Examining the Effects of Blended Learning for Ninth Grade Students Who Struggle with Math

by

Staci Bolley

A Dissertation Presented in Partial Fulfillment
of the Requirements for the Degree
Doctor of Education

Approved March 2013 by the
Graduate Supervisory Committee:

Daniel Schugurensky, Chair
Heather Cruz
Joshua Barnett

ARIZONA STATE UNIVERSITY

May 2013

ABSTRACT

Many students in the United States are graduating from high school without the math skills they need to be considered college ready. For many of these graduates, who find themselves starting their higher education at a community college, remedial math can become an insurmountable barrier that ends their aspirations for a degree or certificate. Some students must take as many as four remedial courses before they are considered college ready. Studies report that between 60% and 70% of students placed into remedial math classes either do not successfully complete the sequence of required courses or avoid taking math altogether and therefore never graduate (Bailey, Jeong, & Cho, 2010). This study compared three low-level freshman math classes in one Arizona high school. The purpose of this study was to implement an innovative learning intervention to find out if there was a causal relationship between the addition of technology with instruction in a blended learning environment and performance in math. The intervention measured growth (pre- and posttest) and grade-level achievement (district-provided benchmark test) in three Foundations of Algebra classes. The three classes ranged on a continuum with the use of technology and personalized instruction. Additionally, focus groups were conducted to better understand the challenges this population of students face when learning math. The changes in classroom practices showed no statistical significance on the student outcomes achieved. Students in a blended online environment learned the Foundations of Algebra concepts similarly to their counterparts in a traditional, face-to-face learning environment.

DEDICATION

Two months prior to the start of my doctoral studies, my life took a different path. I experienced a life-changing event when my left leg was permanently injured. I was told that I would never walk correctly again. Earlier that year, I had been accepted into the prestigious DELTA IX Cohort at Arizona State University. When I was injured, I feared that if I did not start the program on time that I would never be readmitted. As it turns out, the DELTAs were disbanded at the completion of this program. As much as I was tempted and justified to withdraw my application, I am glad that I didn't.

It has been a very emotional three years. The program was grueling, filled with ideas that I had never considered, points of view that were from a culture foreign to me, and bookwork that I could never finish on time. Classes took us to Costa Rica and to Spain, which was extremely difficult for me due to my inability to walk correctly.

I could not have made it through the program and trips had it not been for my family, friends, and cohort peers. I have many people to thank.

Thank you to my husband, Joe Bolley, for taking care of me through many surgeries and for being there for me through this arduous journey while I continue to recover. Thank you for doing everything for me and our family so that I could study and learn, and for supporting and encouraging me throughout this dissertation process. I appreciate your friendship and love. I thank you for supporting me while I pursue my dreams and I promise not to neglect you for the sake of homework ever again!

Thank you to my dad, Ed Sandidge, CLU, for his wealth of knowledge, infinite wisdom, patience, and unending support. Thank you for allowing me to verbally process new information learned and for reading my papers. Thank you for accepting new ideas

and providing thoughtful and abundant feedback. Thank you for supporting my academic endeavors both fiscally and emotionally. My desire to make you proud has brought me to where I am today.

Thank you to my mom, Sandra Barnes, sisters, Peri James and Margo Foran, and my child, Justin Martin, for unconditionally supporting me in pursuit of my dream of becoming Dr. Bolley. Thank you John and Janice Bolley for caring for me when I could not care for myself. Your emotional support and encouragement has allowed me to make it through this program. Thank you Jerry Levesque for talking me "off the ledge" every time I called you to complain about the difficulty I was experiencing with the program.

Thank you to Chuck Jeffery for mentoring me since my freshmen year in college. Your influence has encouraged me to earn this degree. Thank you, Michele Jasper. Were it not for your patience, kindness, intelligence and love, I would have never even applied to this program. I appreciate your advice, wisdom, and encouragement. Thank you Mr. Holiday for allowing me to conduct my study in your class.

Thank you to my cohort members for helping me both physically and emotionally. I have learned so much from each one of you. Thank you to my committee members for guiding me and supporting me through this process. Thank you Heather Cruz for allowing me to conduct my study in your district and for keeping me on track!

Thank you Jeff Dollarhide for allowing me to utilize your work environment throughout this program. Thank you to everyone at Mass Mutual of Arizona for your support throughout this journey.

All of you have served as a friend and coach at various parts in this process, and for that I am deeply grateful.

TABLE OF CONTENTS

CHAPTER Page

CHAPTER Page

CHAPTER Page

CHAPTER Page

APPENDIX Page

LIST OF TABLES

LIST OF FIGURES

Chapter 1

Introduction

Statement of the Problem

Too many students in the United States (US) are graduating from high school without the math skills they need to be considered college ready (they are incapable of enrolling in a 100 level math course). For those graduates who find themselves starting their higher education at community colleges, remedial math has become an insurmountable barrier that ends their aspirations for a degree or certificate due to the requirement to complete a college-level math course. Some students must take as many as four remedial courses before they are considered college ready. Members of The National Center for Public Policy and Higher Education and the Southern Education Board found that as many as 75% of incoming college freshmen needed remedial work (National Center for Public Policy, 2010). In addition, more than 90% of students entering some community colleges were deemed insufficiently prepared to start college-level work (Kerrigan & Slater, 2010). Math in particular appears to be difficult for a large proportion of the community college student population (Achieving the Dream, 2006c).

The fact that many students are leaving high school without the math skills they need to be considered college ready is a problem. In the US, it is common practice for elementary schools to promote students from grade to grade based on seat time (the amount of time a child spends sitting in school) and age. This concept of social promotion is the practice of passing students along from grade to grade with their peers even if the students have not satisfied academic requirements or met performance standards at key grades. It is only when the student begins high school that they are held fully accountable for mastering skills in order to be promoted. This problem is further compounded when a low-skilled student is placed into a ninth grade developmental math class and they are taught third grade through eighth grade skills again, the same way that they have always been taught, but which had not previously been effective. These students may continue to fail, which possibly leads to them remaining in a developmental class for enough semesters to keep them from meeting the four math credit requirement in Arizona schools. Ultimately, this may result in the student not graduating from high school or barely passing and not being prepared for college.

Would the introduction of Internet-based technologies improve student achievement in math? To address this question, I decided to explore the relationship between math interventions and student achievement. Based on my prior experience as a high school math teacher and prior research, my view was that a significant difference in achievement would occur when some form of Internet-based technology is blended with traditional teaching of math with developmental learners at the freshmen high school level.

Personal Significance

Several years after my high school experience, while working in the construction field, I decided to obtain a certificate in project management to build my skills as an effective manager and leader. Upon enrolling at Glendale Community College in Arizona, I was required to take a math placement test. The results of this test deemed me unprepared for college-level math. I was placed into developmental math classes for four semesters before I had the foundation I needed to be successful in a college math class. I remember thinking how badly I wished a teacher in my high school had noticed my low math scores and had helped me. As a result of the remediation requirements and great teachers at the college, I finally understood math. Feeling positive about my newly acquired math skills, I decided to make another change—I changed my degree to education with the belief that I might change math teaching practices to include people like me who fall through the cracks and leave high school without the skills needed to be college ready. Since receiving my teaching degree, I have taught math in grades seven through nine. At every grade level, I have found students who, like me, simply did not understand math. I have learned that understanding math concepts does not happen overnight; students have gaps in their learning that grow over time. I have also learned that in the US, it is common practice to promote students from grade to grade, based on age, because elementary schools rely on high schools to address the math ability problem. Once in high school, many will stay in a freshmen level high school algebra class until they have the skills needed to advance to algebra II or geometry. Passed from grade to grade without having mastered appropriated grade level skills, gaps in student learning occur, and when left unremediated, those gaps may result in frustration and sometimes hopelessness. As a former high school math teacher, I tried to assist these students and have come to the conclusion that more than just the teacher is needed to make large, timely gains.

In this study, I analyzed a blended learning environment with struggling freshmen math students to find out the potential of technology for enhancing math learning. My aspiration was to find out if the addition of technology motivates and engages this population of students so that they might acquire grade-appropriate math skills by the end of their freshmen year and go on to graduate from high school with the ability to proceed, without remediation, into college.

Purpose of the Study

There are two societal concerns taking place right now that make this study relevant. First, this study is being conducted at the same time as the implementation of the Common Core State Standards (CCSS) for college and career readiness. These standards are a result of over a decade of math research, which concluded that the math curriculum in the US must become substantially more focused and coherent in order to improve math achievement. In addition to ensuring a common set of standards for all states, the new standards seek to address the problem of a curriculum that is presently considered by many as a "mile wide and an inch deep," which is a phrase used by the scholar William Schmidt to describe the academic situation (Schmidt, 2004, p. 1). Absent from the CCSS is any discussion of intervention methods or materials necessary to support students who are well below grade-level expectations. The second societal concern, which begins with the high school graduating class of 2013, is that Arizona has added the requirement of a fourth year of math to better equip students for the 21st century. Again, this new requirement does not include a discussion of intervention methods for the developmental math or slower learner to accomplish this requirement.

In an effort to increase skills, and possibly transform the way students learn, grant money to support blended, personalized learning environments is becoming increasingly available. On October 17, 2012, The Next Generation Learning Challenges (NGLC) announced that grants totaling $5.4 million were available for 13 new models of personalized, blended learning at the secondary and postsecondary levels. Rio Salado

College in Phoenix, Arizona, which is part of the Maricopa Community College District, received almost $1 million of those funds to develop high-quality, low-cost, accessible educational opportunities for students in early college programs (Boyle, 2012).

The U.S. Department of Education announced in August 2012 that it would provide nearly $400 million through four-year awards that range from $5 million to $15 million per district, depending on the population of students served through the plan. The purpose of these funds is to implement local reforms that personalize learning, close achievement gaps, and take full advantage of 21st century tools that prepare students for college and their careers (U.S. Department of Education, 2012).

Research Questions

This study seeks to answer two main questions:

1. What is the impact of using technology as a teaching method on math achievement for low achieving ninth grade students?
2. How do students feel about technology as an instructional method in their math class?

This study was designed to determine if receiving a computer or technology-based intervention increased struggling math learners' achievement. In this inquiry, I worked as an observer and data collector with three classes of freshmen math students over one quarter during the fall 2012 semester at an Arizona high school. Observations and data were collected in an effort to determine which of three instructional methods for teaching math to high school students with math deficiencies was the most effective. A single-subject, alternating-treatments research design was used in which two interventions were presented in similar fashion except for the addition of different types of technology. The purpose was to compare three instructional methods: computer-aided or blended instruction, face-to-face blended instruction with the implementation of Internet-based tutorials (see Appendix A), and traditional face-to-face teaching.

Measurements included the use of a pre- and posttest to evaluate achievement growth, a curriculum specific benchmark test, and focus groups of low-ability ninth grade students. One focus group of students from each class was conducted to examine, among other things, the role of the affective channel, which includes the portion of the brain that is responsible for feelings, values, appreciation, enthusiasms, motivations, and attitudes—all of which are important to improved learning. Ignacio, Nieto, and Barona (2006) reported that such factors could well explain the anxiety that students felt when faced with a problem to solve their sensations of unease, of frustration, of insecurity, and the low level of self-esteem they experience, which often prevented them from successfully tackling math tasks (p. 17).

Educational Significance

The general problem of low math achievement for many students has both personal importance and societal importance that affects the entire nation. When students struggle for long periods, there can be detrimental consequences such as students dropping out of school or students who persevere but leave high school without the skills needed to enter a college level class. When students drop out of high school, our society looses valuable assets. It is not fair to the student and it is not fair to the nation. In 1989, the National Research Council (1989) reported:

> More than any other subject, mathematics filters students out of programs leading to scientific and professional careers. From high school through graduate school,

> the half-life of students in the mathematics pipeline is about one year; on average, we lose half the students from mathematics each year, although various requirements hold some students in class temporarily for an extra term or year. Mathematics is the worst curricular villain in driving students to failure in school. When mathematics acts as a filter, it not only filters students out of careers, but frequently out of school itself. (p. 7)

Previous studies have turned up conflicting evidence concerning remedies for this problem. Research suggests that promoting unprepared students does little to increase their achievement or life chances. At the same time, research also shows that the practice of having students repeat a grade often has negative educational consequences, such as increasing their chances of dropping out of school (U.S. Department of Education, 1999).

This study examined the implementation of a program in a real-life setting based on the theory that technological pedagogical content knowledge (TPACK) are all interconnected in a systems approach, which has been widely accepted but little tested in this environment. The population that has been chosen for this study is sufficiently unique and the results of the study seem likely to advance knowledge in the field.

Using either face-to-face teaching or computer-aided instruction (CAI) in isolation has proven to be ineffective for students struggling with math (Boylan, 2002; U.S. Department of Education, 2005). Technology itself is not the solution. On January 22, 2013, Michael Crow, President of Arizona State University (ASU), said in his "2013 and Beyond" speech that in addition to learning from a teacher, students need different modes of learning that incorporate enrichment and remediation at each students' individual pace. To further drive home the point of teaching all students, the vision of

ASU includes the following statement: “To be measured not by who we exclude, but rather by who we include” (ASU vision statement).

Blended learning offers all students the opportunity to learn concepts from many different approaches that make acquiring information appropriate and comfortable. Personalized learning provides opportunities to engage in a manner relevant to one's abilities and interests so that he or she can achieve his or her full potential (U.S. Department of Education, 2005). The online portion of the curriculum provides students with a flexible learning environment that enables them to have continuous access to high-quality curriculum any time, anywhere, and at their own pace. This study sought to find the suitable amount of blend needed to motivate low-skilled learners to engage with and achieve in math.

Although the concepts of blended learning are not new, the applications in this environment are novel. Finding the right blend of media is the key to creating the optimal instructional design that will best impact achievement for these students. This study examined student achievement based on the teacher's use of different technologies while attempting to find the optimal amount of blend to fit the needs of students while considering their skills gaps and different learning styles.

Definition of Terms

For the purposes of this study, the following terms are defined:

Blended learning. This term is used for a formal education program in which a student learns at least in part through online delivery of content and instruction with some element of student control over time, place, path, or pace and at least partially at a supervised brick-and-mortar location away from home (Staker & Horn, 2012).

Causal relationship. This term describes when one variable causes a change in another variable. This type of relationship is investigated by experimental research in order to determine if changes in one variable actually result in changes in another variable (Cherry, 2012).

Computer-aided instruction (CAI). For the purposes of this study, *computer-aided instruction* is an inclusive term for computer-mediated instruction and computer-aided instruction where the delivery format requires a computer and an Internet product to deliver the content of the course. The computer evaluates student's test performance, provides feedback, promotes mastery, guides students to personal and appropriate instructional resources, and keeps records of students' progress.

Developmental math student. This term describes someone who has tested or been placed into a remedial math course. At the college level, these courses are commonly identified by below 100 level numbers in their prefix (i.e., MAT 092).

Face-to-face traditional instruction. In her book *Blended Learning in Grades 4-12*, Catlin Tucker (2012) described the term *traditional classroom* as a classroom usually set up with rows of desks facing a board at the front of the room. Students have pen and paper ready to take notes as the teacher lectures and projects information onto the board. In this classroom, the information flows from the teacher to the students. The teacher stands at the front of the room with all students facing him or her. Students are asked to sit quietly and refrain from talking to one another for most of the period. Cell phones and other wireless devices are turned off and stored in backpacks where they will not distract from the learning (Tucker, 2012, p. 5).

Informal online learning. This term applies to anytime a student uses technology to learn outside a structured education program. For example, students could play educational video games or watch online lectures on their own outside of any recognized school program (Staker & Horn, 2012). In many cases, the student may repeat the instruction as many times as needed.

Remedial. This term applies to basic skill education that is below grade level. It is commonly used in math, English, or reading and writing, and it is a class level that provides instruction to improve basic knowledge and skills within a subject and to develop studying and social habits related to academic success at the college level (Aud et al., 2011).

Technology-rich instruction. This type of instruction refers to a structured education program that shares the features of traditional instruction, but also has digital enhancements such as electronic whiteboards, broad access to Internet devices, document cameras, digital textbooks, Internet tools, and online lesson plans. The Internet, however, does not deliver the content and instruction, or if it does, the student still lacks control of time, place, path, and pace.

Summary

This chapter described the purpose of studying a math intervention using a blended learning model with the use of technology, content, and pedagogy in an attempt to achieve success with students who struggle with math. I related personal experiences to convey my passion toward the study. This dissertation set out to find out if there was a relationship between the addition of technology in a ninth grade low level math class and student achievement. If a relationship existed, then this study would also seek to determine how much technology was required to make a significant difference. By identifying the optimal blend of technology and face-to-face teaching for secondary ninth grade students in a developmental math-learning classroom, the analysis adds to the field of study.

This dissertation is organized into five chapters. Chapter 2 focuses on a review of the literature by first providing background on the problem with US and Arizona math score statistics to illustrate the need for this study. TPACK is introduced as one framework for adding technology to math education through teacher pedagogy and to situate the positive aspect of technology in the classroom. CAI adds another component of positive uses of technology. Blended learning studies show the best combination of teaching and computer integration in the classroom. A summary of these components sets up the need for technology infusion in the development of ninth grade math curriculum and explains the need for this study. Chapter 3 describes the methods used in this mixed-methods study and discusses the purpose of focus groups, pre- and posttest questions, and provides details relevant to the data collection process. An analysis of the data collected through focus group discussion and pre- and posttest results relative to the research questions appears in Chapter 4. Chapter 5 offers a summary, conclusions, and suggestions for further research.

Chapter 2

Literature Review

Introduction

This chapter includes a systematic overview of the research literature on blended learning technology in the math classroom and computer-aided math interventions. Psychological Information (PsycInfo), Education Resources Information Center (ERIC), Proquest, What Works Clearinghouse (WWC), Science Direct, and several other databases provided electronic, peer-reviewed journal articles on interactive computer-aided learning. Articles were discovered using the following subject phrases as search criteria: computer-aided instruction, computer-assisted instruction, computer-managed instruction, mastery learning, web-based learning, web-based instruction, multi-media instruction, Internet-instruction, hybrid, personalized system of instruction, performance-based instruction, computer algebra system, interactive, blended instruction, blended learning, and computer instruction. The bibliographies of the articles found in the initial search were also reviewed for additional pertinent references.

This study focused on the effects of blended learning (as opposed to computer-only programs and solely technology-rich environments) where the teacher has a central instructional role and online resources are tools to enhance teaching and learning. In blended learning courses, students engage in a variety of face-to-face, whole class, small group, and individual activities to learn the targeted concepts and skills just as in a traditional setting. However, in some blended learning environments, instructional materials include self-paced technological tutorials and activities, which provide instant feedback based on student performance.

This literature review is organized in nine sections. The first section reviews math achievement and underachievement in the US. This section illustrates the need for early interventions for high school students who struggle with math. The next section situates the study in the state where it takes place and reviews the literature pertaining to math achievement and underachievement in Arizona. A summary of math achievement and support for this study follows, which is in turn followed by a review of math reform and the role of technology that supports the need for technology in the classroom. The next section is dedicated to technological, pedagogical content knowledge (TPACK) to show the importance of technology use as a methodology for teacher's practice. The literature review then discusses computer-aided instruction (CAI), which highlights computers as a vital part of blended learning and provides a deeper explanation of CAI for the purpose of narrowing the topic from technology to computers in the classroom. CAI is also discussed in connection with community colleges, and blended learning studies at this level are addressed. Following that discussion is literature on blended learning as an intervention in the particular context of achievement in math, which leads into a discussion of blended learning studies. Finally, a summary of the literature is provided.

The Problem: Low Math Scores in the US

The US has a population in excess of 300 million people, which equates to approximately a 10% increase since the year 2000 (U.S. Census Bureau, 2010a). With more than 17 million students in school at the secondary level, or grades nine through 12, (Wolfram, 2013), it is perplexing to comprehend the number of students who will enter postsecondary education unprepared for college-level work, and as a result of this unpreparedness, they will be required to take remedial courses. Each year, the number of students needing remedial math classes is increasing (Hodges & Kennedy, 2004; Krzemien, 2004). Remedial courses, usually in math, English, or reading and writing, provide instruction to improve basic knowledge and skills within a subject and to develop studying and social habits related to academic success at the college level (Aud et al., 2011).

In March 2012, the U.S. Education Reform and National Security report by Joel Klein and Condoleezza Rice and issued from the Council on Foreign Relations was designed to offer recommendations to build upon today's U.S. educational system. The report declared that the U.S. education system was so failed that it put U.S. national security at risk. The report stated that 25% of students who drop out of high school are unqualified to serve in the armed services and approximately 30% of high school graduates who graduate do not know enough math, science, and English to perform well on the mandatory Armed Services Vocational Aptitude Battery (Klein & Rice, 2012, p. 3).

The U.S. Education Reform and National Security report warned that the US cannot be two countries—one educated and one not, and one employable and one not. Such a divide would undermine the country's cohesion and confidence and the US's ability and willingness to lead. Furthermore, it defies the notion that "opportunity and promise for all Americans are bedrock principles upon which this country was founded" (Klein & Rice, 2012, p. xiv).

Approximately 6% of the U.S. population is attending school at the secondary level (Wolfram, 2013). As the population in this group begins to make their way to college, many find that they are underprepared to fully achieve at that level (American

College Test, 2011). Dr. Michael Kirst, a professor emeritus of education at Stanford University who is also the president of the California State Board of Education and has studied the proliferation of remedial courses on American campuses, stated that every year more than 60% of students who enroll at two-year colleges take remedial courses (Kirst, 2011). These first-year college students discover that, despite being fully eligible to attend college, they are not really ready for postsecondary studies. After enrolling, these students learn that they must take remedial courses in English, math, or reading and writing, which do not earn college credits. Dr Kirst (2011) further stated:

> Right now, high schools hand students off to colleges and declare victory. . . . They say, "A high percentage of our graduates went to college," but they don't look at how many had to take remedial courses or never got a degree. The colleges blame the high schools for not preparing students, but do not work to align the courses. The two systems do not communicate well at all. (p. 3)

Kinney (2001) suggested three reasons that explain why college students are in need of developmental math courses when they arrive at postsecondary institutions: (a) they did not take the relevant courses in high school; (b) they took the relevant courses but did not master the content; or (c) they have forgotten much of the content that they had previously mastered (p. 10). The gap between college eligibility and college readiness has attracted much attention, yet the situation persists unchanged. While access to college level classes remains a major challenge for some students due to skill deficiencies, states have been much more successful in getting students into college than in providing them with the knowledge and skills needed to complete certificates or degrees. Even those students who have done everything they were told to do to prepare for college often find their new institution considers them unprepared after they have arrived or enrolled. Their high school diploma, 12 years of school, high school exit examination scores, and college preparatory curriculum did not successfully result in college readiness.

In 2011, only 25% of graduating seniors who took the American College Test (ACT) exhibited college and career readiness in reading, writing, math, and science**.** Likewise, the 2010 U.S. Census Bureau survey reported that 27.9% of the nation and 26.3% of Arizona residents over the age of 25 earned a bachelor's degree between 2006 and 2010. ACT scores indicated that the 2011 class was best prepared for college-level English courses, with 73% meeting standards for that subject, though were most likely to need remedial classes in math and science. Although the results are slightly better than in 2009, only 24% of the 2010 graduating class met all of ACT's four thresholds. Overall, the ACT Condition of College & Career Readiness 2011 Report highlighted a glaring disconnect between finishing high school and being ready for the academic challenges of college: 45% of those tested met the math benchmark for college and career readiness (ACT, 2011, p. 3). If one were running a business and only satisfied half of their customers, then it seems certain that they would not continue to be in business; yet, this has been the case for the US with regard to math for decades. Regarding this situation, Tinto (2008) wrote:

> We must stop tinkering at the margins of institutional life, stop our tendency to take an "add-on" approach to institutional innovation, and stop marginalizing our efforts and in turn our academically underprepared students, and take seriously the task of restructuring what we do. (p. 3)

This quote suggests a need to completely overhaul the way math is taught in order to achieve a different outcome.

Table 1 shows average math test scores in the US in 2009. The ACT reported a score of 21 out of a possible score of 36. It also stated that only 42% of the students who took the test were college ready, which means that they most likely will earn a C or better in a college algebra class. The U.S. standardized test for college admissions (SAT) reported an average math score of 516 out of a possible 800. The Program for International Student Assessment (PISA) reported an average math scale score of 487 out of 1000. All results underscore the lack of math ability and preparedness for college or careers:

Table 1

Average Math Test Scores in the US in 2009

Test	Average Score	Possible Score
ACT	21	36
PISA	487	1000
SAT	516	800

Note. Data obtained from ACT, SAT, and PISA test results. Information can be found at http://www.act.org/newsroom/data/2009/pdf/National2009.pdf, http://nces.ed.gov/fastfacts/display.asp?id=171, and http://nces.ed.gov/surveys/international/reports/2011-mrs.asp#mathematics.

To further emphasize the importance of much-needed math interventions, the convention on the Organisation for Economic Co-operation and Development (OECD) reported the worldwide average score for 15-year-olds taking the PISA test was 496 out of 1000. The U.S. math score for 15-year-old students was below that score, and below the average of the 34 OECD member countries in 2009 as reported in the National Center for Education Statistics (NCES) (U. S. Department of Education, 2009). The poor performance of U.S. students has led math educators to question their instructional practices.

Math Achievement and Underachievement in Arizona

To situate the math scores in the context of the location of this study, data from the Arizona Department of Education State Report Card 2010-2011 indicated that 64% of Arizona's high school students passed the Arizona Instrument to Measure Standards (AIMS) math test in 2011 (see Figure 1). Pearl Chang Esau, President and CEO of Expect More Arizona in 2012, sat down with Arizona's Superintendent of Public Instruction John Huppenthal to gain his firsthand perspective on the state of kindergarten through 12th (K-12) education in Arizona. To summarize, he believed that the education system needed to change and stated that successful students who graduate from high school must be "tech-savvy, task flexible and critically thinking, adaptive problem solvers" (Esau, 2012, p. 3).

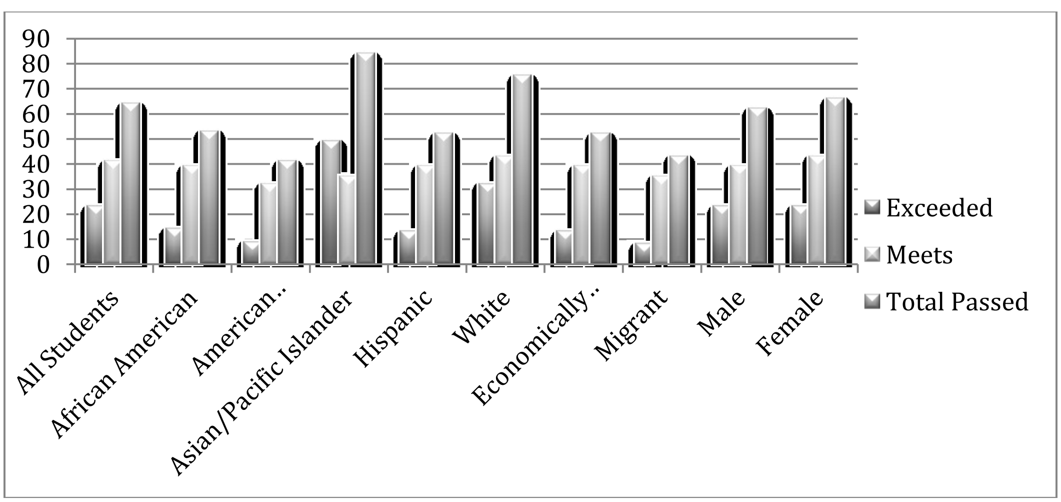


Figure 1. Arizona high school students' 2011 AIMS math test scores. Data from the 2010-11 State of Arizona Department of Education State Report Card.

Superintendent Huppenthal supported the idea of blended learning classrooms with innovative technology and believed it would result in significant academic gains for students; he was dedicated to taking his department in that direction. He understood that students came to class with varying amounts of information and that they learn differently and on different timelines. He proposed that a one-size-fits-all method of instruction created a system of winners and losers whereby some students are trying to catch up and others are waiting for the teacher to catch up with them (http://www.expectmorearizona.org/learn-more/newsletters/raising-expectations-april-2012/). In this scenario, and as indicated by the data in Figure 1, many students are not achieving grade level expectations.

Summary of Achievement Scores

As reported by ACT, SAT, PISA, and the OECD, average U.S. math achievement scores were low. Students continued to graduate from high school without all the skills needed to be considered college ready. This lack of success in math began to drive new reforms. One such reform is a four-year math requirement to graduate from Arizona high schools. Common Core State Standards (CCSS) designed to focus on college and career readiness skills are accepted by all but five U.S. states (http://www.corestandards.org/), and new curricula created by many districts and teachers integrate CCSS. If past reforms are any indication of future promise, though, this may not be enough to close the achievement gaps for students with low skills.

For students with low math skills, the creation and implementation of new standards and additional math classes may only address a small portion of the problem.

Math education depends heavily on foundational learning and mastery. Nevertheless, math education traditionally follows the spiral method whereby instead of teaching concepts in depth to the point of mastery, teachers simply touch on a wide number of math concepts. In this case, numerous, varied topics are presented in units and some students may not be given the time to explore the same topic for several months or possibly until the next grade level. As a result, some students never truly master a concept and therefore lack the foundation needed for connecting concepts and transferring basic knowledge to more complex math. Without basic, complete mastery, students encounter a compounding effect, which creates gaps in skills. Because of the gaps, many students fall behind in grade level skills (Schmidt, McKnight, & Raizen, 1997). Today, too many students have gaps in their math skills and are leaving the U.S. K-12 education system without the skills needed to be considered college ready or military ready in math, as evidenced by ACT, SAT, PISA, and other tests.

Math Reform and the Role of Technology

Professional organizations of math educators have been promoting the reform of math education dating since the 1920s when The National Council of Teachers of Mathematics (NCTM) was founded. The NCTM remains at the center of math education. The association's influence has been evident in the growth of research-based math teaching methods, curriculum, focal points, and standards. Most recently, NCTM's (2008) stated position on technology is that:

> Technology is an essential tool for learning mathematics in the 21st century, and all schools must ensure that all their students have access to technology. Effective teachers maximize the potential of technology to

develop students' understanding, stimulate their interest, and increase their proficiency in mathematics. When technology is used strategically, it can provide access to mathematics for all students.

This suggests that those who have struggled with math concepts may benefit from the infusion of technology into current teaching methods.

In 1996, President Bill Clinton announced a transformative vision for computing in schools. Christensen, Horn, and Johnson (2008) quoted Clinton when discussing the vision of technology and education, which included:

> (1) modern computers and learning devices available to all students, (2) classrooms connected to one another and the outside world, (3) making educational software an integral part of the curriculum and as engaging as the best video game, and (4) having teachers ready to use and teach with technology. (p. 72)

Technology tools in the math classroom can include the use of calculators, interactive software, spreadsheets, online tutorials, etc., to enhance teaching and learning. This is not to say that technology is the cure-all to math achievement for all students, because it cannot replace conceptual understanding, computational fluency, or problem-solving skills (NCTM, 2008). However, in a balanced math program, the strategic use of technology enriches math teaching and learning when teachers are knowledgeable decision makers in determining how much technology to use, when to use it, and what type of technology is appropriate for various learning environments.

Since digital technologies have evolved, strategies for their effective integration into the learning of math have evolved as well. Technology has forever changed what people need to learn as well as the way people acquire information. To reach today's digital natives (those who have been interacting with technology from an early age), it is important that math teachers have an understanding of modern digital technologies in math curriculum and instruction. To this end, other math-related organizations such as the International Society for Technology and Education (ISTE) challenged teachers to think about the technology skills and knowledge students would need in an increasingly tech savvy world (Niess et al., 2009, p. 6). In 2002, the National Educational Technology Standards for Teachers (NETS-T) were released (ISTE, 2002). ISTE's NETS-T was the comprehensive framework for digital-age learning, teaching, and leadership. They defined what students, teachers, and administrators should know and be able to do with technology. At the same time, with the best intentions for reform, these standards did little to change instructional practices in the classroom (Niess et al., 2009). In 2007, ISTE transitioned from its original intent to provide basic skills and knowledge needed to operate the technology to how to effectively use the technology through NETS-S (NETS for students). Earle (2002) framed the shift most clearly when he wrote:

> Integrating technology is not about technology—it is primarily about content and effective instructional practices. Technology involves the tools with which we deliver content and implement practices in better ways. Its focus must be on curriculum and learning. Integration is defined by not only the amount or type of technology used, but by how and why it is used. (as cited by Niess et al., 2009, p.7)

TPACK: Technological Pedagogical Content Knowledge

With the increasing use of Internet-based devices, the development of sophisticated software in our society, and the desire to integrate both into the classroom, professional organizations like NCTM and ISTE have called for students and teachers to become effective users of technology (ISTE, 2002; NCTM, 2008). The Association for Mathematics Teacher Educators (AMTE) wrote in their position statement that "mathematics teacher preparation programs must ensure that all mathematics teachers and teacher candidates have opportunities to acquire the knowledge and experiences needed to incorporate technology in the context of teaching and learning mathematics" (AMTE, 2006, p.1).

To integrate technology effectively, teachers need to have knowledge of pedagogy in their specific content area (Niess, 2005). The concept of TPACK builds on Lee Shulman's (1986) theoretical framework of pedagogical content knowledge (PCK). To build an effective framework for technology integration in the classroom, leading educators have paved the way by adding technology to Schulman's existing PCK framework. The interconnection and intersection of technological, pedagogical, and content knowledge for thinking and learning math with technologies constitutes the TPACK acronym (Niess, 2008). Technology in the classroom is a fluid process that continues to change the way students learn and teachers teach, and TPACK's intention is to provide a framework for viewing teachers' knowledge necessary for the design of curriculum and instruction focused on the preparation of their students thinking and learning of math with digital technologies (Niess et al., 2009). Mishra and Koehler (2006) created a graphic that showed the heart of the TPACK framework as a complex interplay of three primary forms of knowledge: content knowledge (CK), pedagogical knowledge

(PK), and technological knowledge (TK) (see Figure 2).

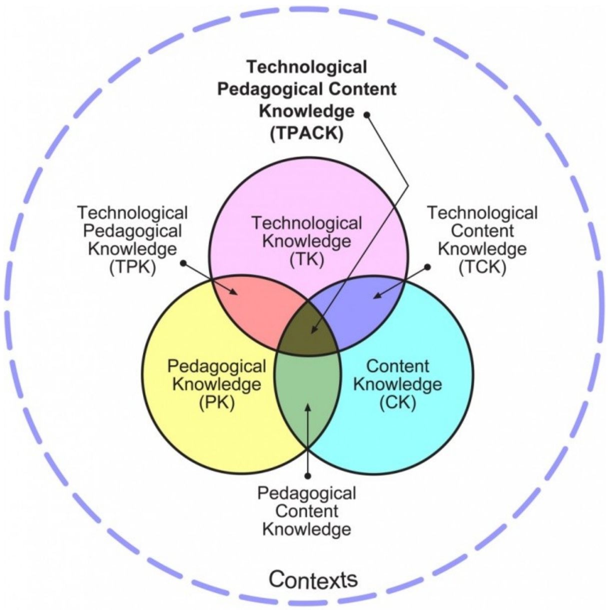


Figure 2. The TPACK model by Mishra and Koehler (2006). Used from http://tpack.org/ and reprinted with permission.

With the addition of the model, TPACK has been labeled by some as the Total PACKage required for integrating technology, pedagogy, and content knowledge in the design and instruction for thinking and learning math with digital technologies (Niess, 2008). This framework informed teachers how to integrate knowledge for appropriately teaching math with suitable technologies, which can assist learners who struggle with math.

Computer-Aided Instruction (CAI)

To catch the wave of technology-infused math reform, TPACK offers a framework for the addition of CAI for struggling math learners in the traditional high school classroom. Although remediation efforts for math learning disabilities have generally focused on early identification and intervention, recent studies indicate that difficulties persist for older children (Gersten, Jordan, & Flojo, 2005; Mabbott & Bisanz, 2008). Another study (Jordan & Montani, 1997) found that students with math deficiencies would be better served if problems were presented visually as compared with orally via direct instruction. In addition, Guskey (2010) emphasized the importance of mastery learning as foundational blocks: “the core elements of mastery learning also provide the foundation for many innovations and interventions that teachers are implementing in classrooms today” (p. 1). Christenesn et al. (2008) wrote that computer-aided learning could fill in gaps for failing students when remedial classes are unavailable (p. 94).

Teaching in a lecture-style venue is typical for math instruction (and for other subjects, too) but can become problematic for some learners because the classes are instructor-paced and not learner-centric. Often times, this method of delivery becomes whole-group based in which the teacher is forced to teach to the middle, which leaves advanced learners bored and slow learners confused. Eventually, many students are left behind as the curriculum moves forward without them (Esau, 2012; Johnson & Rubin, 2011).

Twentieth century research on math pedagogy concluded that CAI programs have failed to revolutionize instruction because most have been designed to replicate traditional instruction; thus, they often produce the same results as previous instruction methods (Englemann, 1992, & Skinner, 1963, as cited by Johnson & Rubin, 2011). Contrary to Tinto’s (2008) suggestions, the literature reported that computers are being used as an add-on to the current educational system to enhance direct instruction. Christensen et al. (2008) wrote, “Schools have crammed the computers into the existing teaching and classroom models. Teachers have implemented computers in the most common-sense way—to sustain their existing practices and pedagogies rather than to displace them" (p. 84). As previously illustrated by statistical data, continuing to do what we have always done has produced the same results. It is only when technology is used differently and for a different purpose that we may see different academic outcomes.

Early research found that blended learning has been widely investigated in the areas of business and higher education for the learner but little tested for effectiveness at the K-12 grade levels. In 2010, the Department of Education published a meta-analysis review of online learning studies, including those that focus on blended learning, and found that there exists very little research on the effects of online learning for K-12 students. Data from this research showed that between 1994 and 2008, there were only five experimental or controlled quasi-experimental studies that compared the learning effectiveness of online and face-to-face instruction for K-12 students. Means, Toyama, Murphy, Bakia, and Jones (2010) reported that student populations from these studies included eighth grade students in social studies classes, eighth and ninth grade students taking algebra I, middle school students taking Spanish, fifth grade students taking science in Taiwan, and elementary school-age students in special education (p. xiii). Three of these studies favored blended learning conditions (Means et al., 2010).

Finding a solution to low math achievement is of constant concern to policy makers and educational leaders from kindergarten through college in the US. Blended courses offer an alternative learning method for students who do not learn well in a lecture-only environment (Garnam & Kaleta, 2002; Spika, 2002). According to Means et al. (2010), policy makers and practitioners wanted to know about the effectiveness of Internet-based interactive learning approaches and need information about the conditions under which online learning is effective (p. xi). Additionally, Cavalluzzo, Lowther, Mokher, and Fan (2012) noted that there was a considerable body of literature on both technologies' effectiveness in improving instruction for teacher delivery and how teachers can use technology most effectively. However, they reported that the evidence on the effectiveness of technology in improving student performance was mixed (p. 3).

Studies that are more recent show favorable results. In a comparison of 10 studies, Johnson and Rubin (2011) found that in eight of them, CAI instruction generated a better performance than lecture-style instruction (p. 66). Other findings indicated that instruction should be designed to promote more meaningful responses than those required by a simple digital textbook. In addition, interactions should be confirming, which requires the learner to show they understand a given point (mastery) before proceeding to new material. Furthermore, using CAI for mastery can be a game changer for some students: "The possibility of allowing economical, enforced, and demonstrative interactions is the one unique offering of CAI, one that distinguishes it from other instructional alternatives" (Johnson & Rubin, 2011, p. 58).

Wenglinsky (1998) created a national assessment on the effects of simulation and higher order thinking technologies on math achievement. Findings led to the conclusion that the use of a computer has positive effects on math instruction. Students who used the software implemented by the study showed gains in math level, and teachers who were trained on how to use the computer showed gains in math scores. Interestingly, this study found that the computer is more effective in high schools than primary schools.

In another study, doctoral students, Aliasgari, Riahinia, and Mojdehavar (2010) studied the effectiveness of CAI on attitude and achievement in math with students in two high schools in Iran. They compared CAI with traditional instruction and found that students' motivation and achievement increased in the CAI class as a result of this intervention. The authors suggest that CAI should be used with all classes and especially math because abstract concepts are taught.

CAI: Community College Connection

Upon graduating from high school, students seeking an associate degree or a transfer to university must take a placement test to assess reading, writing, and math skills. At that point, students who did not receive the correct intervention for their learning style usually find that they test into a developmental math class.

Epper and Baker (2009) studied many community colleges in the US and found that in most cases there was not a significant difference in learning outcomes based on teacher delivery methods. However, they recognized that teaching developmental learners in a variety of ways enhances students' persistence (Epper & Baker, 2009, p. 13).

At the community college level, CAI traditionally has been used as an add-on to direct instruction. Students typically use some form of math tutorial or practice software in a computer laboratory setting or online and work independently to build skill levels while filling in gaps in learning. Epper and Baker (2009) found that many of the math education software products available are designed to identify skill deficiencies and use artificial intelligence systems to help students master increasingly challenging material through feedback and formative assessment. Most programs are commercial products available from a variety of publishing and educational software companies. They used the following examples in their research: My Math Lab, Math Zone, ALEKS, PLATO, Cognitive Tutor, EnableMath, and Nspire. This study was designed to use a CAI intervention similar to these products at a precollege grade level. Theoretically, if the intervention proves successful and is then implemented in precollege curricula, then the need for this intervention at the college level may, over time, be partially eliminated.

While scientific evidence based on controlled experiments is lacking, there are studies documenting improved results for developmental math students who use CAI (Testone, 2005, as cited by Epper & Baker, 2009, p. 10). For instance, one of the community colleges researched in Epper and Baker (2009) in Denver had a 40% success rate in college math three semesters after the technology intervention in comparison to a 12.5% success rate for the comparison group after five semesters (p. 8). The math classes used a mastery approach supported by Pearson's MyMathLab software (Epper & Baker, 2009, p. 8).

Epper and Baker (2009) also noted that students who were successful in algebra II were more than twice as likely to graduate from college as students with less math preparation. Furthermore, the highest level of math completed in high school is one of the strongest predictors of whether a student will enter postsecondary education, be prepared for college-level courses without remediation, and complete a bachelor's degree (Long, Iatarola, & Conger, 2009, as cited by Cavalluzzo et al., 2012). Knowledge of these indicators makes a strong case for early remediation for struggling math learners. The available data suggests that current K-12 methodologies are not doing the job of preparing students for college math. Teachers in high schools may need appropriate technology-enabled means to leverage their skills in order to further engage and excite students to maximize learning. Through the framework provided by TPACK and the standards set forth by ISTE and NCTM, teachers now have the tools to successfully implement technology into their math curriculum.

Blended Learning

The definition of blended learning that is currently accepted in the field has become common in curricular practice, and is expected to evolve, expand, and be refined as needed in order to remain current. For example, in Horn and Staker's 2011 report *The Rise of K-12 Education*, the definition of blended learning included six models whereas in the 2012 report *Classifying K-12 Blended Learning*, blended learning was refined to a four-model taxonomy. The four blended models include: (a) rotation: station rotation, lab rotation, flipped classroom, and individual rotation; (b) flex; (c) self-blend; and (d) enriched-virtual (Staker & Horn, 2012; see Figure 3).

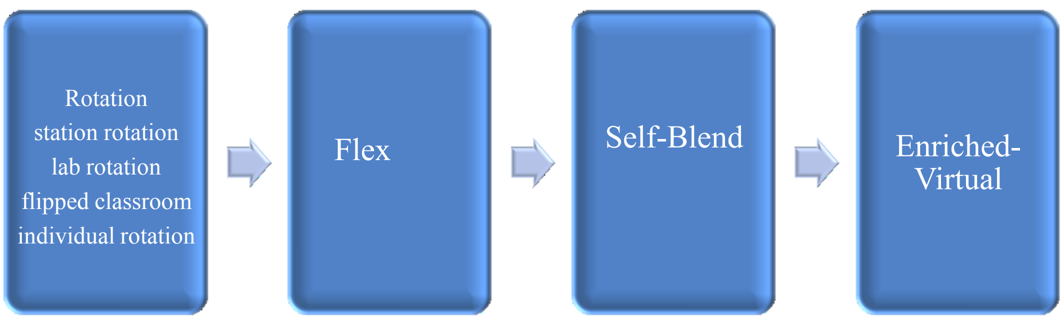


Figure 3. The four aspects of a blended learning model as developed by Staker and Horn (2012). Created with permission from author Heather Staker.

There are many reasons why an instructor may choose a blended learning method over other learning options. Osguthorpe and Graham (2003) identified six reasons why one might choose to use a blended learning system: (a) pedagogical richness, (b) immediate access to knowledge, (c) social interaction, (d) personal agency, (e) cost effectiveness, and (f) ease of revision. Blended learning literature indicates the most common reason instructors chose this method was to combine the best of both worlds:

online and face-to-face, which incorporates all six.

The learning styles of today's students are increasingly viewed as more diverse than ever before. In addition, many students may be more technologically proficient than their teacher. As digital natives, these students have grown up with a computer, have surfed the web, and have used the Internet to conduct research for homework help before they enter high school. Dziuban, Hartman, and Moskal (2012) found that:

> Some characterize today's generation of learners by their technological empowerment: stimulus junkies and gamers who multi-task, demand response immediacy, and communicate by text messaging. They are not proficient in higher order thinking and are unwilling to take intellectual risks and who view problem solving as a series of choices on a monitor. (p. 13)

To reach these learners, an active learning environment may be advantageous. For the learners who struggle, implementing a blend between traditional teaching and the use of technology may be beneficial for addressing various learning styles with those who might need extra practice or repetition.

Blended learning classes may range from fully online with options for face-to-face instruction, to classes that include online resources with limited or no requirements for students to be online. According to Larry Ragan (2007) of Rice University's Connexions, a project for the collaborative development and free sharing of educational content on the web, blended learning is "the planned integration of online and face-to-face instructional approaches in a way that maximizes the positive features of each respective delivery mode" where the goal is to build from each approach and "to create an innovative and effective learning experience for students" (Ragan, 2007, as cited by

Larson & Murray, 2008, p. 9). In this approach, a teacher adds online multimedia to improve her teaching effectiveness and efficiency. She prepares the students ahead of time using face-to-face teaching to create the foundation for class activities and then incorporates CAI. The theory is that blended learning has the potential to offer multi-method instruction through the blend, which can have better results that are increased as more methods are incorporated. Blended learning leverages the strengths of current in-class teachers and extends the total learning experiences of the students through engagement and a strong feedback loop that allows for mastery of skills (Larson & Murray, 2008).

Blended Learning Studies

Researcher and author James Kullik (2003) conducted many formal meta-analytic studies of experimental and quasi-experimental evaluations on the impact of best-described CAI on student outcomes over the last 25 years. Current research might label many of these environments as blended learning (Cavalluzzo et al., 2012). Kullik's (2003) review of 61 studies included seven studies performed in the area of math for Grades 2 through 8. Results reported an effect size (estimated magnitude of a relationship) of + 0.38 for increased math test scores. Kullik also examined six tutorial programs that focused on a single topic in social studies and science from 10 days to six weeks in Grades 3 through 12. His analysis yielded an average effect size of + 0.36 for student test scores.

Other meta-analysis studies on CAI in the traditional classroom published between 1999 and 2003 show small effect sizes. Waxman, Lin, and Michko (2003) looked at 42 journal article studies of approximately 7,000 students with a mean sample size of 184; as a result, 282 effect sizes were calculated from the 42 studies. Most of the studies included in the synthesis used a quasi-experimental pre- and posttest to examine the effects of CAI and online activities for students in traditional K-12 education settings. The authors reported a “small, positive, significant effect on student outcomes when compared to traditional instruction” (Waxman et al., 2003, p. 11). Concerning the views and attitudes of students in the blended leaning environment, Waxman et al. (2003) reported about 57% of the affective outcomes were student attitudes about computers, and 18% were students’ motivation or self-concept (p. 11).

Akkoyunly and Soylu (2006) gathered data directly from students. They used open-ended questionnaires, achievement scores, and they kept a record of the amount of student participation in an online college course. Their study took place in the fall semester in a college class with 64 student participants. Most of the communication was carried out online through a forum, while other materials were downloadable from websites. Students met face-to-face every two weeks. The authors found that students with low achievement felt their barriers to success were having too little face-to-face time with the instructors and difficulty with the technology. The students in this study were completing their online activities away from teacher supervision and without immediate support. This study made the point that blended learning success depends greatly on the self-directed ability, motivation, and attitude of the learner.

More recently, in a bold move to push technology on schools, U.S. Secretary of Education Arne Duncan said on October 2, 2012, that the nation should move as quickly as possible away from printed textbooks and toward digital ones. In addition, Duncan claimed that “over the next few years textbooks should be obsolete” (www.foxnews.com/

politics/2012/10/02/education-chief-duncan-wants-textbooks-to-become-obsolete/). Some in the education reform movement have welcomed this growth of technology in the classroom; however, others who have investigated digitally based programs have found mixed results (Dynarski et al., 2008). In addition, these educators found that various types of education technology applications like Cognitive Tutor, PLATO, and Larson Pre-Algebra had minimal effects on math achievement.

Results from this research prompted a review of more contemporary literature performed by Cheung and Slavin (2011), who set out to find if education technology applications improved math achievement in K-12 classrooms compared to traditional teaching methods without education technology. Data from 75 studies including over 56,000 students at the K-12 level revealed a significant, positive effect in math with educational technology (Cheung & Slavin, 2011, p. 11). Three major categories were tested for academic achievement outcomes: computer managed learning (CML), comprehensive models, and supplemental CAI, including computer-assisted, computer-aided, or computer-based instructional technology. Among the three types of educational technology applications studied, CAI had the largest effect on math achievement, with an effect size of +0.18 (Cheung & Slavin, 2011, p. 17). Over 70% of all studies researched by Cheung and Slavin in 2011 fell into the supplemental program category, which consisted of individual CAI and described programs (as described by the authors) such as PLATO and Jostens. These programs provided additional instruction at students' prescribed level of need to supplement traditional classroom instruction (Cheung & Slavin, 2011, p. 15)

In *The Rise of K-12 Blended Learning*, authors Horn and Staker (2011) of the Innosight Institute, a global strategy and innovation consulting firm committed to advancing the theory and practice of innovation, profiled 40 blended learning programs throughout the US. The profiles provided brief case studies of organizations that were beginning to blend online learning with supervised brick-and-mortar settings (Horn & Staker, 2011). The following school profiles relate to this study.

Grades 6 through 12: all subjects. Carpe Diem Collegiate High School and Middle School (CDCHS) was a charter school located in an urban area of Yuma, Arizona. At the time this study was conducted, the school had been in operation for over 12 years with nearly 300 students learning in Grades 6 through 12. Demographic information indicated that over 60% of the student population received free or subsidized reduced lunches. Per pupil spending was $6,639.00 (http://www.carpediemschools.com/).

CDCHS first launched its blended learning program in the 2006-2007 school year with all core subjects. Technology used in the program included Education2020 with Acuity for additional testing. Students who attended this school arrived each day to a building with 300 cubicles and computers housed in a central learning center, similar to the layout of a call center. Class days consisted of four days from 8:00 a.m. to 4:00 p.m. Students attended school 145 days per year and received a total of 1,007 hours of instruction. Typically, there was little or no outside homework. Students blended their learning by rotating throughout the day between online activities in the learning center and face-to-face classroom instruction where a coach or teacher retaught, enhanced, or applied the material introduced online. Each rotation lasted for 55 minutes. Students completed the cycle between online and face-to-face instruction two to three times per day.

Results of this profile found that in 2009, CDCHS ranked first in its county on the AIMS test in student performance on almost all grade levels and subjects by having at least 90% of all students passing the test in all subject areas. In 2010, CDCHS ranked first in Yuma County in student performance in math and reading and ranked among the top 10% of Arizona charter schools (http://www.innosightinstitute.org/blended-learning-2/blprofiles-innosight/carpe-diem-collegiate-high-school-and-middle-school-cdchs/).

Grades 5 through 8: math. Los Altos School District, located in a suburban area of California, launched their blended learning program in the 2010-2011 school year. Nearly 3% of the student population received free or subsidized reduced lunches and they had a $9,500.00 per pupil funding allotment (http://www.lasdschools.org/).

Starting with the 2011-2012 school year, the blended learning program expanded to include all nine schools in the Los Altos School District—all fifth and sixth grade classrooms, and many seventh and eighth grade math classes, which encompassed over 1,000 students using technology for math instruction and practice.

The technology being used to blend the learning in the Los Altos School District is the program of the Khan Academy. Blended learning in these math classrooms has grown over the last few years from a few simple YouTube videos into a fully featured, interactive educational system that allowed students to learn and measure their progress at their own pace. As directed by individual teachers, students using this program were required to spend fixed amounts of time rotating through Khan Academy during their math period. Students moved through the videos and tutorial lessons and then practiced exercises at their own pace. Students received real-time data on performance and were able to set individual goals that focused on their specific needs; they then worked at their ability to achieve those goals. This model provided teachers with real-time data on student achievement, which enabled them to work one-on-one with struggling students who needed further intervention.

While this profile report is not considered a scientific study, one measure of success has been the California Standards Test (CST) that Los Altos students in pilot year one took at the end of the 2010-2011 school year. In two of the seventh grade classrooms where students did not historically perform well in math, there were significant increases in CST scores. Forty-one percent of the students were proficient or advanced, compared to just 23% the prior year. In the fifth grade classrooms, Los Altos students historically performed quite well and they continued to do so. Over 96% of students in the pilot classrooms were proficient or advanced, but that is comparable to the non-pilot, district-wide performance (91%). CST exam results, however, do not tell the whole story, because the test only measured performance on grade-level skills. Significant benefits in allowing students to challenge themselves with more advanced topics were also noticed with this blended learning model using Khan Academy. At the time of this study, the district was working on how to better evaluate these above-grade-level learning gains (http://www.innosightinstitute.org/blended-learning-2/blprofiles-innosight/los-altos-school-district/).

Grades 9 through 12: all subjects. Virtual Opportunities Inside a School Environment (VOISE) Academy High School was located in the poverty-stricken, crime-ridden neighborhood of Austin on Chicago’s West Side in Illinois and provided schooling for Grades 9 to 12. Almost 100% of these students received free or subsidized reduced lunches, and of the 500 students, per pupil funding was $7,424.00 (http://www.voiseacademy.org/).

Students attending VOISE often entered ninth grade at the fourth grade reading level and fifth grade math level. They often found that jumping into the Apex (personalized digital learning) curriculum was initially too demanding. Thus, the VOISE model has evolved to provide traditional, teacher-led instruction for roughly 20% of the learning time, and online learning for the other 80%. VOISE grouped its students by level to allow teachers to gear the teacher-led instruction time to students at about the same place in the Apex curriculum. Some teachers used this time to introduce key concepts to their class before having the students move individually through an online lesson relating to that topic.

The Apex blended learning environment corresponded to an increase in VOISE's freshman on-track rate by 10% each year since the school opened. The freshman on-track rate was 90% during year three of the blended learning program, which was above Chicago's average freshman on-track rate of 69%. This placed VOISE in the top quintile of Chicago Public Schools high schools (http://www.innosightinstitute.org/blended-learning-2/blprofiles-innosight/voise-academy-high-school/).

Grade 9: math. The U.S. Department of Education published a report on the Kentucky Virtual School's hybrid program in 2012. This hybrid blended learning algebra program for algebra I combined the best features of online and traditional teaching to promote active learning (U.S. Department of Education, 2012, p. vii). The intent-to-treat sample consisted of all ninth grade students in treatment and control schools enrolled on

September 1, 2007. The study enrolled 25 schools in school the 2007-2008 school year (13 treatment and 12 control) and 22 schools (11 treatment and 11 control) in the 2008-2009 school year. The intervention was applied in one school year and evaluated the next fall. The course was structured with 60% face-to-face teaching and 40% use of online resources. The algebra I program prescribed a standard three-part procedure for each lesson. Each lesson began with an activity that activated prior knowledge associated with the day's lesson, and could consist of whole group, small group, or individual work. The second stage introduced new learning, which could include face-to-face or online activities. The final stage was lesson closure, which was designed to have students reflect on their learning by processing information by writing to retain new information. Teachers also used reflection as a formative assessment tool. Cavalluzzo et al. (2012) reported there was no statistically significant main effect of the treatment in the overall sample for performance on the pre-algebra/algebra PLAN test in the fall of 10th grade math. The test results were obtained through the ACT for 10th grade students—a test between the eighth grade EXPLORE test and the usually 11th grade ACT test, but in this case, the 11th grade SAT test. In addition to the intervention, information was collected from teacher surveys and classroom observations. This information was used to describe the extent to which the intervention was being implemented. Lack of significant effects was the result of confounding, uncontrollable limitations of the study.

In other studies, a worldwide trend has developed with technology in schools. There have been several laptop initiatives to increase student achievement in many countries including Australia, Canada, France, and New Zealand (Rosen & Beck-Hill, 2012). The ideas for technology-rich environments for learners have inspired educational stakeholders in the US to implement a similar program. Currently, the US has added a laptop program to 500 schools (Rosen & Beck-Hill, 2012). In an article published in the *Journal of Research on Technology in Education*, Rosen and Beck-Hill (2012) reported on a study of 476 fourth and fifth grade students from four elementary schools in the Dallas, Texas area. The researchers chose to use two experimental schools and two control schools that were demographically matched. The experimental school used technology and the control school used traditional face-to-face teaching methods. The researchers studied their participants during the second year of the program implementation. Their findings showed that learning with technology significantly increased learning achievement. In addition, the study revealed that the technology promoted differentiated learning in the classrooms by effectively implementing a constructivist technology-enriched method. The study also found that more teacher-student interaction occurred by blending technology into the teaching methods (Rosen & Beck-Hill, 2012, p. 236).

Summary

A number of reports from community colleges and the U.S. Department of Education reveal that too many students are graduating from high school without the math skills they need to be considered college ready. As a result, many of these students are forced to take several semesters of developmental math before they are accepted into college math. The literature reviewed in this chapter addressed technology as an intervention in the classroom. The ISTE program challenged teachers to think about the technology skills and knowledge students would need in an increasingly tech savvy world (Niess et al., 2008, p. 6). In 1996, President Clinton addressed the need for computers for all students. Arizona Superintendent Mr. Huppenthal confirmed that students need to be technologically savvy. In 2002, NETS-T released its teaching standards (ISTE, 2002). After some time, researchers found that teachers were not implementing the standards because they did not know how to do so. With increasing knowledge of this fact, leading educators created a model to assist teachers. A model for integrating technology into existing pedagogy and content knowledge—or TPACK—presented a framework that viewed teachers' knowledge as a necessary consideration for designing curriculum and instruction that focused on preparing students to think of and learn about math with digital technologies (Niess et al., 2008). Through the framework provided by TPACK and the standards set forth by ISTE and NCTM, a growing conversation ensued about the need for teachers to successfully implement technology into the math curriculum. A review of the current literature found that, depending on the environment, technology often increased student achievement. Finding the right blend of teaching methodologies within the math curriculum is the focus of this study.

As an addition to traditional instruction, CAI can offer better teaching strategies at the individual level. Unlike group instruction, the pace is tailored to the individual student. Unlike textbooks, interactive engagement occurs. This study set out to find an appropriate blend of teaching methodologies by using different levels of technology for different groups of students in math classes at an Arizona high school. Chapter 3 outlines the methodology used to examine the impact of participation in a technology-infused, blended learning environment with struggling math learners at the ninth grade level.

Chapter 3

Research Methods

This study assessed low-level secondary math students in one high school in Maricopa County in Arizona. The study included three classes, with teaching methods that did not utilize any blended technology as well as methods that included blended technology in the math curriculum. The aim of this study was to assess the academic outcomes of each class to find the impact of technology on academic success. Additionally, I investigated what these students thought and felt about technology being blended into the curriculum as an intervention in their math class.

This study focused on three groups of students who learned the same information using three different methods (see Table 2). Teachers will be introduced in the discussion of Liberty High School. Each group took a pretest before being taught and a posttest after being taught. Outcomes were measured by student academic achievement. Comparing the mean test scores before (pretest) and after (posttest) the students completed a math course. The objective was to determine if the intervention improved students' scores on the test. Data collection consisted of a mixed-methods approach. The mixed-methods design allowed for the use of descriptive statistics for the quantitative analysis (Fraenkel & Wallen, 2006) as well as open coding through a grounded theory approach for qualitative analysis (Auerbauch & Silverstein, 2003; Corbin & Strauss, 2008).

Table 2

The Class, Teacher, and Type of Instruction for the Classes Used in the Study

Class	Class 1	Class 2	Class 3

Teacher	Mrs. Jaycee	Mrs. Jaycee	Mr. Holiday
Instruction Type	Computer-aided Instruction	Add-on Tutorials	Traditional

Research Questions

This study seeks to answer two main questions:

1. What is the impact of using technology as a teaching method on math achievement for low achieving ninth grade students?
2. How do students feel about technology as an instructional method in their math class?

Restatement of the Problem

Too many American students are graduating from high school without the math skills they need to be considered college ready. For those graduates who find themselves starting their higher education at community college, remedial math has become an insurmountable barrier that has sometimes ended their aspirations for a degree or certificate due to the requirement of completion of a college-level math course. Some students must take as many as four remedial courses before they are considered college ready. Members of The National Center for Public Policy and Higher Education, and the Southern Regional Education Board (2010) found that as many as 75% of incoming college freshmen need remedial work. In some community colleges, more than 90% of students who entered the school were deemed insufficiently prepared to start college-level work (Kerrigan & Slater, 2010). Math, in particular, appears to be a nearly insurmountable barrier for a large proportion of the community college student population (Achieving the Dream, 2006c).

Background

Some students who have been struggling with math have experienced years of failure and frustration by the time they receive an intervention. These struggling learners may benefit from early interventions aimed at improving their math ability and ultimately preventing subsequent failure. Some instructional approaches such as direct instruction attempt to overcome this problem by using placement tests to form homogeneous groups in an attempt to ensure that everyone in the group is an average learner (Slocum, 2004). However, when students are still struggling at the high school level, then other options must be utilized. Trends in literature on the issue indicated that the following intervention strategies were helpful: scripted instructional sequences, fill-in-the-blank over multiple-choice exercises, and utilizing a high number of practice items (Johnson & Rubin, 2011). Gersten, Jordan, and Flojo (2005) also reported that students found the following teaching methods helpful: provided detailed, systematic, explicit instructions; used visual representation such as manipulatives, pictures, and graphs; provided peer-assisted instruction; and used ongoing, formative assessments.

The International Association for kindergarten through 12th grade (K-12) online-learning supported that blended learning (combining online delivery of educational content with the best features of classroom interaction and live instruction to personalize learning) increased student achievement. By implementing this method as an intervention with two groups, I attempted to find the best possible blend of traditional instruction and technology for these low-skilled ninth grade students. The intervention was measured based on progress (pre- and posttest) and grade-level achievement (district benchmark).

Research Design and Procedures

Overview. Today's digital native students expect their learning environment to include technology because it is an intrinsic part of their lives. Market research analysis by The NPD Group (https://www.npd.com/wps/portal/ npd/us/news/press-releases/more-than-400-million-devices-are-connected-in-us-homes-according-to-the-npd-group) indicated that there are 425 million devices connected to the Internet in U.S. homes for approximately 311 million people. The National Center for Education Statistics estimated that the average school has one Internet-connected computer for every three students, up from one computer for every seven student in 2007 (http://nces.ed.gov/programs/digest/d11/tables/dt11_109.asp); three decades prior, there was one computer for every 125 students (Christensen, Horn, & Johnson, 2008). Some schools now have a laptop for every child, and if a $100 laptop becomes a reality, then they will likely be everywhere. Over the decades leading up to this study, schools spent well over $60 billion in equipping classrooms with computers (Christensen et al., 2008, p. 81). For students who are comfortable using a computer, computer-aided instruction (CAI) is much like a one-on-one teacher and can offer personalized instruction. For students who struggle with homework problems, Internet-based tutorials give some relief. This study set out to find if a blended learning environment would impact math achievement scores with the population of ninth grade students used for the study.

Three Foundations of Algebra classes with two different teachers were studied. Class 1 received CAI, while tutorials were added to Class 2 with the same teacher. Class 3, taught by a different teacher, learned by traditional, face-to-face instruction with very little technology. The classes ranged in size from 32 to 34 students. All three classes were administered a pretest to measure prior knowledge and a posttest to measure knowledge gained over the study. I observed the implementation of the instruction, took field notes, spoke with students, and analyzed their test scores. The math curriculum in Class 1 and Class 2 had technology for the first quarter of the school year. Students who started at this Foundations of Algebra level were required to take two semesters of elective credit math with the same teacher, which allowed some flexibility in pacing. Instead of this study taking the nine weeks that was originally estimated, it actually took 12 weeks to complete the first quarter. Students were tested for academic and affective outcomes during the fall of the 2012-2013 school year (see Figure 4 for the visual overview of the design plan). Students were taught and tested and academic outcomes were analyzed.

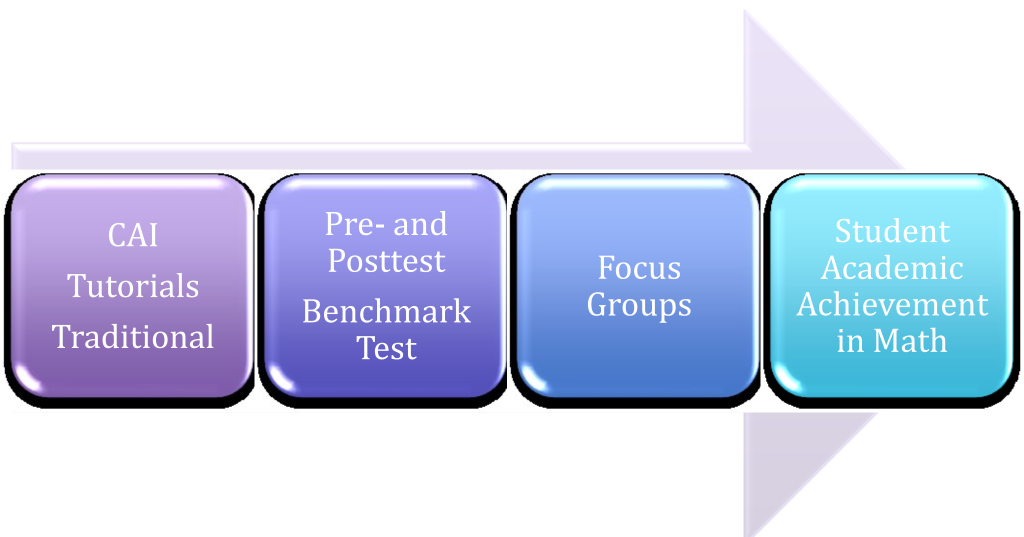


Figure 4. The research design overview used for the study that includes teaching, testing, and outcomes.

Location. This study took place in Arizona. With a population of 6.4 million residents, Arizona is home to a diverse high school population. The high school chosen for this study is located in Maricopa County, Arizona, which has a population of approximately 3.8 million citizens (U.S. Census Bureau, 2010b). Liberty High School is one of seven high schools in the Peoria Unified School District, located in the city of Peoria. According to the 2010 Census Bureau, the population of Peoria is 154,000. Demographically, the population of Peoria is 85% Caucasian, 3% African American, less than 1% Native American, 2% Asian, and 8% other race. A further delineation ethnically identifies Hispanic origins in approximately 18% of the population (www.clrsearch.com/Peoria-Demographics/AZ/Population-by-Race-and-Ethnicity). The average median household income in 2009 was $61,000 and the average home costs approximately $198,000 (http://www.city- data.com/city/Peoria-Arizona.html).

Liberty High School. Liberty High School was chosen for this study based largely on the school's demographics (see Table 3). Additionally, I hypothesized that this student population would be the most likely to have access to a computer at home, would be somewhat tech savvy, and that they would be the most likely to bring their own small version of earbud headphones, which would make working on the computer during class time more personalized for them.

Liberty High School had a student population of 1,772 students, with 471 in the ninth grade (see Table 3 for ethnicity breakdown). Students were 51% male and 49% female. Only 2% received 504 accommodations (a legal document that outlines a plan of instructional services for students in the general education setting), 10% received special education services, none were considered economically disadvantaged, and 0.2% received English Language Learning services.

Table 3

The Ethnicity of the Sample School Population for the 2011-2012 School Year According to Grade Level

Grade	Asian	African American	Hispanic	Native American	Caucasian	Total
9th	2% (10)	1% (7)	15% (71)	0.8% (4)	80% (379)	471
10th	2% (11)	5% (22)	10% (51)	0.4% (2)	82% (389)	475
11th	2 % (10)	2% (8)	14% (67)	0.2% (1)	81% (376)	462
12th	2% (8)	3% (10)	10% (36)	0.4% (2)	85% (308)	364
Total	2% (39)	3% (47)	13% (225)	0.5% (9)	82% (1452)	1772

Students for this study were recruited (see Appendix B) from Liberty High School's ninth grade student population, and the students were presorted for the Foundations of Algebra math classes using a rubric (see Appendix C).

This excelling school reported an 88% pass rate for first-time testers in the area of math on Arizona Instrument to Measure Standards (AIMS)—the Arizona state competency test—an average math score on the standardized test for college admissions (SAT) of 548, and an average math score on the American College Test (ACT) of 20.93 (see Table 4).

Table 4

Liberty High School Math Scores in 2011

Test	Average Score	Possible Score
ACT	20.9	36

	58%	
AIMS	88% PASS RATE	100%
SAT	548 34%	1600

Since the high school's inception in 2006, five years of trend data suggested a 25% failure rate among incoming freshmen in the area of math (freshmen demographics can be found in Table 3). In addition to the demographics, this school was chosen because of the CAI pilot program that occurred on their campus and due to the number of students who entered the school with low math scores, which meant they could be evenly placed into Foundations of Algebra classes, of which three out of four were involved in the study.

Instructors. Two teachers were involved in this study: Mrs. Jaycee and Mr. Holiday (Mrs. Jaycee's name is a pseudonym to protect her identity; Mr. Holiday permitted the use of his real name). Both teachers were highly qualified by the state of Arizona to teach secondary math. They instructed the same subject and grade level; however, their method of delivery was different. They planned together, graded together, and both offered tutoring sessions before and after school to support their students.

Mrs. Jaycee. Mrs. Jaycee is a veteran teacher who possesses deep knowledge of remedial math education and expressed a sincere appreciation for students with deficits in their learning. She earned a bachelor's degree in education and a master's degree in administration. Mrs. Jaycee was highly qualified to teach math as measured by the Arizona Educator Proficiency Assessment Test (AEPA). To her students and her classroom, she brought the benefit of her wisdom from parenting three children and from over 30 years of teaching experience. Mrs. Jaycee is a singer and guitarist who incorporated music into her instruction to emphasize sequential skill development and musical games involving rhythm and pitch to increase student knowledge. She stayed current with state standards by serving as a member of the district math curriculum writing committee and she implemented the Common Core State Standards (CCSS) into her curriculum. As a master teacher of math, social studies, and science, she understood and related how math fit into all areas, which allowed students to grasp the larger context for math while endeavoring to accommodate and assimilate new information.

Mr. Holiday. A recent graduate from the College of Education at Siena Heights University in Adran, Michigan, Mr. Holiday was named to the Dean's List six times and the Academic Achievement List one time. In addition to this, he was named an Academic All-American three times for his abilities on the baseball field and his academic achievement in the classroom. His expertise was in the area of building relationships with students due to his natural ability to work with children. At the time of the study, he was a new teacher with only one year of teaching experience, and he planned to coach the Liberty High School's baseball team when the season opened.

The student participant population sample: sorting students for the Foundations of Algebra classes. The members of the incoming freshman class for the 2012-2013 school year were assigned classes according to their skill level. Eighth grade teachers from the feeder schools along with high school teachers and high school counselors met to discuss the placement of all arriving freshmen. A rubric (see Appendix C) with AIMS test scores along with eighth grade final grades and teacher recommendation were considered when placing students. These incoming freshmen were placed into four Foundations of Algebra classes (see Table 5) along with other students who received special services (whom were not part of this study). In total, there were 130 students placed in the Foundations of Algebra classes. This study compared the outcomes of 3 of those classes. Classes studied were similar and comparable based on skill (which was confirmed by the pretest given within the first week of school).

This study included general education students only and did not include students who received special services. Within the four Foundations of Algebra classes there were 108 total general education students. Within the three sections included in this study, there were 88 students solicited but two were moved to a higher-level class after the pretest revealed their ability to perform on grade level. As a result, 86 students were given the opportunity to participate in this study. From the 86 eligible to participate, 76 students actually returned their parent signed permission slips. I studied the data from 76 students.

Permission to collect data. A parental letter of consent (see Appendix D) was given to each student participant. The letter included a statement that would allow students to withdraw from the study at any time. In addition, this consent allowed me to view each participant's data at any time without discomfort to the participant. After the letter was signed and received from the parents, students were asked for their consent by signing and returning a student consent form (see Appendix E), which allowed me to view their math data and allowed them to possibly be chosen for a focus group.

Table 5

Liberty High School Foundations of Algebra Students Solicited for Study

Classroom Description	Total Enrolled	Total Solicited	Total permission slips returned
Class 1 (Traditional plus 2.0 CAI blended)	34	24	19
Class 2 (Traditional plus Tutorial blend)	32	32	30
Class 3 (Traditional/face-to-face)	34	32	27
Class 4 (Traditional/not used in study)	30	0	0
Totals	130	88	76

Classes

Mrs. Jaycee taught Class 1 and Class 2 while Mr. Holiday taught Class 3 as well as the fourth class. I studied three out of four of these math classes. My intention was to study three classes taught by one teacher, however, near the start of the study, the principal of this school decided to split the classes up between two teachers to create a Professional Learning Community (PLC).

Class 1. Class 1 was held in Mrs. Jaycee's classroom, which had 10 desktop computers lining two sides of the classroom—five on each side. By having the computers in the classroom, students were able to maximize the time they spent on the task while receiving CAI. Catchup Math and CAI blended instruction was designed for implementation in Class 1 only. This class was blended using the rotation model whereby students rotated around separate stations. The plan was for students in Class 1 to spend the first 20 to 30 minutes receiving the day's lesson (traditional face-to-face teaching).

Next, students rotated through four stations: (a) Catchup Math for the CAI component, (b) small group instruction with the teacher, (c) bell work and menus or choice boards where students worked collaboratively on projects, and (d) homework help with peer tutoring. Several weeks into the study, after the teacher was able to get to know each student by name, student rotation was moved from random sorting to teacher-selected groups, which helped to better assist students. Upon entering the classroom, students knew at which station to sit. Eventually, they got started on their own to maximize time spent on a task. There were four groups: two groups of nine and two groups of eight for a total of 34 students; I received permission slips to study 19 of the students. Students put their CAI username and password into their cell phone to ensure that they had it anytime they needed it.

Class 2. Class 2 was held in Mrs. Jaycee's classroom and was taught by traditional means with the addition of online math tutorials via an LCD projector and a computer with Internet access. Internet sites such as Kahn Academy were added onto most lessons and additional instructions on how to view them at home were provided. In addition, during two lessons per month, class was held in the computer lab and students were given a website with a tutorial and instructed to teach themselves. Lesson closure by the teacher included review of content and of correct answers.

Class 3. Class 3 was held in Mr. Holiday's classroom and instruction was taught in a traditional face-to-face manner with very little technology support.

Description of classes. The students in all three classes were observed during the first quarter, which accounted for approximately 12 weeks of the school year. One teacher was in charge of Class 1 and Class 2, and the other teacher was in charge of Class

3. Students were placed in their semester-long class on the first day of school and each class period consisted of a 90-minute teaching block. Within the first week of school, all students were given a pretest to ensure correct placement. The pretest added internal validity to the study because the ability and knowledge of math concepts could be determined and used as a baseline. The establishment of a baseline assisted in figuring out which group actually had the largest gain in scores at the end of the study. Students were given the entire class period to finish the pretest. If students passed a predetermined scoring benchmark, then they moved up and were placed in the algebra I elective credit class. During the 12 weeks of the study that followed the pretest, all the students were exposed to the same math concepts. All classes used the same curriculum in the form of district pacing guide (see Appendix F), which was supplemented with a textbook, worksheets, and other materials.

Supplemental Materials

The eighth grade Glencoe *Pre-Algebra* book was used for all three classes (www.pre-alg.com). The textbook was adopted in 2004, and it was field-tested during the 2001-2002 school year. One main reason for adopting this textbook was due to the variety of technology tools that were included. DVDs were available with engaging videos that showed how math can be implemented in real-life situations. Also included were mind jogger video quizzes that included chapter-by-chapter review sessions in a game show format to make reviewing material more interesting and active.

PowerPoint presentations in chapter format were included to interactively teach each skill. Workbooks, enrichments, remediation worksheets, vocabulary building along with tests and reviews, study guides, practice tests, end-of-chapter tests, mid-chapter tests, 5-minute checks for bell work, and access to the book online with enhancements such as brain-pop videos with short quizzes were also available. The textbook adoption included online Internet tools such as, www.pre-alg.com/webquest, www.pre-alg.com/extra_examples, www.pre-alg.com/self_check_quiz, www.pre-alg.com/vocabulary_review, www.pre-alg.com/chapter_test, www.pre-alg.com/standardized_test, www.pre-alg.com/careers, and www.pre-alg.com/other_calculator_keystrokes. In addition to the Internet tools, the textbook chapters used during this study included:

Chapter 1: Expressions

Decimals, variable expressions, properties, ordered pairs, scatter plots.

Chapter 2: Integers

Absolute value, +, -, x, / integers, coordinate system.

Chapter 3: Equations

Distributive property, solving equations by +, -, x, /, write two-step equations, use formulas.

Chapter 4: Factors and Fractions

Factors, monomials, powers, exponents, GCF, simplifying algebraic fractions, multiplying and dividing monomials, negative exponents, and divisibility shortcuts.

Chapter 5: Rational Numbers (Fractions)

Writing fractions as decimals +, -, x, /, rational numbers, LCM, +, - unlike fractions, solving equations with fractions; multi-step fraction equations.

Students in this study were taught these five chapters and were tested several times during the semester over the material in the chapters. The teachers in this study were involved in a PLC, which allowed them time to plan lessons together and compare student outcomes on quizzes and chapter tests for the purpose of changing practice. However, the way in which the math concepts are taught remained different for each group or class.

Instruments

Pre- and posttest. Prior to the start of the study, the teachers administered a pretest to all participating students to determine prior knowledge of seventh and eighth grade math skills. The Liberty High School math department created the paper and pencil assessment. The pretest was made up of 40 multiple-choice questions (see Appendix G). This test was used to measure student achievement to ensure that students were sorted correctly and evenly across all four Foundation of Algebra classes. The same test was used for the posttest. From the 40 items on each pre- and posttest, the instructors used the first 20 items on the pretest to determine whether incoming students had adequate preparation to enroll in the next level course or to stay in the class in which they were placed. Three students were moved to the next course and their pretest scores were removed from the data. I studied outcomes on 19 students in the CAI class (Class 1), 30 students in the add-on tutorial class (Class 2), and 27 students in the traditional class (Class 3).

District benchmark test. The purpose of analyzing the Foundations of Algebra benchmark test was to obtain clarity of where these students were in relationship to course outcomes and in addition to personal growth from the pretest to the posttest. The test covered math skills from Grade 6 to Grade 8. Students needed foundational skills from Grade 3 through Grade 5 to be able to solve these problems. A committee of highly qualified math teachers created the many-question test bank to correlate with the district pacing guide (see Appendix F). These multiple-choice questions were placed into a testing bank. The test had questions that were pulled from the test bank each year. There were approximately 30 to 35 questions on the test. This test was given in the 12th week of the fall semester. The grade that each student received on this test was recorded and placed into the Internet-based teacher grade book for the first quarter. The score on this test was calculated into the final quarter math grade for each student.

Technology

Literature indicates that technology-filled learning has had an impact on the learning environment. I believe that learning that incorporates technology has tremendous potential in the way it could revolutionize learning for developmental learners, and through much research, I found that curriculum that incorporates technology has rapidly evolved into a concept of blended learning. As the name suggests, blended learning blends online learning with methods that are more traditional. By integrating teacher knowledge of technology, content, and a computer, tailored learning is the most logical and natural solution to the challenges that face struggling math learners. Technological pedagogical content knowledge (TPACK) and blended learning represent an opportunity to integrate the innovative and technological advances offered by online learning while continuing to have interactions with the teacher and participation with other learners.

Catchup Math: CAI intervention used in the study (Class 1). Online math CAI products can be a significant component of math class review or remediation programs. The entirely online, web-based program Catchup Math (catchupmath.com) was chosen for this study because it contained the components needed to influence student achievement in secondary math. Those components being: (a) an intervention providing supplemental and differential instruction and practice in the skills most needed, (b) a multi-modal presentation of lesson material to enhance learning, and (c) ability to work out solutions to develop problem-solving skills. The program aligned well with the study because it adhered to The CCSS and standards of the National Council of Teachers of Mathematics (NCTM) and due to evidence that students who diligently used this program showed large knowledge gains in short amounts of time (catchupmath.com).

Program effectiveness as a remediation tool for struggling learners is proven through research. An analysis conducted by Dr. Sarah Chance, Director of Research at Chance Consulting, collected data in a nationwide study during the 2010-2011 school year by testing growth of students who used catchupmath.com. Data included 20,000 individual pre- and posttest scores. Results indicated that students with an average failing grade of 40% were able to improve their scores by 38% to an average passing score of 78%. Furthermore, the transition from failing to passing a section corresponding to one-sixth of a full math course was achieved in 3.7 sessions—a short amount of time in the context of math instruction. In addition, usage history at Catchup Math showed that students using the program two to three times per week completed a full course review in seven to eight weeks on average. In addition to reporting success, a press release by Catchupmath.com dated April 25, 2012, announced that it would allow schools and students to use its most popular basic programs for free. The program needed and used for this study was *Essentials*, which was one of the programs offered by Catchup Math at no cost.

Essentials is a web-based resource that operates on PC and Mac computers connected to the Internet using any popular modern browser. Adobe Flash Player version 8.0 or higher was required. Students logged on at school, at home, or anywhere that they had access to a computer and the Internet. This easy-to-use, flexible, self-paced, and engaging program's primary function was to remediate students experiencing difficulty with math concepts and skills. Topics for this study included math skills through seventh grade to help struggling secondary students get caught up so that they could achieve personal success in math. The teacher also wove eighth and ninth grade math concepts into the curriculum to meet state standards and grade level success. Students took an Internet-based pretest to diagnose level of proficiency, then, immediately after the test, they were assigned review topics based on their performance. Students were only assigned topics they needed to learn and were prepared to learn. Students were able to take quizzes that determined learning gaps and then they received individualized instruction on those gaps. The quizzes were set at a 70% must-pass rate. In addition, the choice of dozens of multi-model basic math lessons that contain video lessons, activities, skills builders, math games, and more meant that students were able to choose activities that reflected their preferred learning method.

Catchup Math *Essentials* overview. The *Catchup Math Essentials Proficiency Program* used for this study reviewed the course content covered through seventh grade math textbooks and was divided into six sequential sections. Pretests that resembled quizzes were given for each section, and students were assigned lessons based on incorrect answers. Students were given several choices in how they preferred to learn based on their specific learning style. Lessons were offered via text lessons, videos, activities, and practice problems with tutorial solutions. A student took quizzes repeatedly and received lesson prescriptions until the student passed each section. Teachers reviewed student work written on the online whiteboard and that written work gave insight into student thinking. The *Essentials* sections presented material in the following order and included activities that built on the preceding sections' activities, as described here:

1. Adding and subtracting decimals, adding and subtracting fractions, adding and subtracting negatives, basic operations, converting fractions to decimals, equivalent fractions, integers, least common denominator, mean, median, and mode.
2. Adding and subtracting decimals, adding and subtracting fractions, adding and subtracting negatives, basic operations, converting fractions to decimals, irrational numbers, least common denominator, mixed numbers, order of operations, percent and decimals, simplest form of a fraction, square, square roots.
3. Adding and subtracting fractions, adding and subtracting negatives, basic operations, comparing fractions, converting fractions to decimals, exponents, greatest common factors, improper fractions, least common denominator mixed numbers, multiplying and dividing with negatives, order of operations, percent, prime factorization, simplest form of a fraction.
4. Distributive property, dividing by a fraction, exponents, multiplying a fraction by a fraction, prime and composite numbers, quadrants, range of

data, reciprocals, simplest form of a fraction, solving equations, variables, and word problems.

5. Adding and subtracting fractions, dividing by a fraction, divisibility tests, graphing on a coordinate plane, least common denominator, median, mixed numbers, multiplying a fraction by an integer, percent, prime factorization, rounding numbers, simplest form of a fraction.
6. Dividing by a fraction, least common denominator, mixed numbers, multiplying a fraction by an integer, multiplying and dividing with decimals, multiplying and dividing with negatives, percentage, rate, and ratio, simple interest, simplest form of a fraction, square, square roots.

Mrs. Jaycee used an online administrative page for tracking student effort and progress. The administrative page enabled her to view the class as a whole or sort by quiz grade, login, work time, etc. Graphs were created to illustrate general progress of students through assigned problems and to show which lessons were most frequently prescribed so that the teacher could target reteaching lessons or offer one-to-one tutoring on an individual basis. For each student, an individual report card was generated and sent home for parent signature on a biweekly basis. Mrs. Jaycee constantly monitored each student's effort and progress.

History of Catchup Math. Developed by Hotmath, Inc., Catchup Math is an online review and remediation service created for secondary math students. Established in 2000 by a team of math teachers, math professors, educators, and technology developers, Hotmath, Inc., was developed to provide timely help to students struggling with math. At the time of this study, Hotmath, Inc., was reportedly used in more than

10,000 schools and colleges nationwide to provide supplemental support to students (catchupmath.com). Catchup Math was introduced as part of Hotmath, Inc., to meet the growing need for interventions to help overcome difficulties with algebra, which stemmed from insufficient preparation and a need for additional instruction on challenging concepts or skills. Catchup Math has been assisting students in math since 2009.

Math tutorials: intervention used in the study (Class 2). Unlike CAI, tutorials were designed to produce high-quality video lessons for the most important concepts that a student needs to learn. They presented clear explanations in a fun and friendly manner to engage the learner. Tutorials were interesting, and they were accessible through the Internet with the use of any search engine. Instead of looking through a math textbook for a specific skill, students were able to search for a needed skill online and chose the tutorial that best fit their learning style to suit their needs and help them grasp a particular concept. Many free, open source math tutorials were implemented as an intervention to augment classroom instruction and to enrich and engage students in Class 2 (see Appendix A).

Tutorial example: Kahn Academy. Former successful American hedge fund manager and innovator Salman Khan has been assisting students by being a one-on-one teacher in online tutorials. Mr. Kahn is a graduate of Massachusetts Institute of Technology (MIT) who holds degrees in math, electrical engineering, and computer science with a master’s degree from Harvard in business administration. He has helped countless people worldwide by creating and posting tutorials online for all to view. He founded the Khan Academy (khanacademy.org), which is a free online educational outlet with more than 3,000 tutorial videos designed to instruct those who need assistance outside of the classroom, and in addition is a resource for teachers to use in the classroom with their students. The vision for Khan Academy includes: (a) individualized learning by replacing one-size-fits-all lectures with self-paced learning and (b) taking a mastery-based approach to learning critical knowledge and skills whereby every student takes as long as he or she needs to learn and master each concept fully. Kahn Academy tutorials and other Internet-based tutorials were blended into the curriculum of Class 2 in this study to support and enrich lessons. Students who struggled with the day's lesson and who did not have appropriate notes to rely on were encouraged to view the tutorial again at home.

When technology was available, these students were able to access a tutorial online to receive needed information about concepts with which they struggled. These tutorials were personalized because the student watched it whenever he or she wanted and as many times as needed. The tutorial acted much like a personal tutor to assist the student with his or her math homework by using short bursts of systematic procedures to solve problems.

Data Sources and Collection

Quantitative: pre- and posttest. The following research question was used to guide the collection of quantitative data:

> Research Question 1: What is the impact of using technology as a teaching method on math achievement for low achieving ninth grade students?

I utilized quantitative data to address the first research question. In order to ensure the treatment and control groups were equal in regard to their academic math skills, I was provided presorted students based on current AIMS labeling data and other testing criteria in the area of math from prior school years for each student in all three classes (see Appendix C). A pretest was administered and provided evidence of students' preexisting knowledge before treatment. This data was analyzed as soon as it was made available to ensure equal placement of students. Next, a blended learning experience was administered while the traditional face-to-face learning experience in Class 3 remained stable. Math teachers in the Peoria Unified School District (where Liberty High School is located) created the instrument used to measure student academic achievement. This benchmark common assessment was designed to measure a student's level of proficiency for first quarter state standards at the Foundations of Algebra level. A pretest was given within the first week of school in the fall 2012 semester and the posttest was given at the end of the first quarter approximately 12 weeks later.

Qualitative: focus groups. The following research question was used to guide the collection of qualitative data:

Research Question 2: How do students feel about technology as an instructional method in their math class?

A good way to find out about student's perceptions is to ask them. I utilized qualitative data (gathered via focus group) to address the research question. In order to ensure that the treatment groups and control group were equal, a random sample of five students was pulled from each class. A total of three focus groups were conducted near the end of the study during week nine. By that time, the students receiving the technology interventions had some experience with the curriculum. The conversations were led in a relaxed, open dialogue style so that the students would not assume that I was looking for particular answers to any of the questions. Utilizing groups instead of one-to-one interviewing was chosen as a method that could most contribute to student comfort. I conducted post lesson focus groups with five students at a time on the day following a lesson. The focus group sessions were audio taped using an iPad and the Notability app; the recordings were then transcribed. The focus groups took place in the school's library with other professionals observing the group to ensure the emotional safety of students. The focus groups lasted approximately 30 minutes each. The final selection of focus group participants occurred through a random, stratified sample that selected five students from each of the three classes.

The randomized selection was done using Smart Notebook version 10. To sort the students, I utilized the Gallery Essentials tab and then clicked on Lesson Activity toolkit. Next, I clicked on the interactive and multimedia tab. I scrolled down to random group picker (text). I typed the name of each of the students for whom I had a returned form signed by their parent. I selected the option to generate two groups with five members. This tool sorted the students into groups of five. I chose the first group of five for my focus group. The second group of five was kept for my substitute group. This was done for each class.

Focus group questions were semi-structured and recorded. A transcript was created from the recording. The recording and any identifying student information were destroyed immediately upon completion of the study. Focus group questions can be found in Table 6.

Table 6

Focus Group Questions

Question number	Question
1.	What do you think you learned from the lesson on comparing decimals and fractions?
2.	How did you learn the material from the lesson on comparing decimals and fractions?
3.	What do you do at home to support your math homework?
4.	What do you think about your math class this year compared with your math class last year?
5.	What do you like or dislike about this year's class?

Researcher Bias

To be clear on how my past experience may inform how I approach the study, I disclose that I was a former math teacher in the Peoria Unified School District. I have never worked at Liberty High School, nor do I know any of the students at Liberty High School. This allowed me to conduct the study without any undue bias.

Reliability and Validity

In order to ensure reliability and validity with this study, it was necessary to employ triangulation of multiple data sources along with test scores, focus groups, field notes, and observations to measure the research questions. This was a mixed-methods study; therefore, both quantitative and qualitative methods were used.

Data Analysis

Quantitative analysis. The quantitative data was analyzed in an attempt to answer the following research question:

> Research Question 1: What is the impact of using technology as a teaching method on math achievement for low achieving ninth grade students?

The study design included the recruitment of students. These students were sorted into three groups. Each student was allocated to one and only one group. Each of the three groups was given different learning conditions. Each group received the same outcome measure (dependent variable). The study design is illustrated schematically in Figure 5 below.

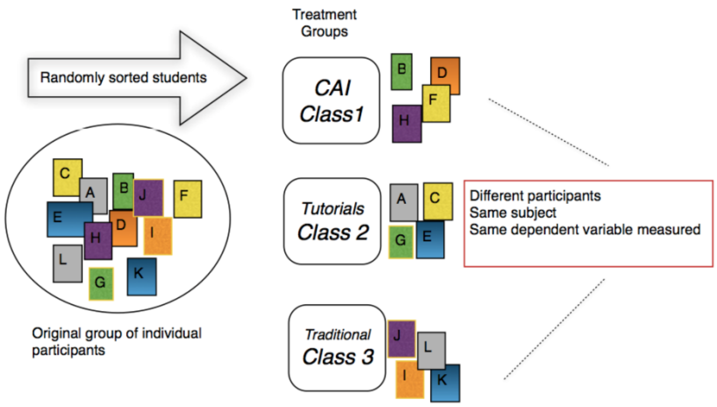


Figure 5. The study design of participants split into three smaller groups.

To answer Research Question 1, I used a mixed factorial design, in which there is more than one treatment factor being explored. This factorial design is a 3 x 2 design (see Table 7). The three indicates that there are three levels of one grouping factor (Class 1, Class 2, and Class 3). The two indicates that there are two levels of the other grouping factor (pre- and posttest).

Table 7

A 3 x 2 Subject Design

Classroom Description	Pretest Score	Posttest Score
Class 1 (Traditional plus 2.0 CAI blended)	43.579	71.263
Class 2 (Traditional plus Tutorial blend)	42.867	68.966

Class 3 (Traditional/face-to-face)	44.185	69.000

I used this design to look for the group's posttest score to stand out. It is the posttest scores between the groups that is important to see, and which are the foci of this study.

A one-way analysis of variance (ANOVA) was used because there are three independent variables (classes) influencing one dependent variable (test scores). One factor is the intervention and the second factor is the test. I measured each group twice (pre- and posttest). The one-way ANOVA was used to determine if there were any significant differences in achievement between the means of the three independent groups. If a significant difference had been found between groups, post hoc tests would have been run to specify which groups were significantly different from each other and which were not.

In addition, to stay abreast of student progress throughout the study, field notes were taken based on observations to help explain possible variances between classes for possible use on the posttest and benchmark test outcome analysis.

Qualitative analysis. The qualitative data was analyzed in an attempt to answer the following research question:

Research Question 2: How do students feel about technology as an instructional method in their math class?

In order to understand students' perceptions about technology use in their math class, focus groups were conducted and audio taped. Randomly selected students conveyed their opinions and attitudes about technology in math class while speaking with me in an interview setting. The audio files of the interviews were downloaded and then transcribed.

Upon reading each transcript, data were coded and categories were created for discussion topics that came up. Corbin and Strauss (2008) recommended beginning the transcript review process with a microanalysis, which they defined as a "detailed coding around a concept, a form of open coding used to break apart data and look for varied meanings of a word or phrase" (p. 46). As each code was defined, it was checked against multiple quotes and against other codes. Codes were expected to change as a deeper analysis was conducted. Chunking and coding text drove the analysis due to the use of a grounded theory approach in which categories were created as concepts emerged. A summary of qualitative findings was written with themes that helped to further explain the quantitative data results by understanding to what degree students felt they were engaged with technology.

Observations

Students were observed throughout the study and field notes were taken. Each day, I met with Mrs. Jaycee prior to the start of the school day to discuss the day's technology implementation. Class 1 used Catchup Math. Student data was collected within the Catchup Math cloud and was analyzed for group patterns on skill achievement for the purpose of scheduling small group assistance during rotation time. Some days, students were given different work to do on Catchup Math to exercise one specific skill from the day's lesson that was hard for them to master. For Class 2, website searches were conducted to find the perfect tutorial to supplement the current day's lesson. I also frequently met with Mrs. Jaycee after school to reflect on the use of technology in Class 1 and Class 2 and to plan for the future. I observed each class on a rotating schedule during this study. I visited one class each day of the study except when the teacher was out. For instance, on Monday I observed Class 1, Tuesday Class 2, Wednesday Class 3, Thursday Class 1, Friday Class 2, Monday Class 3, and so on. I did not observe these classes on the five separate days that a substitute was hired to teach due to teacher absence. On all days that classes were observed, field notes were taken and then analyzed.

Chapter 4

Data Analysis

Today's generation of digital learners were born into a computerized world with smart phones, iPods, iPads, tablets, and computers. According to a 2011 Pew Research Center Report, some 77% of U.S. teens now own cell phones. Digital-born students may benefit from a curriculum rich with Internet access and non-traditional modes of learning. Leveraging technology to create a blended learning curriculum might be the answer to increased academic achievement in math for some students. Technology can transform the way teachers instruct and enhance student learning through instant feedback and personal pacing, which are important features of learning and the ability to store math concepts in one's long-term memory. I believe that the students in this population sample might benefit from a math curriculum that includes the use of digital materials with which they can easily identify.

The collection of both quantitative and qualitative data was intended to provide a degree of triangulation to the study with the expectation that the outcomes of the quantitative data would support the conclusions of the qualitative data, and vice versa (Creswell, 1998). The main focus of the data analysis was to determine whether student achievement was significantly affected by different teaching methods that used technology in a blended learning environment for instruction. The purpose was to compare the learning outcomes of students in three different Foundations of Algebra classes. Each class received instruction in a learning environment with different teaching methods to determine which method best enhanced their learning. Specifically, the study investigated whether there was a significant difference in math performance between classes as measured by a posttest. In addition, field notes were collected and examined to discover how the teaching methods affected achievement.

During the fall 2012 semester, one focus group from each class met with me. In addition, students and teachers were observed, and test scores were collected and analyzed. The overarching purpose of this study was to find information about the effectiveness of technology in a math class with a specific population of students. The inclusion of tutorials—a modification of the lecture approach—was a minor addition to provide added dimension but was not a significant focus of the study. The results of the study are shared in terms of both quantitative and qualitative outcomes.

Quantitative Analysis

The purpose of the quantitative data analysis was to examine the effect of blended learning on achievement scores from students' math pretest to their math posttest. In addition, the district benchmark tests for each class were reviewed to establish curriculum-level competence. The research question pertaining to the quantitative data, as proposed in Chapter 1, is: What is the impact of using technology as a teaching method on math achievement for low achieving ninth grade students?

Pretest. Using the Statistical Package for the Social Sciences (SPSS), an analysis of variance (ANOVA) was used to analyze pretest scores. Table 8 shows the mean pretest scores and standard deviations for each class. An assumption of ANOVA is that variances of the populations from which the samples came are equal, i.e., homogeneity of population variances. Levene's test for equality of variances indicated that the assumption of homogeneity of variances was met, $p = 0.128$.

Table 8

Foundations of Algebra Pretest Score Descriptive Analysis

Method	*N*	*M*	*S.D.*
CAI	19	43.579	11.6729
Tutorial	30	42.867	13.6350
Traditional	27	44.185	11.3002

Note. Means and standard deviations of pretest scores for the three groups of subjects. *N* = number of students; *M* = mean; *S.D.* = standard deviation.

After satisfying the assumption for homogeneity of variance, pretest means of the three classes were analyzed for significant differences. An ANOVA indicated that there was no significant difference in pretest scores among the three groups of subjects, or $F(2,73) = 0.081$, $p > 0.05$ where $p = 0.922$.

Posttest. I investigated the effects on math achievement after students were exposed to different levels of technology. The class to which the students belonged is the treatment variable or the grouping factor. Math achievement was the outcome measure. The experimental design can be found in Table 9 with three levels of one variable (technology).

Table 9

Experimental Design Grouping Factor

Group/Class 1 Computer Aided Instruction	Group/Class 2 Add-on Technology Tutorials	Group/Class 3 Traditional
Foundations of Algebra Math	Foundations of Algebra Math	Foundations of Algebra Math

An ANOVA was calculated using prior data from the pretest to determine if the null hypothesis should be accepted or rejected. Findings indicated that there was no significant difference among the three levels of independent variables: $F(2,72) = 0.295$, $p > 0.05$. The blended learning and the tutorial conditions did not differ significantly from the traditionally taught class in math test scores. I failed to reject the null hypothesis that there is no significant difference between groups because the technology variables did not have an effect on posttest scores. These results show that the students in this population might have scored just as well without the addition of technology. Because a significant difference was not found between groups, post hoc tests were not run to identify significant differences between means.

Benchmark test. The purpose of the quantitative data analysis was to examine the effect of various factors on achievement scores from the pretest to the posttest and to analyze the district benchmark test. To maintain the integrity of the district-provided benchmark test, I was not able to include it as an appendix with this study. Benchmark scores by class can be found in Table 10, and were reviewed for curriculum-level competence.

Table 10

First Quarter Foundations of Algebra Benchmark Average Scores by Class

Methods	*M*	*N*	*S.D.*
CAI	81.105	19	10.2735
Tutorial	78.034	29	13.9527
Traditional	81.480	25	9.4168

Note. *M* = mean; *N* = number of students in class; *S.D.* = standard deviation.

All three classes scored similarly on the district-provided benchmark test and averaged scores from 78% to 81%. The results showed that the average score per class with the added computer-aided instruction (CAI) technology (Class 1) and the traditionally taught class (Class 3) mastered curriculum expectation outcomes with a B average while Class 2, with the added tutorials, scored three percentage points lower. The mean average scores of these classes, which are provided in Table 11, indicated that most of the students were learning the skill expectations of this class.

The results of this study indicated that the participants in all three classes increased their math content understanding (see Table 11). Though the study sought to determine what level of blended learning was most effective, the results indicated that significantly higher levels of academic achievement were not realized with the addition of blended learning when compared to a traditional learning environment.

Table 11

Average Test Scores for Each Subject Class

	Pretest	Posttest	Benchmark
Class 1	43.579	71.263	81.105
Class 2	42.867	68.966	78.034
Class 3	44.185	69.000	81.480

Quantitative data summary. The study sought to discover the extent to which there is a difference between academic outcomes of secondary Foundation of Algebra students learning from curricula that incorporated various levels of technology blended into the learning in comparison to students learning from traditional lectures. It was discovered that students in all three classes showed no significant difference in posttest scores. Although all students' posttest scores greatly improved over their pretest scores, students average scores were virtually the same in all three classes.

Qualitative Analysis

This section presents the processes by which the data for the qualitative component of the study was generated, retrieved, and analyzed. Findings from the qualitative data gathered for this study are reported in the form of lists that depict emerging themes and subthemes from student dialogue obtained during focus groups. My attempt was to answer the second research question as presented in Chapter 1: How do students feel about technology as an instructional method in their math class?

For the focus group data, I audio taped conversations using my iPad. I used the application Notability as a tape recording device while taking notes on the iPad. Dialogue from three separate groups (one group from each class) was recorded. Each group included randomly chosen students who volunteered and the students answered the same set of questions. The students were not required to prepare for the focus group and did not receive the questions prior to the focus group dialogue. I saved the audio files to my Internet-stored Dropbox account and transferred them via the Internet to a transcription service following the focus group sessions. The transcriber then transcribed the audio tapes onto a Word document and sent the transcriptions to me via e-mail.

I organized the data into three groups to represent each class and the type of blended learning incorporated within the group. I analyzed the transcripts and generated themes and patterns for the most frequently occurring words and phrases, discovered relationships, and developed explanations about the issues presented in the research questions. Lastly, the results of the quantitative and qualitative data from all sources were triangulated to provide support for the emerging concepts derived from this study.

Findings from the focus groups. To best interpret the findings from the focus group data, it was important to remember that all of the students in this study have below grade level math skills, which in most cases included students who are at or near frustration levels in math class most of the time. The students in the study were in one of three classes, and each of the classes in the study received a different method of teaching that incorporated different levels of blended learning. There were two teachers in this study: Mrs. Jaycee taught Class 1 and Class 2 while Mr. Holiday taught Class 3.

To assist me in further understanding the data, I used the transcribed focus group responses. I copied student's answers from the Word document and pasted the text into several Wordles (primarily used to visualize frequency distribution of keyword data) to search each class for repeatedly occurring words to make sure that I captured the meaning of students' perceptions. From the results, word art of the most frequently occurring words was generated (see Appendix H). I used this information to cross-check categories to ensure I captured intended meanings to the best of my ability.

Open coding. The analysis of the focus group data was centered on the second research question regarding students' perceptions of technology in their math class. Even though Class 3 was taught by traditional methods, questions were set up to extract student's perceptions about using technology to assist them in their learning of math concepts.

The process of coding the focus group transcripts included a manual system of open coding as described by Creswell (1998) to categorize themes during which the author writes to pull out meanings and then connect those meanings to arrive at explanations and interpretations. This data analysis involved collecting open-ended data by asking general questions and developing an analysis from the information supplied by the students. After several readings of the transcripts, initial themes that ran through the focus group conversations along with their assigned codes were as follows:

Bold = Positive reaction to the addition of technology

Italics = Math homework support

Underline = Type of technology used in the classroom

Yellow highlight = Mention of learning style

Violet highlight = Comments about perception of the class

Red highlight = Negative reactions to the use of technology

Pink highlight = Comments about last year's math class

Blue highlight = Math is easy

Teal highlight = Math is hard

Grey = Perception of how students ended up being placed in their class

Using an inductive framework, I read through the transcripts of each focus group session many times. As patterns and themes emerged from the study of data, I made lists to organize and sort common themes. To find patterns in students' responses, I used the above code list to organize the data by highlighting and applying different formatting to the text. After I coded the data, I opened a new Word document and placed it on my computer desktop next to the coded transcript file. I typed the main categories that emerged into the new Word document. Next, I copied each highlighted, bold, underlined, and italicized section and pasted each one under the corresponding category per class. To assist me in visualizing emerging categories, I created a mind map using the application on my iPad called Idea Sketch (see Appendix I).

Axial coding. The second step in grounded theory is axial coding. After I had all of the data coded using the codes listed above, I began making connections between categories and moving from inductive to deductive analysis by asking myself questions like "What is this?" and "What does it represent?" For each idea, I thought about the conditions that gave rise to the statements, the context from which it was embedded, how it was managed, and the consequences of the conclusions that I was drawing. By expanding my knowledge of the above-coded list, the following broad categories emerged:

- Learning style: how, and under what conditions.
- Self-efficacy: beliefs a student holds regarding their own power to affect situations.
- Homework: difficulty and effort level.
- Technology/blended learning: in class and at home.

With these broad categories in mind, I reviewed all of the excerpts of text under each category by class. Final lists of collected themes for each focus group are discussed in the following sections.

Focus group: Class 1 overview. Five members comprised the first focus group and were from Class 1, which was taught by Mrs. Jaycee using blended learning with CAI. Emerging themes from the student perception data included:

- Learning style: Students reported their preferred way of learning as being taught one-on-one by the teacher, doing hands-on activities, and their last preference was learning by using notes. They enjoyed rotating between stations and appreciated learning visually with the ability to choose a video that reviewed the skill being taught with CAI while at that station.

- Self-efficacy: Students report knowing that it is important to practice math skills and they know they have the power to do so, yet they choose to do other activities after school, such as playing video games.
- Homework: For homework help, students used notes first, then family members, and then Google as a search engine to search math concepts. They expressed having too much math homework.
- Technology/blended learning: The students enjoyed working at their own pace and at their own level. One person reported using Catchup Math at home to fill in skill gaps, which might transfer to 20% of the class using it at home as this sample suggests. Others who reported not using Catchup Math at home reported being too busy with other homework to be able to fit it in. In addition, students appreciated being able to move through stations and at least one person in the group liked each station offered. Students agreed that the CAI would be helpful if they were to give it more time. However, during the study they did not feel as if it helped them to increase their math skills because it was not directly related to the current lesson being taught.

Focus group: Class 2 overview. Five members comprised the second focus group and were from Class 2, which received the add-on tutorials in Mrs. Jaycee's class. Emerging themes from the student perception data included:

- Learning style: Students reported that, in order to learn, they need one-on-one sessions with their teacher, guided notes, quiet time to practice math skills, and accountability for math work. Students pointed out that their biggest math deficits are lack of focus, not knowing their multiplication facts, and trouble working with big numbers.

- Self-efficacy: Students admit to lack of effort sometimes when it comes to classwork and completing homework. Students blame the classroom management in their previous year's math class for their low skills and placement into their current class.
- Homework: Students report that they rarely, if ever, did their homework. They stated that they did not have enough time to do it when they returned home. Although they had the day's lesson tutorial link to assist them with their math, some reported either forgetting about it or not getting to it for various reasons. Four out of five students did not use the link at home, and they reported finding the addition of tutorials engaging during class but not useful at home.
- Technology/blended learning: One student in this group used Internet tutorials at home to assist him with math homework when his notes failed. (This method was taught to this class.) Students reported enjoying going to the computer lab to complete the day's lesson by playing structured math games on the computer and being held accountable for the day's math work on paper. They admitted to searching the web when the teacher was not looking. They all like technology when it is fun but did not leverage it for homework help, which they viewed as not fun.

Focus group: Class 3 overview: Three of the students on the first list of five focus group members were absent, so I used the substitute list to fill the three spots. Five members comprised the third focus group where very little technology was incorporated into the curriculum and material was taught in the traditional, face-to-face method. The perceptional data for the students in Mr. Holiday's class (Class 3) included the following emerging themes:

- Learning style: Students said that receiving a visual representation of the material helped them the most. They also learned best with one-on-one teacher support and with many notes and bell work problems visually illustrated on the whiteboard. Students said that they needed the classroom to be quiet and free from distractions while working on math problems. Additionally, they reported enjoying math during the year in which this study was conducted because their teacher took his time by staying on one topic for a long period and for assisting them one-on-one.
- Self-efficacy: Students reported classroom management problems with the previous year's math teacher. During the previous school year, students had teachers who incorporated Smart technology through the use of a Smart board. They reported that this level of technology did not help them learn.
- Homework: When a student's notes failed, he or she turned to a family member for help. When the family member was not available, two of the students turned to the Internet to search for math tutorials. At times, they felt distracted because there were so many things to look at on the Internet.
- Technology/blended learning: Two students searched Google and resourced YouTube for homework math help and for personal reasons.

Focus group summary. Overall, students from the three classes offered similar answers with regard to learning style, self-efficacy, homework, and the use of technology and blended learning by teachers and themselves. I gleaned the following helpful information from these groups:

- Students believe themselves to be visual learners.
- Students need the class to be quiet in order to learn.
- Students prefer to be taught one-on-one by their instructor.
- Students blame others for their low math skills.
- Students first ask family members for homework help before going to the Internet for assistance.
- Students use technology mostly for their own personal needs.
- Most students do not view technology as a medium for learning math.
- Students are engaged by technology while at school but this does not transfer to using the same technology at home for homework help.

During the focus group sessions, student responses were forthcoming and candid. Students openly shared their concerns regarding homework, teacher quality, technology use, and their personal needs to achieve academically.

The qualitative data matches the quantitative data in that the student population in the study all started out at the same math level with lower than grade level skills. The students were sorted into the different classes. Students knew what they needed to do to be successful, yet they did not always take the steps necessary to achieve the best outcome for themselves. For example, students know they needed to practice math skills correctly in order to become proficient, but they stated that they did not think it was fair that they go to school all day and were then expected to do homework when they get home; therefore, they did not always complete their homework. There were many commonalities between the focus groups in how they felt and how they achieved, and these similarities led to comparable outcomes in achievement. With or without technology, different teaching methods did not make any significant difference for this student population.

Supervised by a school administrator, I facilitated the focus group sessions. The discussions that took place during the focus groups allowed me to gain insights and viewpoints that otherwise could not be acquired. Unlike one-on-one interviews, participants were able to exchange ideas and share information with others in the group. These feedback sessions provided me with ideas and opinions in a nonthreatening environment.

The framework for discussion was based on how or if technology assisted this population of students to learn math. Students were encouraged to share personal views of classroom practices. Responses were recorded verbatim in order to deliver authentic statements that honored each participant's thoughts. Students from all three classes shared similar viewpoints toward math and the use of technology in class for learning.

Observations and Field Notes

Students from all three classes freely and without being asked shared with me the reasons they were placed in this class. Themes were consistent throughout all three classes. Students said that they did not put forth very much effort during the previous year's math class, which was in part because their classroom was in a state of constant chaos due to weak classroom management by teachers. The students were not held accountable for homework or for tests scores, and when given the opportunity to work in the computer lab, it was free time used for playing games. Students had the perception that they would be promoted to high school whether they did any math work or not during their eighth grade year.

Online learning is becoming increasingly popular. In Arizona State University's (ASU) 2013 mission and goals statement, they aspired to enroll 100,000 students in online and distance education programs. Knowing this, I asked a few students from each class how they felt about using the Internet as a tool to assist them with math. Most students responded by saying that they liked using technology for social and personal pleasure while also noting that they did not respond favorably to leveraging it for learning math because it was easier to ask a family member.

After combing through all my notes and data, I am of the opinion that student responses indicated that they do not leverage the Internet for math help because they do not have the intrinsic motivation to complete their homework. When the homework became difficult, they gave up. The students indicated to me that they would be promoted to the next class regardless of whether they completed their math work. This perception may have made the mastery of math skills less likely because the students could easily give up when the math became difficult, perceiving that they would still pass their class. As an educator, I believe that this is a response to years of being promoted from grade to grade without being held accountable for mastery of skills.

There are many reasons why these particular students responded negatively and I have offered my best assessment. Perhaps given the right atmosphere for their individual circumstances, their opinion would change to one of finding favor with the blended mode of learning. Future research should control for motivation to better understand student's negative responses.

I observed the three classes many times. These classes were, at most, one day apart in their lessons. All of the students in this study were taught the same skills using different teaching methods. The classes were comprised of students with low math skills who stated that they were accustomed to more freedom in their previous math class. The structure of high school and their current teachers were a new concept for them. When I asked why, they said that they never had so much homework before, stating that they had homework in every class, Monday through Thursday. When I asked if they were given time in class to complete the work, they replied with "sometimes." As I probed deeper, I tried to find out if they were taking advantage of the time that some teachers gave them. Over 60% of the students in the focus group said that they do not use their time wisely by completing homework during the time allotted. Probing further, I asked them if they thought it would be a good idea to complete their homework with their teacher present, just in case they needed assistance and most replied "no" because they have a family member to help them later that day.

Student feelings about homework included the following comment, verbatim, from one student:

> I do it when I get home because I have an older sister that's in like Algebra II, I think, right now and she's really smart, so I just ask her for help, but normally she won't help me so I just look back at my notes, and well, we have like the computer stuff that you guys give us, but I don't really go on that so I just don't do it.

Another student said:

> If I'm stuck on a problem, I usually go to my grandma and ask her for help, because she was a teacher, I mean she used to be a sub. She had like straight A's and 4.0 throughout all high school, so I just usually go to her.

Other responses included: “When I don't get it, I just stare at it till it pops in my head, or I just skip it until later, because I learned it once, so I try to remember” or “I don't really do anything when I'm home, like, I usually forget about homework, but when I do remember, I usually go to my dad” and “I go to my parents, but most of the time they don't remember, so then I just try to work it out again, and sometimes I get it, but other times I go to the teacher the next day.”

During a focus group with Class 2, students had the following dialogue about homework:

> D: The thing that I don't understand much is, like, we have school for seven hours and then we have homework. Like, homework, it obviously isn't for another seven hours, but it's still homework, and people, listen, we still don't like it that much, and, like, when you get older and you go to work, you work, like, however many hours a day, and then you get to go home and relax, instead of going home and doing homework.
>
> Q: I agree with D. Like, honestly, I think we should not have homework every day, and we go home from school that we had for seven hours, now, that's hard right there. Like, that homework takes me two hours to do sometimes and that's nine hours, like, basically, of school, then we get the rest off. I think, at least, we should have homework, like, probably, like, three times a week, like, or we could

just have a huge packet of homework and it's due on Friday.

K: I agree with Q, like, yeah, I think, like, we should start doing that instead of homework, because, like, dude, especially the homework she gives us, holy frickin', it's like 30 problems. I'm just like, holy crap. I can't finish that. It's hard to finish homework. I don't even know how other people do it. And I'm like, I can never call anyone, like, at home it's hard for me to concentrate, because I got six other siblings. So I'm just like, I'm like, I have, like, three brothers and they're all smaller than me. I'm the oldest one, so they're always asking me, can you get this, can you do that, can you fix that? I'm just like, so, I give up and help my brothers.

The students also listed a big change in being accountable for their behavior. They reported that in high school, they had to be quiet and listen to the teacher. They reported that unlike elementary school, they received lunch detentions or worse if they were to disrupt the learning environment. Classroom management is not easy in this type of class.

The teachers I observed were experienced in lesson delivery. Classes were taught during a 90-minute block. A typical day had the following sequence: bell work, homework review, lesson delivery, and time to begin homework. Each class had its own plan for engagement (computers, tutorials, projects, board work, etc.) that was mixed into the framework to help motivate students to learn and achieve. Time was given for homework during class. When students did not finish, it was an expectation that it would be completed after school.

Homework was a problem for most of these students. When they returned home from school, for many it was after clubs or sports, several hours later. They told me that they had forgotten the steps for how to complete the math problems. Most of the time, they would return the next day without their homework done because it was too hard. The problem is that the next skill taught in their class was built on the foundation from the previous skill. This is how students develop gaps in their learning. By moving on before they master a skill, students become confused and stay that way for the remainder of the chapter. Students seem to understand this, yet they do not take the needed steps to take charge of their learning and master these skills by asking questions during the teaching of the lesson or attending personal tutoring.

Students in Class 1, who learned in a CAI environment, reported that they liked Catchup Math. They liked being able to work on skills that they had not mastered. The problem is that these skills are not the skills being taught in class at that time. While the program is helping them in the long run, it did not transfer to higher test scores in the math class during the short time of this study. Students reported that they only worked on Catchup Math at school and did not work on it at home because it was not connected to the day’s lesson and appeared to be extra work.

Throughout the study, I asked teachers to report their perceptions of progress to me so that I could stay current with the possible immediate effects of the interventions. I fully expected to hear outcomes ranging from high to low from Class 1 to Class 3. During the first two chapters, the results matched my expectations. In Chapters 3 and 4, the traditionally taught class scored better than the tutorial class. In Chapter 4 and especially in Chapter 5 during the unit with fractions, scores decreased for all classes.

Keeping in mind that every skill taught in this class is a review for these students, Chapters 4 and 5 included fractions, decimals, and percentages. Adding and subtracting fractions are among the most challenging math skills for students at any grade level to learn, and the concepts behind the skills are foundational to many math concepts. Previously, these students showed lack of competency in dividing whole numbers in their homework problems and on bell work problems. Long division is a fourth grade math skill, which was generally the skill where many students said that math began to become difficult for them. Without solid knowledge of multiplication and division, working with fractions became challenging for many students as evidenced by test scores.

Teachers are aware of the need for students to master multiplication tables no later than third grade so that division skills can be mastered in fourth grade. These essential skills are missing for many of the students at the Foundations of Algebra ninth grade level—the level being studied here—which leads to low grade level math scores.

Students showed misconceptions about working with fractions that were left unaddressed for years. For instance, it was not uncommon to see students solve 1/2 plus 2/3 as 3/5 due to their existing knowledge of adding whole numbers without distinguishing the difference between whole numbers and fractional numbers.

Summary

Regarding Research Question 1, the data shows that blended learning did not make a significant difference in academic outcomes for this student population. As for Research Question 2, students liked technology for their personal use but did not prioritize it as a tool to be used for math learning. Students in Class 1 rotated through the CAI station every day for 20 minutes. Most reported that they enjoyed getting up to rotate and learning at their own pace, but this did not transfer to increased test scores for Class 1 as compared to their peers in Class 2 and Class 3. Students in Class 2 enjoyed watching the videos as an added visual representation to their lessons, but overall did not report viewing them at home when their notes failed during homework time. Students in Class 3 reported using the Internet for homework help even though they were not taught to do so and only after they attempted to receive help from a family member. The answer to Research Question 2 helped to support the findings in Research Question 1. Overall, all classes performed, on average, the same. Through field notes, I noted that some students in all three classes used the Internet, on occasion for homework help. Students in Class 1 reported that the implementation of blended learning in class was engaging; students enjoyed the rotation sequence and working at their own pace on the computer through the use of CAI. Students in Class 2 reported having enjoyed the visual tutorials implemented into the direct instruction. However, this did not raise student achievement for Class 1 and Class 2 during this study when compared to the traditionally taught class.

Chapter 5

Discussion

The purpose of this study was to evaluate the effectiveness of blended learning environments in comparison to a traditional, face-to-face learning environment on student academic achievement for ninth grade developmental math students. This chapter focuses on the key findings and provides conclusions, limitations, recommendations and implications based on the research. The results were reported to address the following research questions:

1. What is the impact of using technology as a teaching method on math achievement for low achieving ninth grade students?
2. How do students feel about technology as an instructional method in their math class?

Summary of the Study

As stated in Chapter 1, low math scores in the US are a problem. Too many students are leaving high school without the math skills they need to be considered college ready. This phenomenon of unpreparedness has been documented by Hodges and Kennedy (2004), Kinney (2001), Kirst (2011), Klein and Rice (2012), Krzemien (2004) and has been previously reported throughout this dissertation by the standardized test for college admissions, the Program for International Student Assessment, the Organisation for Economic Co-operation and Development and the American College Test. The lack of college preparedness is a problem that established a rationale for studying a math intervention for the ninth grade students presented in this study. During the study, a blended learning model with the use of technology, pedagogy, and content was implemented in the teaching curriculum to determine if blended learning increased academic outcomes. My passion for this topic was directly related to my own personal learning practices during my college experience at Glendale Community College in Arizona.

By using blended learning as a teaching method, this dissertation set out to find out if there was a relationship between the addition of technology in a ninth grade, low level math class and achievement. If there had been a relationship, then this study would have also attempted to find out how much technology was required to make a significant difference. By finding the perfect blend of technology and face-to-face teaching for secondary ninth grade students in a developmental math-learning classroom, the study attempted to add to the field of knowledge on the evolving topic of blended learning.

Some literature prior to 2008 showed inconsistent findings about a relationship between technology and academic achievement in the kindergarten through 12th grade (K-12) setting. As blended learning has evolved, more recent literature from authors Horn and Staker (2011) and other similar studies reported increasing success with different blended learning models throughout the US.

Today, several organizations are dedicating significant human and material resources to address the problem of low math skills and are looking for schools to draft grant proposals to include some form of blended learning where students have some control over time, place, path, or pace and at least partially at a supervised brick-and-mortar location away from home. The fact that this is a trend in education makes this topic increasingly important to study because schools applying for grant money want to know what type and what extent of blend has been found to be most successful for academic achievement. This mixed-methods study consisted of quantitative data using pre- and posttests, a district-provided benchmark test, and qualitative data using focus groups, notes, and observations. All of this data was analyzed to establish and support the findings presented here.

Key Findings

Regarding Research Question 1, the blended learning and the tutorial conditions did not differ significantly from the traditionally taught class with regard to math test scores. Therefore, I accepted the null hypothesis that there is no difference between groups because the interventions did not have a significant effect on posttest scores, comparatively speaking. One can conclude that the outcome indicated the students in this population might have scored just as well without the use of any technology and with the traditional, face-to-face method of teaching. I was surprised at this outcome because this generation of students is living in a world in which they are immersed in digital technology. By their own reports, they spend over 10 hours a day using cell phones, computers, and surfing the web (Rideout, Foehr, & Roberts, 2010), thus, I fully expected to see Class 1 have the highest outcomes followed by Class 2 and then Class 3.

Key finding 1. In Class 1, students did not leverage the potential of Catchup Math's capacity for development by working on it at home.

Key finding 2. In Class 2, students did not view the online tutorials for homework help after school.

The data gathered in order to answer Research Question 2 assisted me to understand the quantitative data through student responses from focus groups, field notes, and observations. Students' answers to my questions were categorized to find themes that would bind them together. Students from all three classes shared similar viewpoints toward math, homework, and the use of technology in class for learning. They reported being engaged by the technology while at school but did not leverage it at home because that was their time. They report that they go to school for seven hours and should not be required to do "more school" at home. I believe that this is due to years of being socially promoted from grade to grade, year after year, without being held accountable or required to master skills in order to move to the next level. My perception is that these students believe that they will be promoted to the next course level whether they complete their homework or not due to this being the pattern for years. Typically, without this extra practice, concepts are not mastered, which can result in skills gaps. Retaining students is not the answer, unless students are taught differently than they were previously, and these students have learned from years of social promotion not to try.

As presented in Chapter 3 and Chapter 4, students in this study fell behind or began to struggle when they were exposed to fractions. This is because many students did not have the foundational knowledge needed to complete these complex tasks. Due to district-mandated curricular expectations, students did not have the time needed to master these below-grade-level skills during class. Students were not motivated enough to practice these skills outside of school because they do not believe that there would be consequences such as being held at their current grade level until they mastered the foundational skills needed to move to the next grade.

Conclusions

Students in this study need to be met where they are in relation to their skill level. They need to be taught according to their learning style and be given enough time to master a concept before they move on to the next, more difficult skill. In addition, in order to be successful, they need to be taught study habits, including how to move information from short-term memory to long-term memory.

Students in Class 1 liked having the opportunity to get up and rotate around the room. Their classes were 90 minutes, and they told me that they enjoyed being able to get up, move around, and to do different tasks. They liked parts of the computer-aided instruction (CAI), such as progressing at their own pace and learning only what they needed to learn. However, due to the program change, CAI was intended to fill in their individual skills gaps and did not directly relate to the day's lesson, chapter, or unit. As such, the CAI did not really help them in class from an immediate perspective. Students in Class 2 enjoyed having the direct instruction being broken up with a visual tutorial but reported that it did not help them learn because they preferred to learn one-on-one from the teacher. Most of the time, they did not remember to view the tutorial again at home because they were too busy or just did not want to complete their homework. If they struggled on their homework, then they would ask their parent or a family member for help because it was easier than turning on the computer, searching for the tutorial, watching the tutorial, learning the skill, and then transferring that knowledge to help them with their homework. Students in Class 3 reported that they liked it when their teacher used a projector to illustrate problems on a whiteboard because the problems were easier to see. The teacher would allow students to write under the projected problems on the white board to show their work. They liked this form of direct instruction because it allowed them to get up and to write on the white board. Class 3 also reported that they sometimes resourced the Internet for assistance with homework even though they were not taught to do so. Students in all classes appreciated the engagement that their teachers added; however, motivation for using technology at home to support the learning of math did not occur on a regular basis.

While student motivation was not the focus of this study, it is important to touch on it because students in remedial classes at the high school level are sometimes found to be unmotivated due to years of feeling unsuccessful. Christensen, Horn, & Johnson (2008) wrote that the U.S. education system does not intrinsically motivate a large percentage of students, which is often considered the root cause of the country's struggles. They also noted that the best blended learning schools at the time of their study were great because they reached the students who appeared to be unmotivated. With the knowledge that there could be a connection between blended learning and motivation, the population sample for this study was considered an ideal population. The students in the sample had been previously socially promoted from grade to grade based on seat time and not on mastery of skills. Hypothetically, using digital learning coupled with a competency-based learning system where students kept working on a concept until they mastered it should have shown increased outcomes over other classes, but it did not. Therefore, the data suggests that when CAI is used as an add-on to the curriculum, remedial students are unlikely to increase their math test scores as compared to remedial students who are taught by traditional means.

Limitations

High school sorted students. After the group of students was selected for the Foundations of Algebra class, they were assigned consistent with school protocol and placed into Class 1, 2, or 3. By luck of the draw, Class 2 ended up being composed of

73% boys, and half of the class was from one elementary school. According to the teacher, "this class was impacted because these students were not expected to do much math work last year, which included taking notes and doing homework." She believed that the class's previous math class experience accounted for the fact that they did not watch the videos outside of class and did not do their homework. By individually sorting the students, this scenario could have been prevented and some of these students may have increased their achievement.

CAI. The biggest problem with the data collection for the study was the fact that the CAI was used as an add-on to the curriculum. The study was designed for the CAI to be the curriculum, but when students tested at the fourth and fifth grade level on the CAI pretest, the CAI, which was designed to assist at the students' level (not at the class curriculum level), ended up filling in skills gaps while the teacher taught the district-mandated curriculum. For the intended blended learning model to have worked to its fullest potential, the district-mandated curriculum would have had to be disregarded and the students would have had to be permitted to work at their own skill level and progress at their own pace.

Tutorials. Tutorial viewing did not work for Class 2 for various reasons. No access to a computer at home and no desire were among the most frequent reasons reported by the students in the focus group session. Some students said that they worked enough at school and they did not feel that it was fair to have to do more work at home. More than once, a student used the statement "that's my time." This response indicated that it is important to know one's audience, and it would be important to take such an attitude into account when planning innovations.

Permission slips. Not having access to data for all the students created a smaller sample size for me to study. The recruitment strategy that I had developed included handing out permission letters on the first day of school with all of the other papers that went home with the students. However, certain conditions were beyond my control. Due to the principal making last minute faculty changes and the governing board rescheduling my presentation to the school board, I was not able to receive permission to proceed with my study until after the first day of school. Ultimately, I was not able to receive every student's permission slip. Each school system will have unique procedures for studies conducted on its campuses, therefore, it is important for future studies to plan accordingly and anticipate possible delays in approval as well as to allow permissions to be handed out and received as planned.

Teacher effect. Another limitation of the study was that the study included two different teachers who had different amounts of teaching and life experience. I planned this study to have one teacher with three classes. However, changes in faculty assignments necessitated my studying two teachers with three classes.

While both teachers were highly capable, it is useful to be mindful of the pressure faculty is under when they enter a classroom. This is especially true for teachers who have classes full of developmental ninth grade students who are not accustomed to being held accountable for course work mastery, which can cause a great deal of stress for the teacher. A great amount of effort was required to perform confidently in front of a group of students who had yet to find the connection between math and their lives. The developmental levels of the students mandated that, beyond teaching, both teachers spend time managing the behaviors in their classrooms. Keeping the attention of these students for 90 minutes required masterful classroom management skills. Both teachers had to account for this time when planning instruction, which is a common reality with this student population. Comparing the novice teacher to the veteran teacher was not necessary because Class 3 (novice teacher) scored equally to Class 1 and Class 2.

Implementation challenges. The fact that 77% of teens own cell phones and 79% own iPods or equivalents (http://www.pewinternet.org/Static-Pages/Trend-Data-(Teens)/Teen-Gadget-Ownership.aspx) led me to believe that the students in this population would have earbuds to listen to the lesson on the computer on their own, but more than half did not. The inability to hear the CAI was a problem for these students. In future studies of this nature, earbuds or headphones need to be made available for student use.

Internet tutorial links. Blended learning is intended to break down the barriers of time, place, path, and pace. In this study, students in Class 2 were given daily links to view tutorials pertinent to the day's lesson. The tutorials could be viewed in any place, at any time, in the order they preferred, and at their own pace. I think that some students may have been limited in their ability to proceed due to waiting on the day's link. In future studies, I recommend having all of those tutorials with links posted on the teacher's website along with content outcomes before the start of the school year so that students have the opportunity to progress at their own pace without being in the physical presence of the instructor.

Computers. The computers in the classroom were another limitation for Class 1 because the technology needed to work consistently and reliably for the intervention to be used. On a few occasions, a computer or two would malfunction and have to be shut down until fixed. On those days, a backup plan was required to allow students to rotate naturally.

Computer Lab. The computer lab was only available on every other Tuesday. Students may have increased their achievement with more time using the computer. Class 1 may have advanced with more time spent on CAI and Class 2 may have benefitted with increased time during the school day to view the tutorials.

Collaboration. Socialization is often perceived as a negative process in many schools, but in the literature and in blended learning schools, social interactions are reported to be far healthier and focused on helping each student improve. To be able to rotate, a longer class period is ideal. For the implementation in Class 1, long class periods made it possible to rotate stations. Students are social, so it may be beneficial to allow a rotation that encourages collaboration. I found that students wanted to get up and rotate to see new people, to power up, to learn something new, and to be slightly challenged.

Time. I was not able to eliminate the barrier of time. Although all classes were taught using different methods and students were expected to do some math work outside of school, the intervention classes moved at the same pace as the face-to-face traditional class. Therefore, students in the blended learning environment were not able to work at a different pace than the traditional class. A faster pace could have allowed students to gain a deeper understanding of the curriculum standards, which consequently could have increased their academic achievement in the course.

Recommendations and Implications

The scope of this study was narrow and only incorporated three classes, two teachers, and one subject. Results showed that the students in the intervention classes did not academically surpass those in the traditionally taught class. Perhaps this was due to the length of the study (12 weeks). With CAI as an add-on technology component instead of being the curriculum itself, it is possible to suggest that the study did not last long enough to be conclusive. Providing CAI for the entire course (18 weeks) might have increased scores for Class 1 in comparison to the other classes because, theoretically, students would have mastered the foundational skills they needed to problem solve correctly by the end of the course.

As noted in an earlier chapter, Professor of Education Vincent Tinto (2008) appealed to people in education to stop tinkering at the margins of the problem, but I believe that is exactly what the teacher and I did by adding on technology in a blended learning format. The implication of using CAI to fill in skills gaps over a short amount of time resulted in not solving the developmental math problem. The challenge, as I see it, is to redesign the practices from which CAI was implemented by changing policy to allow students to be met at their individual skill level and to work independently at their own pace.

A model school that completely changed from traditional teaching methods is Carpe Diem in Yuma, Arizona. This school reported great achievement with its blended learning program. Students in this school learned several full subjects using CAI. Teachers constantly reviewed and analyzed student data. With this information, they created groups of like-skilled students to remediate or enrich through the rotation model of blended learning. Students knew what they needed to do learn, and they were given choice regarding the time, place, path, and pace for learning. I recommend future researchers study this type of blended learning environment.

Blended learning is important to study and some school districts have responded to the popularity of media use among students by increasing the presence of technology in schools by adding new computers and high-speed Internet access (Gray & Lewis, 2009). As more devices are utilized in the classroom, there is growing consensus that mobile computing will be commonplace in all schools in the not too distant future (Johnson, Smith, Levine, & Haywood, 2010). The knowledge that an increasing number of students are receiving access to Internet services helps to leverage mobile devices to better serve individual learning styles and is plausible through the supplementation of blended learning into the curriculum. Many colleges are finding the addition of technology through blended learning classes helpful for closing the achievement gap for math students (Young, 2002) and that is what I attempted to do here.

Furthermore, researchers Christensen et al. (2008) predicted high amounts of blended learning opportunities in the future. More specifically, regarding blended learning, they wrote:

> It results from four factors, (1) technological improvements that make learning more engaging, (2) research advances that enable the design of student-centric software appropriate to each type of learner, (3) the looming teacher shortage from the baby boomer era retiring, and (4) inexorable cost pressures. These factors have scholars predicting that ten years from now, computer-based, student-centric learning will account for 50% of the classes in U.S. secondary schools. Given this current trajectory about 80% of courses in 2024 will have been taught online in a student-centric way (Christenson et al., 2008, p. 102).

At Liberty High School, students in Class 1 were given the opportunity to fill in their math gaps with CAI. This program taught students math skills that they had learned but had not yet mastered. Due to this method of additional math being taught versus learning math that would reinforce the day's lesson, many students reported feeling like they were being made to due extra work. The stress created by being asked to do more work caused a lack of motivation and resulted in students not taking full advantage of the program's potential. I was surprised by the disconnect between theory and practice. Theoretically, the personalization of working on the skills that they needed should have motivated them to learn and practice as much of it as they could. However, in practice, the implication of using technology was that some of the students in this study did not want to learn at the computer station because it did not allow them to interact with other students and because they viewed it as more work, even though they needed it.

Recommendations for Future Research

It is critical to acknowledge that all children learn differently and teaching them all the same things, on the same day, and in the same way, will never allow teachers to educate students in customized ways. Ultimately, by finding out what works for each individual student instead of what works on average for students, we will finally have answers to the problem of low achievement in the US. Opportunities for future research include studies of the abnormalities and outliers in current blended learning research. Such studies would help to gain insight for planning future studies. According to reports, computer-based learning works best with motivated students. Future studies should research different software packages to find programs that offer learning paths for different learners. Additionally, future researchers should study programs that offer a curriculum where the teacher acts in the role of one-on-one tutor rather than teaching monolithically (preparing to teach, actually teaching, and testing the entire class) (Christensen et al., 2008, p. 111). A tutor-based environment would allow a shift away from keeping order and commanding attention to assisting students based on need.

This study was conducted with ninth grade math students. I recommend the study be broadened to include other grade levels and subjects. Teaching through this method may contribute to increased outcomes for students of different ages and could have a different effect on academic achievement. Future researchers should examine as many blended learning studies as they can find in K-12 schools to better understand the effects it has on learning. Studies should incorporate different software in as many different ways as they can.

In conclusion, the process of this project proved to be highly effective in determining the effects of a blended online learning environment. While the results of this study showed no significant positive effect of the intervention on student academic achievement, it also implied that the blended online learning environment did not have a significant negative effect on student learning either. The students in the blended groups had academic outcomes comparable to the traditionally taught class. Furthermore, students' perceptions did not affect their academic achievement in any class. Therefore, students performed similarly on all measures of student academic achievement regardless of their perceptions on technology. Finally, motivation is often the catalyzing ingredient of successful innovation and the same is true for learning. Using the results of this study along with the addition of studying student motivation, future researchers along with other stakeholders will continue to explore the potential of blended learning to increase academic outcomes for all students.

REFERENCES

Achieving the Dream. (2006c, November/December). Developmental math students and college-level coursework. *Data Notes, 1*(8).

ACT. (2011). ACT National Curriculum Survey®. Retrieved from www.act.org/research/policymakers/cccr11/pdf/ConditionofCollegeandCareerReadiness2011.pdf

Akkoyunlu, B., & Soylu, Y. M. (2006). A study on students' views on blended learning environment. *Turkish Online Journal of Distance Education, 7*(3), 43-56. Retrieved from http://tojde.anadolu.edu.tr/tojde23/articles/article3.htm

Aliasgari, M., Riahinia, N., & Mojdehavar, F. (2010). Computer-assisted instruction and student attitudes towards learning mathematics. *Education, Business and Society: Contemporary Middle Eastern Issues, 3*(1), 6-14. doi:10.1108/17537981011022779

Arizona Department of Education (2010-2011). State Report Card. Retrieved from http://www.azed.gov/research-evaluation/files/2012/04/2011statereportcard.pdf

Association of Mathematics Teacher Educators (2006). Preparing teachers to use technology to enhance the learning of mathematics. Retrieved from http://www.amte.net/sites/all/themes/amte/resources/AMTETechnologyPositionStatement.pdf

Aud, S., Hussar, W., Kena, G., Bianco, K., Frohlich, L., Kemp, J., & Tahan, K. (2011). The Condition of Education 2011 (NCES 2011-033). U.S. Department of Education, National Center for Education Statistics. Retrieved from http://nces.ed.gov/programs/coe/pdf/coe_rmc.pdf

Auerbach, C. F., & Silverstein, L. B. (2003). *Qualitative data*. New York, NY: New York University Press.

Bailey, T., Jeong, D. W., & Cho, S. (2010). Referral, enrollment, and completion in developmental education sequences in community college. *Economics of Education Review, 29*(2), 255-270.

Boylan, H. R. (2002). *What works: Research-based best practices in developmental education*. Boone, NC: Continuous Quality Improvement Network/National Center for Developmental Education.

Boyle, P. (2012). NGLC announces $5.4 million in latest grants supporting breakthrough models for college readiness and completion. Retrieved from http://www.nextgenlearning.org/press-release/nglc-announces-54-million-latest-grants-supporting-breakthrough-models-college.

Cavalluzzo, L., Lowther, D., Mokher, C., & Fan, X. (2012). *Effects of the Kentucky Virtual School's hybrid program for algebra 1 on grade 9 student math achievement*. (NCEE 2012-4020). Washington, DC: National Center for Education Evaluation and Regional Assistance, Institute of Educational Sciences, U.S. Department of Education. Retrieved from http://ncee.ed.gov

Cherry, K. (2012). Introduction to research methods: Causal relationships between variables. *About.com*. Retrieved October 18, 2012 from http://psychology.about.com/od/researchmethods/ss/expdesintro_4.htm

Cheung, A. C. K., & Slavin, R. E. (2011, July). *The effectiveness of educational technology applications for enhancing mathematics achievement in K-12 classrooms: A meta-analysis.* Baltimore, MD: Johns Hopkins University, Center for Data-Driven Reform in Education.

Christensen, C. M., Horn, M. B., & Johnson, C. W. (2008). *Disrupting class: How disruptive innovation will change the way the world learns*. New York, NY: McGraw-Hill.

Corbin, J., & Strauss, A. (2008). *Basics of qualitative research: Techniques and procedures for developing grounded theory* (3rd ed.). Thousand Oaks, CA: Sage Publications.

Creswell, J. W. (1998). *Qualitative inquiry and research design: Choosing among five traditions.* Thousand Oaks, CA: SAGE Publications.

Dynarski, M., Agodini, R., Heaviside, S., Novak, T., Carey, N., Campuzano, L., . . . Sussex, W. (2008). *Effectiveness of reading and mathematics software products: Findings from the first student cohort* (NCEE 2007-4005). Washington, DC: U.S. Department of Education.

Dziuban, C. D., Hartman, J., & Moskal, P. (2012). *Higher education, blended learning and the generations: Knowledge is power no more*. Research initiative for teaching effectiveness, LIB 118. University of Central Florida. Retrieved from http://www.sc.edu/ cte/dziuban/ doc/blendedlearning.pdf

Epper, R. M., & Baker, E. D. (2009). *Technology solutions for developmental math: An overview of current and emerging practices.* Funded by the William and Flora Hewlett Foundation and the Bill & Melinda Gates Foundation. Retrieved from http://cbacademy.squarespace.com/storage/ documents/reports-that-include-ace/ TechSolutionsMath_EpperBakerReport_Jan09.pdf

Esau, P. C. (2012, April). Raising expectations. *Expect More Arizona*. Retrieved from http:www.expectmorearizona.org/learn-more/newsletters/raising-expectations-april-2012/

Fraenkel, J. R., & Wallen, N. E. (2006). How to design and evaluate research in education. Boston, MA: McGraw-Hill.

Garnam, C., & Kaleta, R. (2002). Introduction to hybrid courses. *Teaching with Technology Today*, *8*(6).

Gersten, R., Jordan, N. C., & Flojo, J. R. (2005). Early identification and interventions for students with mathematics difficulties. *Journal of Learning Disabilities, 38*(4), 293-304.

Gray, L., & Lewis, L. (2009). *Educational technology in public school districts: Fall 2008* (NCES 2010–003). Washington, DC: U.S. Department of Education.

Guskey, T. R. (2010). Lessons of mastery learning. *Educational Leadership, 68*(2), 52-57.

Hodges, D. Z., & Kennedy, N. H. (2004). Post-testing in developmental education: A success story. *Community College Review, 32*(3), 35-42.

Horn, M., & Staker, H. (2011, January). *The rise of K-12 blended learning*. Retrieved from www.innosightinstitute.org

Ignacio, N., Nieto, L., & Barona, E. (2006). The affective domain in mathematics learning. *International Electronic Journal of Mathematics Education. 1*(1), 17.

International Society for Technology in Education. (2002). *National educational technology standards for teachers: Preparing teachers to use technology.* Eugene, OR: International Society for Technology in Education.

Johnson, D., & Rubin, S. (2011): Effectiveness of interactive computer-based instruction: A review of studies published between 1995 and 2007. *Journal of Organizational Behavior Management, 31*(1), 55-94.

Johnson, L., Smith, R., Levine, A., & Haywood, K. (2010). *2010 Horizon Report: K-12 edition*. Austin, TX: The New Media Consortium.

Jordan, N., & Montani, T. (1997). Cognitive arithmetic and problem solving: A comparison of children with specific and general mathematics difficulties. *Journal of Learning Disabilities, 30*(6), 624.

Kerrigan, M. R., & Slater, D. (2010). *Collaborating to create change: How El Paso Community College improved the readiness of its incoming students through Achieving the Dream* (Culture of Evidence Series, Report No. 4). New York, NY: Community College Research Center and MDRC.

Kinney, D. P. (2001). Developmental theory: Application in a developmental mathematics program. *Journal of Developmental Education, 25*(2), 10-18.

Kirst, M.W. (2011, January). Reports worth reading. *The College Puzzle*. Stanford University. Retrieved from http://collegepuzzle.stanford.edu/

Klein, J., & Rice, C. (2012). *U.S. Education Reform and National Security* (Independent Task Force Report No. 68). New York, NY: Council on Foreign Relations Press. Retrieved from http://www.cfr.org/united-states/us-education-reform-national-security/p27618.

Krzemien, G. L. (2004). A community college basic arithmetic course: Predictive factors for success. *Dissertation Abstracts International*, *64*, 12. Retrieved from http://search.proquest.com.ezproxy1.lib.asu.edu/pqdtft/docview/305334138/abstract/13A992746695F9B2A8F/1?accountid=4485

Kullik, J. A. (2003). *Effects of using instructional technology in elementary and secondary schools: What controlled evaluation studies say* (Project No. P10446.001). Arlington, VA: SRI International.

Larson, R. C., & Murray, M. E. (2008). Open educational resources for blended learning in high schools: Overcoming impediments in developing countries. *Journal of Asynchronous Learning Networks*, *12*(1), 85-103. Retrieved from http://login.ezproxy1.lib.asu.edu/login?url=http://search.proquest.com/docview/61888775?accountid=4485;http://sloanconsortium.org/jaln/v12n1/open-educational-resources-blended-learning-high-schools-overcoming-impediments-developin

Mabbott, D. J., & Bisanz, J. (2008). Computational skills, working memory, and conceptual knowledge in older children with mathematics learning disabilities. *Journal of Learning Disabilities, 41*(1), 15-28. doi:10.1177/0022219407311003

Means, B., Toyama, Y., Murphy, R., Bakia, M., & Jones, K. (2010). *Evaluation of evidence-based practices in online learning: A meta-analysis and review of online learning studies*. Washington, DC: U.S. Department of Education.

Mishra, P., & Koehler, M. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108*, 1017-1054.

National Center for Public Policy and Higher Education and the Southern Regional Education Board. (2010). *Beyond the rhetoric. Improving college readiness through coherent state policy.* Retrieved from http://www.highereducation.org/reports/college_readiness/CollegeReadiness.pdf

National Council of Teachers of Mathematics. (2008). *The role of technology in the teaching and learning of mathematics: A position of the national council of teachers of mathematics*. Retrieved from http://www.nctm.org/about/ content.aspx?id=14233

National Research Council. (1989). *Everybody counts: A report to the nation on the future of mathematics education*. Washington, DC: National Academy Press.

Niess, M. (2005). Preparing teachers to teach science and mathematics with technology: Developing a technology pedagogical content knowledge. *Teaching and Teacher Education, 21*, 509-523.

Niess, M. (2008). Knowledge needed for teaching with technologies: Call it TPACK. *AMTE Connections, 17*(2), 9-10.

Niess, M., Ronau, R., Shafer, K., Driskell, S., Harper, S., Johnston, C., … Kersaint, G. (2009). Mathematics teacher TPACK standards and development model. *Contemporary Issues in Technology & Teacher Education, 9*(1), 4-24. Retrieved from http://login.ezproxy1.lib.asu.edu/ login?url=http://search.proquest.com/docview/622186743?accountid=4485

Osguthorpe, R. T., & Graham, C. R. (2003). Blended learning systems: Definitions and directions. *Quarterly Review of Distance Education, 4*(3), 227-234.

Pew Research Center (2011). Internet and American life project 2011 teen/parent survey, April 19-July 14, 2011. Retrieved from http://www.pewinternet.org/Static-Pages/Trend-Data-(Teens)/Teen-Gadget-Ownership.aspx

Ragan, L. (2007). Best practices in online teaching: Pulling it all together–teaching blended courses. *Connexions* Program of Rice University. Retrieved from http://cnx.org/content/ m15048/latest/.

Rideout, V. J., Foehr, U. G., & Roberts, D. F. (2010). *Generation M2: Media in the lives of 8- to 18-year-olds* (A Kaiser Family Foundation Study). Menlo Park, CA: The Henry J. Kaiser Family Foundation.

Rosen, Y., & Beck-Hill, D. (2012). Intertwining digital content and a one-to-one laptop environment in teaching and learning: Lessons from the time to know program. *Journal of Research and Technology in Education*, *44*(3), 225-241.

Schmidt, W. H. (2004). *Presidential address: Mathematics and science initiative*. Retrieved from the U.S. Department of Education website: http://www2.ed.gov/ rschstat/research/progs/ mathscience/schmidt.html

Schmidt, W. H., McKnight, C. C., & Raizen, S. A. (1997). *A splintered vision: An Investigation of U.S. Science and Mathematics Education*. Boston, MA: Kluwer Academic Publishers.

Shulman, L. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*, 4-14.

Slocum, T. A. (2004). Direct instruction: The big ideas. In D. J. Moran & R. W. Malott (Eds.), *Evidence-based educational methods* (pp. 81–94). Boston, MA: Elsevier.

Spilka, R. (2002, March). Approximately "real world" learning with the hybrid model. *Teaching with Technology Today, (8)*6.

Staker, H., & Horn, M. (2012). *Classifying K-12 blended learning*. San Mateo, CA: Innosight Institute. Retrieved from http://www.innosightinstitute.org/ innosight/wp-content/uploads/ 2012/05/Classifying-K-12-blended-learning2.pdf

Tinto, V. (2008). Access without support is not opportunity. *Inside Higher Ed*. Retrieved from http://insidehighered.com/views/ 2008/06/09/tinto

Tucker, C. R. (2012). *Blended learning in grades 4-12: Leveraging the power of technology to create student-centered classrooms*. Thousand Oaks, CA: Corwin/SAGE.

U. S. Census Bureau. (2010a). U.S. Department of Commerce Economics and Statistics Administration. Retrieved from http://www.census.gov/prod/cen2010/briefs/ c2010br-14.pdf

U. S. Census Bureau. (2010b). U.S. Department of Commerce Economics and Statistics Administration. Retrieved from http://quickfacts.census.gov/qfd/states/ 04000.html

United States Department of Education. (1999). *Taking responsibility for ending social promotion: A guide for educators and state and local leaders.* Washington, DC: Author.

United States Department of Education. (2005). *Strengthening mathematics skills at the postsecondary level: Literature review and analysis*. Washington, DC: Office of Vocational and Adult Education, Division of Adult Education and Literacy.

United States Department of Education, Institute of Education Sciences, National Center for Education Statistics. (2009). The Nation's Report Card: Mathematics 2009 (NCES 2010-451). Washington, DC: Author.

United States Department of Education. (2012). *Education department invites districts to apply for $400 million Race to the Top competition to support classroom-level reform efforts*. Retrieved from http://www.ed.gov/news/press-releases/education-department-invites-districts-apply-400-million-race-top-competition-su

Waxman, H. C., Lin, M. F., & Michko, G. M. (2003). *A meta-analysis of the effectiveness of teaching and learning with technology on student outcomes*. Naperville, IL: Learning Point Associates. Retrieved from http://treeves.coe.uga.edu/edit6900/ metaanalysisNCREL.pdf

Wenglinsky, H. (1998). *Does it compute? The relationship between educational technology and student achievement in mathematics*. Princeton, NJ: Educational Testing Service.

Wolfram Alpha (2013). *Computational knowledge engine*. Retrieved from http://www.wolframalpha.com/

Young, J. (2002, March 22). 'Hybrid' teaching seeks to end the divide between traditional and online instruction. *Chronicle of Higher Education*. Retrieved from http://chronicle.com/article/Hybrid-Teaching-Seeks-to/18487

APPENDIX A

MATH WEBSITES FOR PRACTICE OR HELP AT HOME

www.khanacademy.org

www.mathplayground.com

www.ehow.com

www.virtualnerd.com

www.aplusmath.com

www.aaamath.com

http://nlvm.edu/en/nav/vlibrary.html

www.catchupmath.com

www.regentsprep.com

www.mathforum.com

www.teachertube.com

www.phschool.com

mathantics.com

learnzillions.com

APPENDIX B

STUDENT RECRUITMENT SCRIPT

My name is Staci Bolley, I am a doctoral student under the direction of Professor Schugurensky in the Mary Lou Foulton Teachers College at Arizona State University. I am conducting a research study that looks at technology in the math classroom.

I am recruiting 9th grade students to allow me to view their first quarter pre and post test benchmark math scores. Additionally, I will be recruiting students who would like to participate in a small focus group, which will take approximately one hour. The focus group will be audio taped and the tape will be destroyed upon the completion of the study. If you are willing to participate in allowing me to view your test scores and/or in the focus group, you will need to return an assent form that must be signed by you and a parental permission form that must be signed by your parent.

Your participation in this study is voluntary. If you have any questions concerning the research study, please e-mail me at sabolley@yahoo.com.

APPENDIX C

FOUNDATIONS OF ALGEBRA PLACEMENT RUBRIC

Achievement Data Descriptor	**Recommended Placement for High School Mathematics**				
	Foundations of Algebra	**Algebra I Yearlong**	**Algebra I Block**	**Algebra II Block**	**Advanced Geometry Honors**
Average District Benchmarks – 8th grade	Less than 70% - Pre-Algebra	From 70% to 92% - Pre-Algebra	93% to 100% - Pre-Algebra OR Less than 80% - Algebra I*	From 70% to 90% - Algebra I*	Greater than 90% - Algebra I
Stanford 10 NP Score – 7th grade Math	Below the 25th percentile	26th – 40th percentile	41st – 89th percentile	75th – 90th percentile	85th – 100th percentile
AIMS **Math 7th grade** Performance Level	FFB / Low Approaches	Approaches / Low Meets	Meets / Low Exceeds	Very High Meets / Exceeds	Exceeds
AIMS **Math 5th grade** Performance Level	FFB / Low Approaches	Approaches / Low Meets	Very High Approaches / Meets / Low Exceeds	Very High Meets / Exceeds	Exceeds
AIMS **Math 3rd grade** Performance Level	FFB / Low Approaches	Approaches / Low Meets	Very High Approaches / Meets / Low Exceeds	Very High Meets / Exceeds	Exceeds
DSS – **Student Profile** Math Performance	Consistently struggles in Math Courses (D's & F's)	Math Courses show mostly B's, C's & D's	Doesn't appear to struggle greatly with math (mostly A's, some B's)	Appears to excel in math, but may need to adjust to block scheduling	Excels in all math courses taken
District **Placement** Test – new students	Less than 70%	From 70% to 85%	From 85% to 100%	Records of Alg I Competency Test Required $\geq$ 70%	Records of Alg I Competency Test Required $\geq$ 85%

APPENDIX D

PARENT LETTER OF CONSENT

Dear Parents:

I am currently pursuing my doctoral degree at the Mary Lou Fulton's Teacher's College at Arizona State University under the direction of Professor Schugurensky. I am conducting a research study to understand the effects on student achievement that different levels of technology use have in freshmen level math classes at Liberty High School.

I am inviting your child's participation, which will involve allowing me to see his/her first quarter, district provided pre and post-test, and the possibility of being chosen at random for participation in a focus group. Your child's participation in this study is voluntary. Your child may decline participation in a focus group and having me view their test scores at any time. There will be no penalty or discomfort and, it will not affect your child's grade.

Although there may be no direct benefit to your child, the possible benefit of your child's participation in the study may be used to make decisions regarding the district chosen at random for participants respond favorably or unfavorably to the interventions it could have an effect on future policy making by the school district. There are no foreseeable risks or discomforts to your child possible benefit of your child's participation in the study may develop a deeper understanding of how students respond to technology as an intervention in math class at Liberty High School. This information may assist in making changes to technology innovations to better suit the needs of all students in the Peoria Unified School District.

Scores on all tests will be anonymous and any other forms of identifying information will not be requested. If your child volunteers to participate in a focus group, it will be tape-recorded. The tape recording will only be heard by the researchers involved in the study and will not be made public. Students will provide their first name only for the focus group. Due to the nature of focus groups complete confidentiality may not be able to be maintained. However, no questions will be asked that may be sensitive in nature and the tape recordings will be destroyed upon the completion of the study. The results of this study may be used in reports, presentations, or publications but your child's name will not be used.

If you have any questions concerning the research study or your child's participation in this study, you may e-mail me at sabolley@yahoo.com or call Deputy Superintendent Dr. Heather Cruz at (623) 486-6000.

Sincerely,

Staci Bolley, M.Ed

By signing below, you are giving consent for your child ______________________________ (Child's name) to participate in the above study.

Please identify your child's level of participation.

Signing here means that you consent for your child to participate in one focus group interview.

______________________ ______________________ _____________

Signature Printed Name Date

Signing here means that you consent for your child to be audio taped during the focus group interview.

______________________ ______________________ _____________

Signature Printed Name Date

Signing here means that you consent for me to view your child's first quarter benchmark math test scores (without me seeing their name).

______________________ ______________________ _____________

Signature Printed Name Date

If you have any questions about you or your child's rights as a subject/participant in this research, or if you feel you or your child have been placed at risk, you can contact the Chair of the Human Subjects Institutional Review Board, through the Office of Research Integrity and Assurance, at (480) 965-6788.

APPENDIX E

STUDENT LETTER OF CONSENT

August 2012

Dear Liberty High School Student:
I am currently pursuing my doctoral degree at the Mary Lou Fulton's Teacher's College at Arizona State University under the direction of Professor Schugurensky. I am conducting a research study to understand the effects on student achievement that different levels of technology use have in freshmen level math classes.

I am inviting your participation, which will involve allowing me to see first quarter, district provided pre and post-test scores, and the possibility of you being chosen at random for participation in a focus group. The focus group will last for approximately one hour and I will ask you 5 questions about a math lesson that you previously experienced. Your participation in this study is voluntary. You may decline participation in a focus group and having me view your test scores at any time. There will be no penalty or discomfort and, it will not affect your grade.
There are no foreseeable risks or discomforts to your participation. Through this work, you will help me to develop a deeper understanding of how students respond to technology as an intervention in math class at Liberty High School. This information may assist in making changes to technology innovations to better suit the needs of all students in the Peoria Unified School District.
Student confidentiality will be maintained because student-identifying information such as name or identification number will not be requested on your test scores. Due to the nature of focus groups complete confidentiality may not be able to be maintained. Students who participate will not use their full name and may use an alternate name if desired. Tape recordings of the focus groups will be used for research purposes only and will be destroyed upon completion of the study. The results of this study may be used in reports, presentations, or publications but your name or any identifying information will not be used.
If you give permission to be tape recorded, you have the right to ask for the tape recording to be stopped. The tape recording will be stored on the computer of the researcher and will be destroyed by removing the information from the computer no later than May 2013. If you are under the age of 18 your parents must give you permission to participate by signing the parent consent form. The tape recording will only be heard by the researchers involved in the study and will not be made public.

If you have any questions concerning the research study or your participation in this study, you may e-mail me at sabolley@yahoo.com or Dschugur@asu.edu.

Sincerely,
Staci Bolley, M.Ed

Signing here means that you have read this form and that you are willing to allow me to see your first quarter benchmark math test scores (without your name on the test).

______________________ _________________________ ______

Signature Printed Name Date

Signing here means that if chosen you consent to be audio taped during the focus group interview.

______________________ _________________________ ______
Signature Printed Name Date

Signing here means that if chosen you consent to participate in one focus group interview.

______________________ _________________________ ______
Signature Printed Name Date

If you have any questions about you or your child's rights as a subject/participant in this research, or if you feel you or your child have been placed at risk, you can contact the Chair of the Human Subjects Institutional Review Board, through the Office of Research Integrity and Assurance, at (480) 965-6788.

APPENDIX F

DISTRICT PACING GUIDE

Unit Overview with Benchmarking Periods –
Foundation Block & Year Long

This document's purpose is to show a brief overview of units and their content, across one academic school year. This document is not a stand-alone document-it must be used with the unit planning guides

Please note – Allocation of questions for each benchmarking period will be determined by an assessment committee representing each high school. Information regarding the number of questions from each Unit will be made available at least 1 month prior to each benchmarking period.

Benchmark 1 - Block	
Benchmark 1 – Year Long	**Benchmark 2 – Year Long**
UNIT A: Whole number operations A.1 Properties of numbers A.2 Round and name whole numbers A.3 Compare whole numbers A.4 **a**-Add 2 whole numbers **b**-subtract two whole numbers **c**-multiply whole numbers **d**-Divide whole numbers A.5 Long Division A.6 Exponents A.7 Simplify square roots(perfect squares through 225) A.8 Matrices A.9 **a**-Order of operations (+-) **b**- Order of operations(x/) **c**- Order of op.(Powers and square roots) **d**- Order of op. (grouping symbols) A.10 Combining like terms A.11 **a/b**-Distribution & with like terms A.12 **a**-Evaluate expressions without grouping symbols **b**- Evaluate expressions with grouping symbols A.13 **a**-Solve one-step equations(all 4 operations) **b**-Solve two-step equations(all 4 operations) **c**-Solve two step equations with variables on both sides **d**-Solve two step equations with like terms on one side of the equation **e**- Solve multi-step equations with distributive property and like terms **f**- Solve multi-step equations with like terms on both sides **g**-Solve multi-step equations with distributive property on both sides **h**-Solve multi-step equations with distributive property and adding like terms on both sides **A.**14 Solve for a variable (one-step)	**UNIT B: Integer Operations** B.1**a/b** – Round positive and negative numbers and identify numbers and opposites B.2**a**/b – Add, subtract, multiply and divide integers. B.3**a** – Perform long division with and without remainders B.4**a** – Apply properties of exponents B.5**a** – Simplify perfect square roots including positive and negative coefficients B.6 **a** – Simplify absolute values B.7 a – Perform operation on matrices B.8 a – Simplify expressions – order of ops b – Simplify – order of ops – grouping B.9 Simplify expressions – like terms B.10a/b Simplify expressions – distributive property and like terms B.11a/b – Evaluate expressions B.12a-f – Solve one-step to multi-step equations B.13 – Solve for a variable in a given formula **Unit C: Decimal Operations** C.1 a – Name, Round, Compare C.2 a – Combine **b** – Multiply/Divide (Without Remainders) **c** – Long Divide (Round answer to nearest hundredth) **d** – Exponents **e** – Absolute Value **f** – Matrix Addition/Subtraction/Scalar Multiplication C.3 **++a** – Simplify Square Roots (Perfect Squares Only) **b** – Estimate Irrational Square Roots

Benchmark 2 – Block (Course Assessment)	
Benchmark 3 – Year Long	**Benchmark 4 (CA) – Year Long**
C.4 **a** – Order of Operations with/without grouping symbols **b** – Evaluation Expression with/without grouping symbols **c** – Distributive Property C.5 Solving Equations (with/without clearing decimals): **a** – One-step Equations **b** – Two-step Equations **c** – Variable on Both Sides of Equation **d** – Like Terms on One Side of Equation **e** – Distributive Property 1-side **<u>UNIT D: Fraction Operations</u>** D.1 **a** – Find the prime factorization of whole number **b** – Find the greatest common factor of two whole numbers **c** – Find the least common multiple of two whole numbers **d** – Find the least common denominator of two fractions D.2 Name fractions, improper fractions, and mixed numbers D.3 **a** – Simplify to lowest terms **b** – Write equivalent fractions **c/d** – Convert mixed numbers to Improper fractions (visa versa) D.4 Compare D.5 **a** – Combine **b** – Multiply and divide D.6 Exponents D.7 Simplify perfect fractional square roots (high value = 225) D.8 Scalar Multiplication D.9 Absolute value with one operation D.10 a – Order of Operations D.11 Combine Like Terms D.12 a/b Distribution and w/ Like Terms D.13 Evaluate w/ & w/o Grouping Symbols	D.14 a – One-Step Equations b – Two-Step equations c – Two-Step variables both sides d – Two-Step Like terms one side e – Multi-Step dist. and like terms f – Multi-Step like terms D.15 a – Solve for variable one-step b – Solve for variable multi-step **<u>UNIT E:Area, Volume, and Surface Area</u>** E.1 **a** – Area of rectangle, square, triangle, parallelogram, trapezoid **b** – Area of Circle and semi-circle **c** – Area addition postulate E.2 Volume of cube, cylinder, sphere, cone, square pyramid E.3 **a** – Nets of cube, cylinder, cone, square pyramid **<u>UNIT F:Measurements of Angles</u>** F.1 Find a counterexample. F.2 Find the length using the segment addition postulate. F.3 **a-** Vertical Angles **b-** Complementary Angles **c-** Supplementary Angles **d-** Angle Bisectors F.4 Angle Chasing

Unit Overview with Benchmarking Periods – Foundations Block & Year Long

This document's purpose is to show a brief overview of units and their content, across one academic school year.
This document is not a stand-alone document-it must be used with the unit planning guides

Please note – Allocation of questions for each benchmarking period will be determined by an assessment committee representing each high school. Information regarding the number of questions from each Unit will be made available at least 1 month prior to each benchmarking period.

Benchmark 1 - Block		Benchmark 2 – Block (Course Assessment)	
Benchmark 1 – Year Long	**Benchmark 2 – Year Long**	**Benchmark 3 – Year Long**	**Benchmark 4 (CA) – Year Long**
UNIT A: Whole number operations A.1 Properties of numbers A.2 Round and name whole numbers A.3 Compare whole numbers A.4 a-Add 2 whole numbers b-subtract two whole numbers c-multiply whole numbers d-Divide whole numbers A.5 Long Division A.6 Exponents A.7 Simplify square roots(perfect squares through 225) A.8 Matrices A.9 a-Order of operations (+-) b- Order of operations(x÷) c- Order of op.(Powers and square roots) d- Order of op. (grouping symbols) A.10 Combining like terms A.11 a/b-Distribution & with like terms A.12 a-Evaluate expressions without grouping symbols b- Evaluate expressions with grouping symbols A.13 a-Solve one-step equations(all 4 operations) b-Solve two-step equations(all 4 operations) c-Solve two step equations with variables on both sides d-Solve two step equations with like terms on one side of the equation e- Solve multi-step equations with distributive property and like terms f- Solve multi-step equations with like terms on both sides g-Solve multi-step equations with distributive property on both sides h-Solve multi-step equations with distributive property and adding like terms on both sides A.14 Solve for a variable (one-step)	UNIT B: Integer Operations B.1a/b – Round positive and negative numbers and identify numbers and opposites B.2a/b – Add, subtract, multiply and divide integers. B.3a – Perform long division with and without remainders B.4a – Apply properties of exponents B.5a – Simplify perfect square roots including positive and negative coefficients B.6 a – Simplify absolute values B.7 a – Perform operation on matrices B.8 a – Simplify expressions – order of ops b– Simplify – order of ops – grouping B.9 Simplify expressions – like terms B.10a/b Simplify expressions – distributive property and like terms B.11a/b – Evaluate expressions B.12a-f – Solve one-step to multi-step equations B.13 – Solve for a variable in a given formula Unit C: Decimal Operations C.1 a – Name, Round, Compare C.2 a – Combine b – Multiply/Divide (Without Remainders) c – Long Divide (Round answer to nearest hundredth) d – Exponents e – Absolute Value f – Matrix Addition/Subtraction/Scalar Multiplication C.3 ++a – Simplify Square Roots (Perfect Squares Only) b – Estimate Irrational Square Roots	C.4 a – Order of Operations with/without grouping symbols b – Evaluation Expression with/without grouping symbols c – Distributive Property C.5 Solving Equations (with/without clearing decimals): a – One-step Equations b – Two-step Equations c – Variable on Both Sides of Equation d – Like Terms on One Side of Equation e – Distributive Property 1-side UNIT D: Fraction Operations D.1 a – Find the prime factorization of whole number b – Find the greatest common factor of two whole numbers c – Find the least common multiple of two whole numbers d – Find the least common denominator of two fractions D.2 Name fractions, improper fractions, and mixed numbers D.3 a – Simplify to lowest terms b – Write equivalent fractions c/d – Convert mixed numbers to Improper fractions (vice versa) D.4 Compare D.5 a – Combine b – Multiply and divide D.6 Exponents D.7 Simplify perfect fractional square roots (high value = 225) D.8 Scalar Multiplication D.9 Absolute value with one operation D.10 a – Order of Operations D.11 Combine Like Terms D.12 a/b Distribution and w/ Like Terms D.13 Evaluate w/ & w/o Grouping Symbols	D.14 a – One-Step Equations b – Two-Step equations c – Two-Step variables both sides d – Two-Step Like terms one side e – Multi-Step dist. and like terms f – Multi-Step like terms D.15 a – Solve for variable one-step b – Solve for variable multi-step UNIT E-Area, Volume, and Surface Area E.1 a – Area of rectangle, square, triangle, parallelogram, trapezoid b – Area of Circle and semi-circle c – Area addition postulate E.2 Volume of cube, cylinder, sphere, cone, square pyramid E.3 a – Nets of cube, cylinder, cone, square pyramid UNIT F-Measurements of Angles F.1 Find a counterexample. F.2 Find the length using the segment addition postulate. F.3 a- Vertical Angles b- Complementary Angles c- Supplementary Angles d- Angle Bisectors F.4 Angle Chasing

APPENDIX G

FOUNDATIONS OF ALGEBRA: PRE- AND POSTTEST

Name ______________________________# ___

Pre/Post Test
Date: ______________________ Per: ______

1. Mary purchased 8 boxes of cereal at WalMart and paid a total of $24. Which equation can be used to find out how much Mary paid for each box?

A. x + 8 = 24

C. x – 8 = 24

M08-S3C3-01

B. 8x = 24

D. $\frac{x}{8} = 24$

2. Evaluate: $48 \div [(z - \;)]$ for x = 8, y = 3, and z = 6

A. 18

C. 2

B. 3

D. $\frac{1}{2}$

3. Simplify the expression and state the property you used. $4 + \quad +$

A. 4x + 7, Distributive

C. x + 11, Associative

M08-S3C3-03

B. x + 11, Commutative

D. 4x + 7, Commutative

4. Simplify:

A. –10

C. 6

M08-S1C1-04

B. – 6

D. 10

5. Simplify: 4 – (–3)

A. –1

C. 7

M07-S1C2-01

B. –7

D. 1

6. Simplify: 2 (–3)(10)

A. –50 C. 60
M07-S1C2-01

B. –60 D. 50

7. Simplify: $\frac{-\ 4}{-\ .}$

A. 16 C. –16
M07-S1C2-01

B. 18 D. –18

8. Name the quadrant that the point (–4, –2) lies in.

A. Quadrant I C. Quadrant II
M06-S4C3-01

B. Quadrant III D. Quadrant IV

9. Simplify: 12(x + 4) – 2x

A. 10x + 4 C. 10x + 48
M08-S3C3-03

B. 14x + 4 D. 14x + 48

10. Translate the verbal sentence into an algebraic equation.

"Four less than three times a number is 20."

A. 4 – 3n = 20 C. 4 – 20 = 3n
M08-S3C3-03
B. 3n – 4 = 20 D. 3n – 20 = 4

11. Solve: –12 + x = 8

A. x = 20 C. x = –20
M08-S3C3-01

B. x = 4 D. x = –4

12. Solve: $\frac{x}{-\ 0} = 5$

A. x = –2 C. x = –5

M08-S3C3-01

B. x = 50 D. x = –50

13. Solve: 4 – x = 10

A. x = 6 C. x = 14

M08-S3C3-01

B. x = –6 D. x = –14

14. Solve: 4x – 18 = –34

A. x = –13 C. x = 13

M08-S3C3-01

B. x = 4 D. x = –4

15. Solve: x – 6x + 5 = –30

A. x = –5 C. x = 5

M08-S3C3-03

B. x = –7 D. x = 7

16. Solve: 25 = 2x – 9

A. x = 17 C. x = 8

M08-S3C3-03

B. $x = -17$ D. $x = -8$

17. Write the expression using exponents:

$-3 \cdot -3 \cdot -3 \cdot -3 \cdot x \cdot x \cdot y \cdot y \cdot y$

A. $-12 \cdot x^2 \cdot y^3$ C. $12 \cdot x^2 \cdot y^3$

M08-S1C2-01

B. $-81 \cdot x^2 \cdot y^3$ D. $81 \cdot x^2 \cdot y^3$

18. Factor completely: $50xy^2$

A. $5 \cdot 10 \cdot x \cdot y \cdot y$ C. $2 \cdot 25 \cdot x \cdot y^2$

M08-S1C2-01

B. $2 \cdot 5 \cdot 5 \cdot x \cdot y \cdot y$ D. $2 \cdot 5 \cdot 5 \cdot x \cdot y^2$

19. Find the GCF: 70 and 28

A. 2 C. 140

M08-S1C2-01

B. 7 D. 14

20. Simplify: $\frac{56m^3n}{32mn}$

A. $\frac{28m^2}{16}$ C. $\frac{7m^2n}{4}$

M08-S1C2-05

B. $\frac{7m^2}{4}$

D. $\frac{14m^2}{8}$

21. Find the product and express using exponents: $5^{3\cdot}$ ^{6}

A. 5^9

C. 25^9

M08-S1C2-01

B. 10^9

D. 5^{18}

22. Write 0.00036 in scientific notation.

A. 36 ×

C. 3.6 ×

M08-S1C2-04

B. 36 ×

D. 3.6 ×

23. Write $\frac{8}{15}$ as a decimal.

A. 0.5

C. 5.

M08-S1C1-01

B. 1.875

D. 0.53

24. Write 0.48 as a fraction in simplest form.

A. $\frac{48}{100}$

C. $\frac{24}{50}$

M08-S1C1-01

B. $\frac{12}{25}$

D. $\frac{1}{2}$

25. Which symbol makes the following statement true?

$0.3 \bigcirc \frac{1}{3}$

A. >

M08-S1C1-01

B. <

C. =

D. +

26. Find the Least Common Denominator of $\frac{5}{8}$ and $\frac{3}{12}$.

A. 8

M08-S1C2-01

B. 24

C. 20

D. 48

27. Add: $\frac{23}{6} + \frac{11}{9}$, write your answer in simplest form.

A. $\frac{34}{15}$

M08-S1C2-01

B. $\frac{17}{9}$

C. $\frac{91}{18}$

D. $\frac{34}{18}$

28. Solve: x + 4.1 = 9.3

A. x = 5.2

M08-S3C3-01

B. x = 13.4

C. x = –5.2

D. x = 5.4

29. Solve: $-\frac{3}{5} = \frac{5}{8}x$

A. $x = -\frac{3}{8}$

M08-S3C3-01

C. $x = \frac{24}{25}$

B. $x = -\frac{24}{25}$ D. $x = -\frac{25}{24}$

30. Max drives 8 hours and travels 496 miles. What is the average rate of his travel? (Use d = rt)

A. 3,968mph C. 72 mph

M08-S3C3-02

B. 512 mph D. 62 mph

31. Solve: $5x - 12 = 2x$

A. $x = 3$ C. $x = 4$

M08-S3C3-03

B. $x = -4$ D. $x = \frac{12}{7}$

32. Solve: $\frac{3}{8}x - \quad = \frac{7}{8}x -$

A. $x = -12$ C. $x = -4$

M08-S3C3-03

B. $x = -\frac{24}{25}$ D. $x = 7$

33. Solve: $6 - 2(x - 4) = 3(x - 4)$

A. $x = \frac{26}{5}$ C. $x = 26$

M08-S3C3-03

B. $x = -\frac{5}{2}$ D. $x = -\frac{26}{5}$

34. Solve: $\frac{1}{4}(1\ \ 2x + \quad \cdot\, x$

A. $x = -\frac{13}{8}$ C. $x = -\frac{7}{2}$

M08-S3C3-03

B. $x = -\frac{19}{8}$ D. $x = -\frac{7}{3}$

35. Solve: 8(2x – 6) = 3(5 + 2x)

A. $x = \frac{63}{10}$ C. $x = \frac{14}{9}$

M08-S3C3-03

B. $x = \frac{9}{14}$ D. $x = \frac{53}{10}$

36. Solve: 0.4x + 3 = x – 0.12

A. x = 5.2 C. x = 0.15

M08-S3C3-03

B. x = 0.025 D. x = 0.52

37. Write an equation and then solve for:

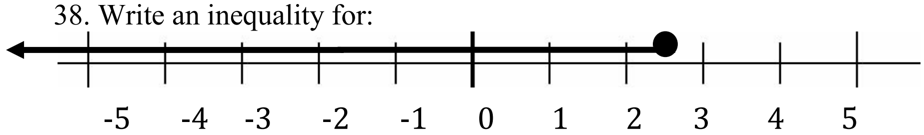
"Six more than twice a number is three less than the number."

A. $2n + 6 = 3 - n$; $n = -1$ C. $2n + 6 = n - 3$; $n = -9$

M08-S3C3-03

B. $2n + 6 = 3 - n$; $n = -3$ D. $2n + 6 = n - 3$; $n = 1$

38. Write an inequality for:



A. $x > 2$ C. $x \geq 2$

M08-S3C3-05

B. $x < 2$ D. $x \leq 2$

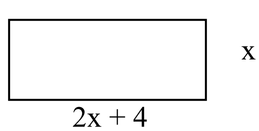
39. Solve the inequality: $4 \leq 2x + 10$

A. $x \leq 3$ C. $x \leq -3$

M08-S3C3-03

B. $x \geq 3$ D. $x \geq -3$

40. The perimeter of the rectangle is 56 feet. Find the dimensions of the rectangle.



A. 10 ft by 18 ft C. 8 ft by 20 ft

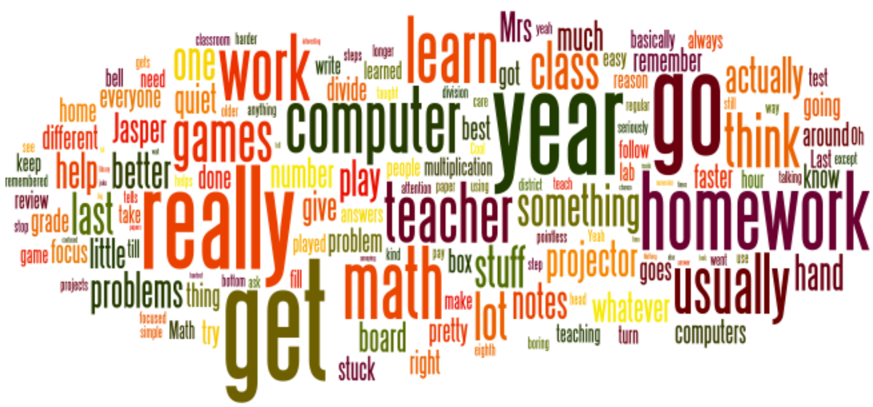
M08-S3C3-01

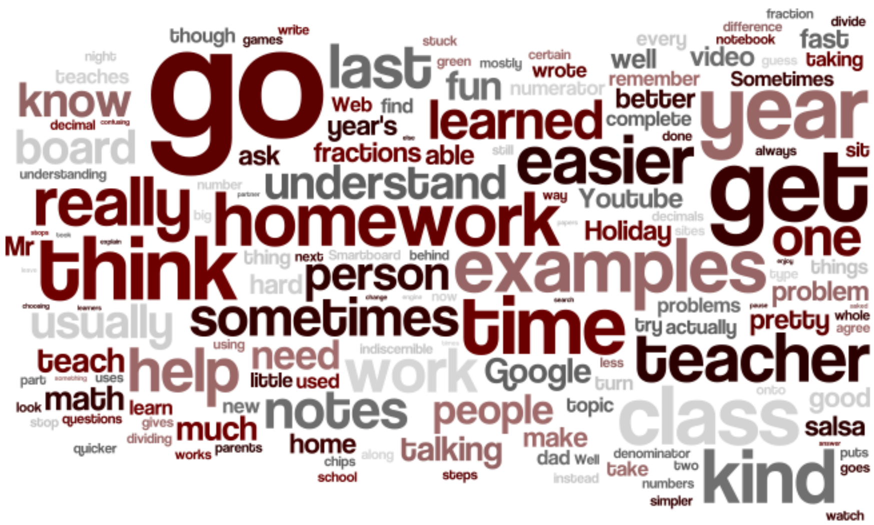
B. 16 ft by 40 ft D. 5 ft by 23 ft

APPENDIX H

WORDLES


LIKE
NOTES
CLASS
TEACHER
LOT
YEAR
MATH
HELP
GET
PRETTY
UNDERSTAND
HOMEWORK
COMPUTER
GO
ACTUALLY
MATH
KNOW
CATCHUP
REALLY
STUFF
EASIER
PUT
WORK
FIGURE
SCHOOL
ACTIVITIES
DIFFERENT
QUESTION
SOMETHING
GAMES
LAST
LIKE
TIME
ANYTHING
THINGS
LESSONS
DIFFICULT
LEARNED
WROTE
MOVE
ASK
VIDEOS
GIVES
HARD
NEED
BOARD
WRITE
MUCH
CLASSROOM
THINK
MENUS
GOT
WELL
TEACHERS

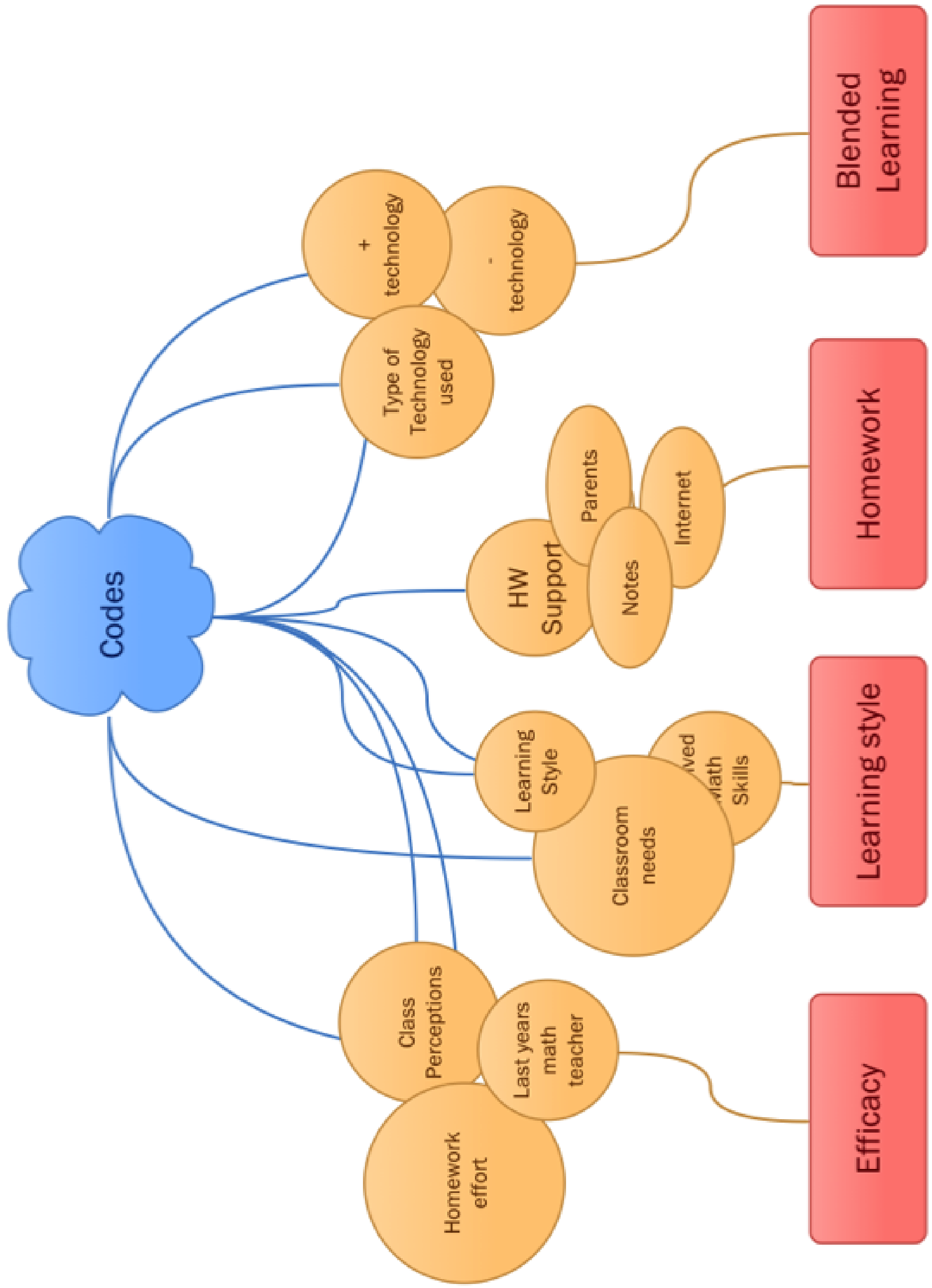

year
really
get
homework
go
computer
math
learn
work
teacher
games
usually
think
class
something
actually
lot
stuff
projector
notes
last
help
better
problems
one
play
Mrs
much
number
give
quiet
Jasper
little
hand
board
whatever
different
home
everyone
focus
grade
review
keep
going
around
know
faster
remember
basically
always
divide
learned
write
multiplication
best
got
easy
test
reason
follow
lab
goes
computers
teaching
turn
pretty
right
stuck
make
box
problem
played
answers
try
Math
thing
fill
done
take
till
people
bell
need
game
hour
Last
except
Oh
classroom
harder
longer
steps
division
care
attention
paper
using
district
teach
step
pointless
went
use
kind
pay
boring
eighth
bottom
ask
focused
simple
projects
remembered
stop
see
anything
older
taught
seriously
regular
still
way
talking
yeah
tells
helps
Yeah
head



though
games
write
stuck
fraction
divide
night
every
difference
notebook
fast
teaches
go
last
green
mostly
certain
wrote
well
video
taking
know
fun
numerator
remember
Sometimes
decimal
Web
find
learned
better
complete
year
board
year's
easier
done
fractions
able
always
sit
ask
understanding
understand
get
really
Youtube
homework
Holiday
one
Mr
think
next
Smartboard
behind
examples
thing
things
hard
person
type
problem
problems
usually
sometimes
time
try
actually
pretty
whole
agree
teach
help
need
using
indiscernible
less
teacher
part
uses
work
Google
turn
look
math
little
used
new
class
good
questions
learn
notes
people
topic
stop
gives
much
salsa
quicker
dividing
home
make
works
parents
chips
along
talking
dad
Well
take
denominator
puts
two
goes
school
steps
instead
kind
numbers
simpler
watch

APPENDIX I

FOCUS GROUP CODING



Codes
+ technology
- technology
Type of Technology used
HW Support
Parents
Notes
Internet
Learning Style
Skills
Classroom needs
Class Perceptions
Last years math teacher
Homework effort
Blended Learning
Homework
Learning style
Efficacy

APPENDIX J

IRB APPROVAL

To: Daniel Schugurensky

From: Mark Roosa, Chair Soc Beh IRB

Date: 07/06/2012

Committee Action: Exemption Granted

IRB Action Date: 07/06/2012

IRB Protocol #: 1207008000

Study Title: Examining the effects of technology in the math curriculum in grade 9.

The above-referenced protocol is considered exempt after review by the Institutional Review Board pursuant to Federal regulations, 45 CFR Part 46.101(b)(1) .

This part of the federal regulations requires that the information be recorded by investigators in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects. It is necessary that the information obtained not be such that if disclosed outside the research, it could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.