpose of the study is to describe the implementation and stakeholder perceptions of the Algebra Math Lab intervention so that the Smithville School district, and others like it, can continue to adjust and improve such programs.

What will I be asked to do?
If you agree to participate, you will be asked to complete a brief survey, which will be distributed via e-mail. The survey will ask you to provide specific details about your perceptions of the Algebra Math Lab intervention. Prior to distributing the survey, the project will be explained in easy-to-understand terms and participation is voluntary.

Where will this take place and how much of my time will it take?
The survey may be taken on any computer that has internet access and will take 10-15 minutes on average to complete.

Will there be any risk or discomfort to me?
There is no risk associated with participation in this study. Your decision whether or not to participate will not affect the services normally provided to you or your family by the Smithville School District.

Will I benefit by being in this research?
There is no direct benefit to you for participating in the study.

Who will see the information about me?
Only the researcher will have access to information you provide. At the conclusion of the study, all responses will be reported as group results only. This summary will be available to all interested participants. If you would like the summary of group results, simply indicate that preference on the attached consent form.
Parent responses will be collected via an on-line survey tool. Individual responses will be downloaded into a Microsoft Excel spreadsheet and maintained by the researcher. No names will be associated with responses. The spreadsheet will be stored in an on-line “dropbox” to which the researcher alone has access.

**Can I stop my participation in this study?**

Your participation in this research is completely voluntary. You do not have to participate if you do not want to. Even if you begin the study, you may quit at any time. If you do not participate or if you decide to quit, you will not lose any rights, benefits, or services that would otherwise be provided by the Smithville School District.

**Who can I contact if I have questions or problems?**

Should you have any questions or desire further information, please call or email Dr. Kelly Conn at 857-205-9585 or k.conn@neu.edu or Michelle Kratofil 816-532-0406 or kratofil.m@husky.neu.edu.

**Who can I contact about my rights as a participant?**

If you have any questions about your rights in this research, you may contact Nan C. Regina, Director, Human Subject Research Protection, 960 Renaissance Park, Northeastern University, Boston, MA 02115. Tel: 617.373.4588, Email: irb@neu.edu. You may call anonymously if you wish.

**Will it cost me anything to participate?**

There are no costs associated with participation in this study.

**I agree to take part in this research.**

____________________________
Signature of person agreeing to take part

____________________________
Date

____________________________
Printed name of person above

____________________________
Signature of person who explained the study to the participant above and obtained consent

____________________________
Date

____________________________
Printed name of person above

____________________________
Sign here if you would like a summary of results at the conclusion of the study
Informed Consent to Participate in a Research Study

We are inviting your child to take part in a research study. This form will tell you about the study, but the researcher will explain it to you first. You may ask this person any questions that you have. When you are ready to make a decision, you may tell the researcher if you want to participate or not. You do not have to participate if you do not want to. If you decide to participate, the researcher will ask you to sign this statement and will give you a copy to keep.

Why am I being asked to take part in this research study?
Your child is invited to participate in this study because he/she was enrolled or is currently enrolled in the Algebra Math Lab at Smithville High School.

Why is this research study being done?
The purpose of the study is to describe the implementation and stakeholder perceptions of the Algebra Math Lab intervention so that the Smithville School district, and others like it, can continue to adjust and improve such programs.

What will I be asked to do?
If you grant permission for your child to participate in this study and if your child agrees to participate, he/she will be asked to complete a brief survey, which will be distributed through school e-mail accounts. The survey will ask your child to provide specific details about his/her Math Lab experience. Prior to distributing the survey, the project will be explained in terms that your child can understand, and your child will participate only if he or she is willing to do so.

Where will this take place and how much of my time will it take?
The survey may be taken on any computer that has internet access and will take 10-15 minutes on average for students to complete.

Will there be any risk or discomfort to me?
There is no risk associated with participation in this study. Your decision whether or not to allow your child to participate will not affect the services normally provided to your child by the Smithville School District nor will it affect your child’s grade in any class. Even if you give your permission for your child to participate, your child is free to refuse.

Will I benefit by being in this research?
If your child agrees to participate in this study, he/she will be given a $5 Quik Trip gift card to compensate for time spent responding to the survey.
Who will see the information about me?
Only the researcher will have access to information provided by your child. At the conclusion of the study, all responses will be reported as group results only. This summary will be available to all interested parents and students. If you would like the summary of group results, simply indicate that preference on the attached consent form.

Student responses will be collected via an on-line survey tool. Individual responses will be downloaded into a Microsoft Excel spreadsheet and maintained by the researcher. No names will be associated with student responses. Names will only be collected in order to distribute the gift cards for participation in the study. The spreadsheet will be stored in an on-line “dropbox” to which the researcher alone has access.

Can I stop my participation in this study?
Your child’s participation in this research is completely voluntary. He/She does not have to participate if he/she does not want to. Even if your child begins the study, he/she may quit at any time. If your child does not participate or if your child decides to quit, he/she will not lose any rights, benefits, or services that he/she would otherwise have as a student of the Smithville School District.

Who can I contact if I have questions or problems?
Should you have any questions or desire further information, please call or email Dr. Kelly Conn at 857-205-9585 or k.conn@neu.edu or Michelle Kratofil 816-532-0406 or kratofil.m@husky.neu.edu.

Who can I contact about my rights as a participant?
If you have any questions about your rights in this research, you may contact Nan C. Regina, Director, Human Subject Research Protection, 960 Renaissance Park, Northeastern University, Boston, MA 02115. Tel: 617.373.4588, Email: irb@neu.edu. You may call anonymously if you wish.

Will it cost me anything to participate?
There are no costs associated with participation in this study.
I agree to have my child take part in this research.

Signature of person [parent] agreeing to take part ________________________________ Date __________

Printed name of person above ________________________________________________

Signature of person who explained the study to the participant above and obtained consent ________________________________ Date __________

Printed name of person above ________________________________________________

Sign here if you would like a summary of results at the conclusion of the study ________________________________________________
Appendix B
Administrator Interview Protocol: A Case Study of a “Double-Dose” Mathematics Intervention

Time of Interview:  
Date:  
Place:  
Interviewer:  
Interviewee:  

Questions:

1. Please tell me about yourself and your professional experiences. (ie. Educational background, previous teaching/administration experiences, etc.)

2. What process was used to develop the Math Lab intervention?  
   a. Probe: What critical elements was the intervention based upon?

3. Based upon your observations and discussions with teachers and students, describe the structure of Math Lab #1.  
   a. Probe: What activities did you observe the students engaged in? What was the purpose of the activity?

4. Based upon your observations and discussions with teachers and students, describe the structure of Math Lab #2.  
   a. Probe: What activities did you observe the students engaged in? What was the purpose of the activity?

5. What component of Math Lab is most beneficial for students?  
   a. Probe: What specifically did you observe in the classroom or hear from participants that supports your statement?

6. What could be done to improve the Math Lab intervention?  
   a. Probe: Any changes to processes, structure, etc.?

7. How do you think the Math Lab intervention can potentially impact student success?

8. Is there anything else that you’d like to share regarding the Math Lab Intervention?

Prompts: Previously, you stated __________. Can you tell me more about that?

   I’d like to go back to your statement about __________. [Connect that statement to the next question to re-focus the interview.]

Thank you for participating in this interview. All responses will be kept confidential.
Instructor Interview Protocol: A Case Study of a “Double-Dose” Mathematics Intervention

Time of Interview:
Date:
Place:
Interviewer:
Interviewee:

Questions:

1. Please tell me about yourself and your teaching experiences. (ie. Educational background, previous teaching experiences, etc.)
2. What process was used to develop the Math Lab intervention?
3. In the planning stage of the intervention, what were the critical elements that became the basis of the program?
   a. Probe: Do you recall any details from the research conducted or the observations in other districts?
4. How is your Math Lab class structured?
   a. Probe: What activities did you observe the students engaged in? What was the purpose of the activity?
5. What could be done to improve the Math Lab intervention?
   a. Probe: Any changes to processes, structure, etc.?
6. How do you think the Math Lab intervention can potentially impact student success?
7. Is there anything else that you’d like to share regarding the Math Lab Intervention?

Prompts: Previously, you stated ________. Can you tell me more about that?
   I’d like to go back to your statement about _________. [Connect that statement to the next question to re-focus the interview.]

Thank you for participating in this interview. All responses will be kept confidential.
Student Survey: A Case Study of a “Double-Dose” Mathematics Intervention

It is very important to capture your personal thoughts, feelings and experiences regarding Math Lab on this survey. Please do not confer with anyone else to answer the survey questions. If there is a question that you cannot answer or would prefer not to answer, you may leave it blank. Thank you!

1. Name (required):
2. Identify the school year in which you participated in Math Lab: 2011-2012 or 2012-2013
3. Before participating in Math Lab, what were your impressions of math?
4. How, if at all, has participating in Math Lab influenced your performance in math?
5. Describe a typical day in Math Lab. What kind of activities did you engage in? Please provide as much detail as you can.
6. What, if anything, did you find most helpful about Math Lab?
7. What, if anything, did you find least helpful about Math Lab?
8. After participating in Math Lab, what are your impressions of math?
9. Is there anything else about your Math Lab experience that you would like to share?

Thank you for participating in this survey. Your responses will only be seen by the researcher and will be kept confidential. Your $5 Quik Trip card will be delivered within 5 school days.
Parent Survey: A Case Study of a “Double-Dose” Mathematics Intervention

It is very important to capture your personal thoughts, feelings and recollections of your son’s/daughter’s Math Lab experience. Your child will take a similar survey to capture his/her thoughts, feelings and experiences. Please do not confer with your child prior to completing the survey. If there is a question that you cannot answer, you may leave it blank. Thank you!

1. Name of Math Lab participant:
2. Before participating in Math Lab, what were your son’s/daughter’s impressions of math?
3. How, if at all, has participating in Math Lab influenced your son’s/daughter’s performance in math?
4. What, if anything, did your son/daughter find most helpful about the activities done in Math Lab?
5. What, if anything did your son/daughter find least helpful about the activities done in Math Lab?
6. After participating in Math Lab, how have your son’s/daughter’s impressions of math changed, if at all?
7. Is there anything else about your son’s/daughter’s Math Lab experience that you would like to share?

Thank you for participating in this survey. Your responses will only be seen by the researcher and will be kept confidential.
Appendix C
Seating Chart: Movement, Interaction, and/or Behavior Patterns

<table>
<thead>
<tr>
<th>Teaching Standard:</th>
<th>Observation Focus:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Content Standard:</th>
<th>Lesson Topic:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Grade Level/Subject Area:</th>
<th>Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mentor:</th>
<th>Name:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Selective Scripting

Name: ___________________________ Mentor: ___________________________

Grade Level/Subject Area: ___________________________ Date: __________________

Lesson Topic: ___________________________ Teaching Standard: __________________

Observation Focus: ___________________________ Content Standard: __________________

<table>
<thead>
<tr>
<th>Time</th>
<th>Teacher</th>
<th>Students</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Code:
Dear Parent/Guardian,

I am writing to extend an exciting opportunity for your student. As an educational community, we are well aware of the importance of strong foundational skills in academics for the life-long success of our students. We are also aware that many of the job opportunities that will be available to today’s students are ones that require a solid foundation in math. For some of our students, however, math is a considerable challenge.

For the past two years, the School District has offered a program designed to provide effective support for students who find math challenging. This program is based upon recent research that shows the importance of providing additional time and instruction for students who have difficulty in math. To better meet the needs of our students, we are pleased to offer Algebra I Math Lab to a select few. Each Algebra I Math Lab will be limited to a maximum of 12 students who will be assigned to a math teacher for an additional block each semester with the schedule arranged so that students have math every day. The Algebra I Math Labs will utilize hands-on activities and computer-assisted programs to help students better understand math concepts.

We are inviting your child to be included in this program, which will take the place of one elective in his/her schedule. Based upon the research we have conducted and the response of past Math Lab students, we are confident that this approach will help us serve your child so that he/she may build more confidence and skill in mathematics. The end result will be a student who can participate in any math class he/she chooses in upper grades and who can pursue any career path of interest.

Your student’s schedule has already been adjusted to reflect this change. If you have any questions, please feel free to call me at the number below. Thank you in advance for partnering with us to best serve your child’s academic needs.
Appendix E
The Modality Preferences Instrument

Follow the directions below to get a score that will indicate your own modality (sense) preference(s). This instrument, keep in mind that sensory preferences are usually evident only during prolonged and complex learning tasks.

Identifying Sensory Preferences

Directions: For each item, circle “A” if you agree that the statement describes you most of the time.

1. I prefer reading a story rather than listening to someone tell it. A
2. I would rather watch television than listen to the radio. A
3. I remember names faces better than names. A
4. I like classrooms with lots of posters and pictures around the room. A
5. The appearance of my handwriting is important to me. A
6. I think more often in pictures. A
7. I am distracted by visual disorder or movement. A
8. I have difficulty remembering directions that were told to me. A
9. I would rather watch athletic events than participate in them. A
10. I tend to organize my thoughts by writing them down. A
11. My facial expression is a good indicator of my emotions. A
12. I tend to remember names better than faces. A
13. I would enjoy taking part in dramatic events like plays. A
14. I tend to sub vocalize and think in sounds. A
15. I am easily distracted by sounds. A
16. I easily forget what I read unless I talk about it. A
17. I would rather listen to the radio than watch TV. A
18. My handwriting is not very good. A
19. When faced with a problem, I tend to talk it through. A
20. I express my emotions verbally. A
21. I would rather be in a group discussion then read about a topic. A
22. I prefer talking on the phone rather than writing a letter to someone. A
23. I would rather participate in athletic events than watch them. A
24. I prefer going to museums where I can touch the exhibits. A
25. My handwriting deteriorates when the space becomes smaller. A
26. My mental pictures are usually accompanied by movement. A
27. I like being outdoors and doing things like biking, camping, swimming, hiking etc. A
28. I remember best what was done rather then what was seen or talked about. A
29. When faced with a problem, I often select the solution involving the greatest activity. A
30. I like to make models or other hand crafted items. A
31. I would rather do experiments rather then read about them. A
32. My body language is a good indicator of my emotions. A
33. I have difficulty remembering verbal directions if I have not done the activity before. A

Interpreting the Instrument’s Score

Total the number of “A” responses in items 1-11
This is your visual score
Total the number of “A” responses in items 12-22
This is your auditory score
Total the number of “A” responses in items 23-33
This is you tactile/kinesthetic score

- If you scored a lot higher in any one area: This indicates that this modality is very likely your preference during a protracted and complex learning situation.
- If you scored a lot lower in any one area: This indicates that this modality is not likely to be your preference(s) in a learning situation.
- If you got similar scores in all three areas: This indicates that you can learn things in almost any way they are presented.
The Theory of Multiple Intelligences
Self Assessment

Where does your true intelligence (processing ability) lie? This quiz can help you determine where you stand. Read each statement. If it expresses some characteristic of yours and sounds true for the most part, jot down “T.” If the statement is sometimes true, sometimes false, leave it blank.

1. ______ I’d rather draw a map than give someone verbal directions.
2. ______ I can play (or used to play) a musical instrument.
3. ______ I can associate music with my moods.
4. ______ I can add or multiply quickly in my head.
5. ______ I like to work with calculators and computers.
6. ______ I pick up new dance steps quickly.
7. ______ It is easy for me to say what I think in an argument or debate.
8. ______ I enjoy a good lecture, speech, or sermon.
9. ______ I always know north from south no matter where I am.
10. ______ Life seems empty without music.
11. ______ I always understand the direction that comes with new gadgets or appliances.
12. ______ I like to learn puzzles and play games.
13. ______ Learning to ride a bike (or skate) was easy.
14. ______ I am irritated when I hear an argument that is illogical.
15. ______ My sense of balance and coordination is good.
16. ______ I often see patterns and relationships to numbers faster and easier than others.
17. ______ I enjoy building models or sculpting.
18. ______ I am good at finding the fine points of word meaning.
19. ______ I can look at an object one way and see it turned sideways or backwards just as easily.
20. ______ I often connect a piece of music with some event in my life.
21. ______ I like to work with numbers and figures.
22. ______ Just looking at shapes of buildings and structures is pleasurable to me.
23. ______ I like to hum, whistle, and sing in the shower or when I am alone.
24. ______ I am good at athletics.
25. ______ I would like to study the structure and logic of languages.
26. ______ I am usually aware of the expressions on my face.
27. ______ I am sensitive to the expression on other people’s faces.
28. ______ I stay in touch with my moods. I have no trouble identifying them.
29. ______ I am sensitive to the moods of others.
30. ______ I have a good sense of what others think of me.

Scoring Sheet
Place a checkmark by each item, which you marked as “True.” Add your totals. A total of four in any of the categories A through E indicates strong ability. In categories F through G a score of one or more means you have abilities in these areas as well.

<table>
<thead>
<tr>
<th></th>
<th>A: Linguistics</th>
<th>B: Logical/Math</th>
<th>C: Musical</th>
<th>D: Spatial</th>
<th>E: Body/Kinesthetic</th>
<th>F: Intrapersonal</th>
<th>G: Interpersonal</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>______</td>
<td>4</td>
<td>______</td>
<td>______</td>
<td>______</td>
<td>26</td>
<td>______</td>
</tr>
<tr>
<td>8</td>
<td>______</td>
<td>5</td>
<td>______</td>
<td>______</td>
<td>______</td>
<td>28</td>
<td>______</td>
</tr>
<tr>
<td>14</td>
<td>______</td>
<td>12</td>
<td>______</td>
<td>______</td>
<td>______</td>
<td>29</td>
<td>______</td>
</tr>
<tr>
<td>18</td>
<td>______</td>
<td>16</td>
<td>______</td>
<td>______</td>
<td>______</td>
<td>30</td>
<td>______</td>
</tr>
<tr>
<td>25</td>
<td>______</td>
<td>21</td>
<td>______</td>
<td>______</td>
<td>______</td>
<td>______</td>
<td>______</td>
</tr>
</tbody>
</table>
## Triarchic Theory of Intelligences - Robert Sternberg

Mark each sentence T if you like to do the activity

1. Analyzing characters when I'm reading or listening to a story
2. Designing new things
3. Taking things apart and fixing them
4. Comparing and contrasting points of view
5. Coming up with ideas
6. Learning through hands-on activities
7. Criticizing my own and other kids' work
8. Using my imagination
9. Putting into practice things I learned
10. Thinking clearly and analytically
11. Thinking of alternative solutions
12. Working with people in teams or groups
13. Solving logical problems
14. Noticing things others often ignore
15. Resolving conflicts
16. Evaluating my own and other's points of view
17. Thinking in pictures and images
18. Advising friends on their problems
19. Explaining difficult ideas or problems to others
20. Supposing things were different
21. Convincing someone to do something
22. Making inferences and deriving conclusions
23. Drawing
24. Learning by interacting with others
25. Sorting and classifying
26. Inventing new words, games, approaches
27. Applying my knowledge
28. Using graphic organizers or images to organize your thoughts
29. Composing
30. Adapting to new situations

Transfer your answers from the survey to the key. The column with the most "True" responses is your dominant intelligence.

<table>
<thead>
<tr>
<th>Analytical</th>
<th>Creative</th>
<th>Practical</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. ___</td>
<td>2. ___</td>
<td>3. ___</td>
</tr>
<tr>
<td>4. ___</td>
<td>5. ___</td>
<td>6. ___</td>
</tr>
<tr>
<td>7. ___</td>
<td>8. ___</td>
<td>9. ___</td>
</tr>
<tr>
<td>10. ___</td>
<td>11. ___</td>
<td>12. ___</td>
</tr>
<tr>
<td>13. ___</td>
<td>14. ___</td>
<td>15. ___</td>
</tr>
<tr>
<td>16. ___</td>
<td>17. ___</td>
<td>18. ___</td>
</tr>
<tr>
<td>19. ___</td>
<td>20. ___</td>
<td>21. ___</td>
</tr>
<tr>
<td>22. ___</td>
<td>23. ___</td>
<td>24. ___</td>
</tr>
<tr>
<td>25. ___</td>
<td>26. ___</td>
<td>27. ___</td>
</tr>
<tr>
<td>28. ___</td>
<td>29. ___</td>
<td>30. ___</td>
</tr>
</tbody>
</table>

Total Number of True:

Analytical ___  Creative ___  Practical ___
## Interaction Inventory

### Directions:
- Rank order the responses in rows below on a scale from 1 to 4 with 1 being "least like me" to 4 being "most like me."
- After you have ranked each row, add down each column.
- The column(s) with the highest score(s) shows your primary Personal Objective(s) in your personality.

<table>
<thead>
<tr>
<th>Nurturing Sensitive Caring</th>
<th>Logical Systematic Organized</th>
<th>Spontaneous Creative Playful</th>
<th>Quiet Insightful Reflective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harmony Relationships are important</td>
<td>Work Time schedules are important</td>
<td>Stimulation Having fun is important</td>
<td>Reflection Having some time alone is important</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Authentic Compassionate Harmonious</th>
<th>Traditional Responsible Parental</th>
<th>Active Opportunistic Spontaneous</th>
<th>Inventive Competent Seeking</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Empathetic Communicative Devoted</th>
<th>Practical Competitive Loyal</th>
<th>Impetuous Impulsive Daring</th>
<th>Conceptual Knowledgeable Composed</th>
</tr>
</thead>
</table>

You approach most tasks in a(n) __________ manner:

<table>
<thead>
<tr>
<th>Affectionate Inspirational Vivacious</th>
<th>Conventional Orderly Concerned</th>
<th>Courageous Adventurous Impulsive</th>
<th>Rational Philosophical Complex</th>
</tr>
</thead>
</table>

When things start to "not go your way" and you are tired and worn down, what might your responses be?
- Say "I'm sorry"
- Make mistakes
- Feel badly
- Over-control
- Become critical
- Take charge
- "It's not my fault"
- Manipulate
- Act out
- Withdraw
- Don't talk
- Become indecisive

When you've "had a bad day" and you become frustrated, how might you respond?
- Over-please
- Cry
- Feel depressed
- Be perfectionistic
- Verbally attack
- Overwork
- Become physical
- Be irresponsible
- Demand attention
- Disengage
- Delay
- Daydream

Add score:

| Harmony | Production | Connection | Status Quo |