Using Technology to Close Gaps in Mathematics Content Knowledge

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Abstract

This quasi-experimental research project investigated the use of the Qwizdom wireless interactive learning and student response hand-held system in a technology-rich geometry classroom and the effect on the acquisition and application of mathematical content knowledge. By means of an experimental design, the Qwizdom system and proprietary software, in conjunction with the district’s own standards-based curriculum were presented using an interactive white board (IWB), projector, and laptop. The instruments for data collection included the Qwizdom system, pre- and post-exams, pre- and post-affective surveys, written work, feedback prompts, and observations. The Qwizdom system provided immediate feedback to the students as well as a formative assessment for the teacher. It was used to collect, evaluate, and report on the data. The gain-scores when compared and analyzed using a $t$ test with a confidence level of $p < .05$ resulted in a $p$ value of 0.0014. The students that used the Qwizdom system showed significant gains in conceptual understanding of the geometry content and expressed an improvement in their attitudes and motivations toward math and the use of technology through surveys and feedback prompts.
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CHAPTER ONE: INTRODUCTION TO THE PROBLEM

High-stakes testing required by No Child Left Behind has become the driving force behind personnel decisions, curriculum and technology purchases, and course offerings. State tests and compilation reports have illuminated learning deficits, achievement gaps, and less than favorable learning opportunities for students.

In an effort to address mathematics content achievement gaps, schools have incorporated intervention programs, differentiated instruction, and technology. In each case, the goal is to assist students in closing gaps in content knowledge while continuing to impart the mathematics content required for them to demonstrate proficiency on state tests. Because the problem as it exists has many dimensions, a multi-faceted approach was designed.

The district’s Executive Director of Curriculum requested best practices be employed to instruct students and to provide the most intensive and comprehensive approach. The district’s, standards-based curriculum was offered in an interactive environment where technology was integrated into the presentation, acquisition, application, and evaluation of mathematical concepts. This approach embodied the recommendations of the National Council of Teachers of Mathematics (2000) and paved the way for this study of an interactive hand-held student response system in addressing the needs of districts, educators, and students.

Problem Statement

The problem as presented was a group of geometry students that exhibited gaps in mathematics content knowledge on recent exams. Differentiated instruction was required to close achievement gaps on four state objectives: formulating and using linear equations and inequalities, demonstrating an understanding of geometric relationships and spatial reasoning, demonstrating and understanding of two- and three-dimensional representations of geometric relationships and shapes, and demonstrating an understanding of the concepts and uses of
measurement and similarity. Technology has been used by teachers in remediation programs to close gaps in mathematics content knowledge (Taylor, 2008).

The essential knowledge and skills required for mastery of these objectives were considered seventh grade, eighth grade, and algebra level skills. These gaps in knowledge and understanding could only grow as the already failing foundational structure was tested with new mathematical concepts being taught daily. The building blocks that were the foundation of math content knowledge must be restored in order to ensure a stable base on which to build. From there, students would be able to process new math concepts into their old understanding and build deeper and greater meaning.

**Possible Causes**

There were numerous possible causes for gaps in mathematics content knowledge. It has long been a practice to promote students through their elementary grades even if they have not passed required classes. One rationale supporting these decisions has included the importance of keeping students with their peers. With the inception of standards-based instruction, high-stakes testing, and objectives mastery, students continue to be promoted to the next grade without demonstrating mastery on the state exams. Now in high school, students are faced with the realization that if they cannot pass the exit level state exam then they will not graduate.

Inclusion has placed students being served in special education programs into the mainstream classroom as the least restrictive environment. Their cognitive abilities may not be hindered but their specific learning disability may provide obstacles to their learning. Teachers must provide accommodations and/or modifications to the daily notes, work, and tests in an attempt to provide a level field for these students to learn.

In addition, students with limited English proficiency are also placed into the mainstream classroom. Student abilities range from beginning English language acquisition to proficiency in
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English language. Students that do not have the ability to speak or comprehend English will quickly fall behind and there again, gaps in content knowledge are created.

Other possible causes are socioeconomic status, excessive absenteeism, and frequent illnesses on the part of the students. Additional causes identified are teachers that do not exhibit the confidence in their own ability to teach math concepts. Some teachers have said that their lack of confidence stems from never “doing well” in math when they were in school.

Background Information

Educators are charged with the task of imparting knowledge within the guidelines of the district’s curriculum and scope and sequence. Their goal is to assess their own teaching as well as the acquisition and application of objectives for each student and be able to make those assessments simultaneously while teaching the lesson. Unfortunately, students arrive with varied ability levels, educational experiences, and gaps in content knowledge which impact their ability to learn on grade level. Now, in addition to their primary task, the educator must attempt to close those gaps or restore the foundation of content knowledge by reteaching skills and concepts required for further development in their current subject. After a few years of what may have started as the inability to demonstrate mastery in only one or two objectives now encompasses half a dozen objectives over multiple grade levels.

In researching background information relating to gaps in content knowledge, numerous personal conversations and direct observations have revealed that there are inconsistencies in geometry content presented, in teacher’s expectations, and with regards to formative and summative feedback. There exist misunderstandings in students’ true mastery of concepts, excessive student absenteeism, and conflict in the support for teachers. I have witnessed a disjunction between what students are actually taught and how they are expected to demonstrate their understanding of those concepts. These disparities exist within the geometry course from teacher to teacher and even class period to class period. On exams, problems from material
covered in class were presented but answer choices were in an unfamiliar format. In other
instances, material on the exam had not been covered at all in class. This warranted further
investigation. I was informed that this was a difficult topic for the students and that students are
told to use their calculators to work out the problem and use their best guess to match their
answer to the answer choices provided. When I pressed for actually teaching the topic, it was
stated that the students cannot do it so we do not teach it. Further discussions with
administrators that had previously taught math said that they had taught the topic; and one added
that her son who was currently in eighth grade had been doing the same thing.

A teacher’s expectations of his or her class and each student also appear to have an
impact as to the depth that a concept is covered and for the length of time spent covering it. On
topics where students struggle or complain that they struggle, the material is covered but only at
a glance and then a new concept is presented. It is not expected that students will grasp the
concept; instead, it is believed that they will not grasp it and so on to the next concept they move.
A lack of expectation extends to participation during class discussions or collaborative work.
Students can be observed with their heads down, reading a book, or talking to friends during
instruction time. This problem may tie in to the lack of feedback both immediate and overall.

When a new concept is presented, it is necessary for the teacher to receive accurate
feedback from his or her students. Such feedback may be in the form of questions and answers
or a few problems to establish student acquisition of the concept and to determine if further
discussion is needed. Likewise, it is imperative for students to receive immediate feedback to
their questions and homework to assure they have a firm foundation on which the next lesson
will be built. If students are not participating in class the teacher cannot receive the immediate
feedback required for formative assessments. Homework is the next area that suffers, because
what students do not understand, they do not do. It is the case however, that for students that do
participate and complete their homework, these students still may have to wait for a week, or
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two, for graded homework and tests to be returned. By this time, incorrect answers are only red Xs on the page and misunderstood concepts that have been replaced by more questions. This appears as a vicious circle with no end.

In recent decades the focus from memorizing formulas and simply working problems has changed to developing understanding of concepts, using a calculator to simplify unnecessary mathematical processes, and applying concepts in real-life situations. Unfortunately vital aspects of the new philosophy are being omitted as problems are modeled. Formulas are extracted from a formula chart, the problems are worked, a calculator is used to simplify lengthy mathematical computations, but an understanding has not been developed. Many students are unable to give written or verbal explanation to the work that they have completed and when asked to attempt the same type of problem on the following day, many cannot. There is a misperception that students are demonstrating an understanding of concepts simply because they can use a calculator to work the problems. Students may be able to use the calculator to arrive at an answer but may be unable to alter their answer and provide it in a different format. In addition, when the problem format is altered, students say they cannot do the problem or they do not understand it.

Excessive student absenteeism is a significant problem for educators. Absences are more than missed days from school; they are lost instructional time that cannot be easily recouped. States have clear guidelines regulating absences and tying excessive absences to the loss of class credits and yet, the problem still exists. Schools have developed plans to allow students to salvage their credits by making up missed hours after school in the corresponding class. The thought behind this idea was to help students keep their credits and hopefully to deter them from missing days if they have to stay after school to make it up. This plan has not rectified excessive absences. In addition, the plan does not attempt to recoup valuable instructional time but instead increases the demands on a teacher’s time.
Teachers wear many hats but some are not comfortable in donning the hat of the conflict manager or the hat of the resolution facilitator. Teachers require support from their department peers, their campus administration, the district’s support departments, and the district’s administrators as well. In gathering materials, curriculum, and names of individuals to request assistance in order to begin teaching, it became apparent that when teachers reach an impasse or a difficulty of any kind, they just give up. I found that of the three teachers teaching geometry, that only one of them could access the curriculum DVDs purchased by the district. These DVDs contained pertinent lesson documents, presentations, and video clips necessary for teachers in lesson planning and instruction as well as student materials. When I inquired why no other teacher could access the materials on their DVDs I was informed that the technology department had been able to block the use of DVDs on all computers but had unblocked the one teacher’s computer. A similar happening occurred concerning the use of dynamic geometry software that was developed by a now university professor. This program is used in educational institutions around the world. When we requested it be loaded onto the lab computers, internet access to the site was blocked with no explanation why. While teachers have shared a genuine interest in using software and other forms of technology for instruction and learning, they need support to implement it. With all they have been dealt, they are cautiously optimistic at the idea of introducing more technology into their classrooms.

**Research Questions**

In this study to ascertain the efficacy of the Qwizdom system in closing gaps in mathematical content knowledge, the following questions became the foundation on which this study was built.

1. Do students make greater gains toward closing achievement gaps in mathematics content knowledge when teachers integrate technology into instruction and acquisition?
2. Does using technology affect a student’s ability to acquire math concepts and apply them in everyday situations?

3. Does using technology increase participation?

4. Does using technology increase motivation?

5. Does using technology transform attitudes about mathematics?

6. Does technology have the potential to become the language of meaningful interaction between students and teachers?

7. Does a student response system provide immediate formative assessment on student improvement for the teacher and for the student?

The designed treatment will be determined to be effective if participants in the experimental group make greater gains on the post-exam than the participants in the control group. The Qwizdom system will track participation in classroom discussions which will increase as the treatment progresses. The data collected from the control group will provide a base line in which the data from the experimental group will be compared. Participant motivation and attitudes shall also show an improvement in the responses on the affective survey. In a study using technology in a remediation program, there was an improvement in attitudes towards math, and increased achievement on math content (Taylor, 2008). Feedback will be used to examine how participants feel the use of technology has affected their learning, understanding, and attitudes.

**Goal Statement**

The multi-dimensional problem requires multiple goals. Participants are expected to close gaps in mathematical content knowledge and thereby improve their performance on exams assessing mastery on formulating and using linear equations and inequalities, demonstrating an understanding of geometric relationships and spatial reasoning, demonstrating an understanding of two- and three-dimensional representations of geometric relationships and shapes, and
demonstrating an understanding of the concepts and uses of measurement and similarity.

Participants are expected to demonstrate their ability to apply these concepts using technology and to demonstrate mastery of grade level objectives. In a study using technology that was closely aligned with the constructivist philosophy, students did not just score well, but they scored well consistently, and with significant improvement (Connell, 1998). They are also expected to participate in discussions, complete written work, and interact within the connected classroom.

**Hypothesis**

Students in a technology-integrated geometry class who are instructed using a wireless interactive learning and student response system with standards-based instructional and assessment curriculum will make greater gains towards closing achievement gaps in mathematics content knowledge as measured by assessments used for pre- and post-exams, than students who receive traditional instruction.
CHAPTER TWO: LITERATURE REVIEW

At the outset, my search for information pertaining to the use of technology in the classroom returned a large number of reports; however, as I refined by searches, first with math and then specifying how technology might be used, the number of reports became fewer and yet, more informative. My first questions, how does the use of technology in the classroom affect mathematical literacy and does technology motivate students or change attitudes about math, were soon expanded to include does technology increase participation or reduce anxiety. From the current research I was able to more clearly ask how it is that technology affects teaching and learning when it is used in alignment with instructional philosophy and approaches.

As I studied the research regarding technology usage when aligned with certain instructional philosophies and approaches I realized that when searching for methods that have proven successful in closing achievement gaps that I also needed to search for best practices that have been effective in remediation with at-risk or low-achieving students. This also helped to formulate the question, how does technology coincide with best practices in teaching and what are its affects on learning. The literature returned provided a wealth of information that became the guide for the research questions and methodology.

One driving force behind this project is to determine if technology, when used in a connected classroom, metamorphoses and moves beyond a tool for teaching and learning to become a meaningful language used during interaction between students and teachers. The search on this topic turned up only a couple of studies. The fact that there are so few returns leads me to believe that this is one aspect of technology that has yet to be fully explored.

In my initial searches for student response systems (SRS) the few returns seemed almost unrelated to what I wanted to achieve. After some time as I searched again I found more pertinent literature that helped me to articulate my ideas concerning the use of student response systems for the students and also for the teachers. Upon closer inspection I also realized that the
literature related to SRSs also shows promising research toward answering the question whether technology, when used in a connected classroom, moves beyond a tool for teaching and learning to become a meaningful language. Overall the research did provide a clearer direction for the project and a refashioning of research questions while substantiating and supporting ideas and proposals related to the issues.

**Technology and Mathematical Literacy**

Mathematical literacy is about making math relevant to everyone, applying math in real-life situations and to real-world problems, as well as across content areas. Many have studied technology’s use in teaching and learning and its effects on both. In a study using technology within the constructivist philosophy, students became active participants in their own learning where technology assisted the students in their construction of mathematical learning and thereby made math relevant (Pugalee, 2001). In a like situation, students used technology within the constructivist orientation as a tool to help them to construct their own, personally meaningful, representations (Connell, 1998). In both situations technology was used by students in the construction of their own understanding of math and thereby made math meaningful to them.

**Technology: Transforming the Learning Environment**

Technology usage in the classroom has been researched as it pertains to increasing mathematical literacy as well as improving scores in high-stakes testing. The question, too, has been asked and answered concerning technology’s ability to motivate students, increase participation, improve attitudes toward math, and reduce math anxiety. In a study using technology, it was reported that an increase in student motivation and participation was found where interactive whiteboards were used for teaching and modeling (Mounce, 2008). When technology was used in conjunction with dynamic, representationally-rich mathematics software an increase in participation was reported as technology challenged the traditional roles within connected classrooms (Hegedus & Penuel, 2008).
Additionally, the same study using technology and dynamic software also reported that students demonstrated more favorable attitudes toward subjects when computers were used for instruction and more positive attitudes toward courses that included computer-based instruction (Hegedus & Penuel, 2008). Decreasing anxiety has been noted as a positive response after an algebra course using computer-mediated instruction and when using technology in mathematics problem solving (Taylor, 2008).

It is important to note that one study that produced increased academic self-concept actually was a study of the effects on pre-teaching and re-teaching with no mention of using technology at all. It was the pre-teaching method used that noted an increase in self-concept without the use of technology (Lalley and Miller, 2006).

Language of Meaningful Interaction

Studies evaluating technology’s ability to transform motivation, participation, and attitudes in students and teachers are plentiful (Mounce, 2008; Taylor, 2008; Hegedus & Penuel, 2008); however, finding any research on the question of whether technology has the potential to transform the language and interaction between students and teacher has proven a challenge. One university is leading the way with research on the transforming power of a connected learning environment (Hegedus & Penuel, 2008). University of Massachusetts at Dartmouth and the researchers at the James J. Kaput Center for Research and Innovation in Mathematics Education have published a few studies. Most interesting to this research project is the unfinished work of the Center’s namesake, Dr. James J. Kaput.

One of Dr. Kaput’s thoughts regarding classroom connectivity is that “wireless connectivity inside the classroom would change the communicative heart of the mathematics classroom” (Hegedus and Penuel, 2008, p. 1). He believed that the traditional roles of teachers and students would be transformed through the connectivity of multiple technologies not just the internet (Hegedus & Penuel, 2008). Through the SimCalc Math Worlds research funded by the
National Science Foundation as well as other projects, Dr. Kaput, Hegedus, and Roschelle observed “students interacting mathematically with each other and their teacher” as new forms of connectivity are emphasized in the classroom (Kaput, n.d., p. 8). These observations led Dr. Kaput to view technology as a “medium in which teaching and learning are instantiated in the social space of the classroom” (Kaput, n.d., p. 8). In a study of new forms of participation and identity, specific discourse analytic methods have been outlined as they have been utilized in measuring participation and methodologies in answering their primary question concerning new forms of participation that occur when teachers combine two unique technological ingredients and the resulting human interactions (Hegedus & Penuel, 2008).

**Instructional Philosophy and Approaches with Technology**

Numerous studies have applied technology in classrooms with differing philosophies and approaches and have been shown to positively affect both the teaching and the learning (Connell, 1998; Mounce, 2008; Pugalee, 2001). One study in particular applied technology in a class where it was used in line with the constructivist approach, but in the second classroom technology was used in a manner at odds with the constructivist approach; yet, students in both classrooms exceeded expectations (Connell, 1998). Students in the classroom where technology was closely aligned with the constructivist philosophy did not just score well, but they scored well consistently, and with significant improvement (Connell, 1998).

Integrating concrete manipulatives into the mathematics environment has been used by teachers for many years. With the expense of integrating technology into the mathematics classroom and the increased time required to do so, teachers have had to justify the specific contributions that technology can make in improving mathematics education (Crawford & Brown, 2003). It is necessary that teachers consider how they would incorporate technology to create student-centered learning using digital manipulatives, and how they will use technology to enhance the learner’s understanding of advanced theories while achieving deeper levels of
understanding (Crawford & Brown, 2003). In a case study considering ways the interactive whiteboard (IWB) may be used to support and enhance pedagogic practice through whole-class instruction, it was concluded that the IWB enhances the delivery and the pace of the lesson (Wood & Ashfield, 2008). Findings also indicated that it is the skill and professional knowledge of the teacher that directly effects the enhancement of the whole-class teaching and learning (Wood & Ashfield, 2008). The evidence shows that no matter what the instructional philosophy or the method of integration, technology greatly enhances both the teaching and the learning.

**Best Practices**

Best practices are instructional approaches, strategies, and methods for teaching and learning in an educational environment. Some effective instructional practices are concept development, instructional scaffolds, and differentiation. Concept development is a strategy teachers use to provide personally-meaningful material the student will use to update the patterns that represent past experiences and understandings of a wide range of concepts. Instructional scaffolding is a strategy where the teacher will provide the necessary instruction and support a student requires to build scaffolds that will take the student’s learning from one level to the next level. The teacher must design this scaffold to bridge the gap between what the student knows and what the student can do and the concept or the skill that the student is attempting to achieve. Differentiated instruction is a necessary practice where the teacher adapts instruction to fit each student’s ability, style, and need to process and learn content material.

**Effective methods in remediation of at-risk or low-achieving students.**

Teachers have many strategies that they may use when teaching at-risk or low-achieving students. In a study designed to examine the effects of two methods, pre-teaching and re-teaching on math achievement, both practices have resulted in significant increases in math concepts, math problems, and math computation (Lalley and Miller, 2006). An additional note
to their findings shows that there was a measurable increase in self-concept for students receiving pre-teaching but not for students receiving re-teaching (Lalley and Miller, 2006).

Technology has also been used by teachers in remediation programs to close gaps in mathematics content knowledge. In a dissertation on the effects of a computerized algebra program on mathematics achievement of students in a developmental mathematics course suggested that math achievement had improved for students using a computer algebra system, A L E K S (Taylor, 2008). Also included in this study were findings that highlighted a decrease in math anxiety, an improvement in attitude towards math, and increased achievement on math content (Taylor, 2008).

In an algebra course for at-risk students, the application of technology in a constructivist classroom students exhibited improved mathematics literacy and more specifically these students became active participants in their own learning where technology assisted the students in constructing their own mathematical knowledge (Pugalee, 2001). Likewise, a case study of computer-based instruction as a remediation strategy reported a positive impact with a group of students who were considered some of the most disenfranchised in the system (Hannafin & Foshay, 2008).

**Integrating Technology and Its Effects on Learning**

With regards to best practices in effective instructional teaching methods, differentiated instruction is considered necessary to teach all students. Because students arrive with varying ability levels, learning styles, and previous experiences, teachers must adapt instruction to fit each learner’s needs, abilities, and styles. Integrating technology into the learning environment accomplishes these goals. Technology is differentiation in action. Teachers employ technology to connect learning to the real world and thereby increasing mathematical literacy. Technology can be the helping hand for a student that requires more time to do tasks as they are user friendly and require no training. Technology is also the springboard from which a gifted student can
explore the universe and the endless ideas that fill their minds. As Renzulli (2008, p. 3) said, “When technology does some of the hard work, true differentiation can occur”.

There are many forms of technology. For future reference technology will include information technologies, both hardware and software, computers of various sizes and configurations, visual displays and communication systems, and memory storage systems. In the case study of a high school using computer-based instruction to improve pass rates on high-stakes testing, researchers found that typically computer-based instruction yielded higher achievement with less instruction time (Hannefin and Foshay, 2006). Additionally, in a study of technology in constructivist mathematics classrooms, it was determined that students, in a classroom where technology was aligned with the constructivist philosophy, showed a significant improvement in performance scores, a marked increase in students that scored well and scored well consistently, and that their time by treatment effect was also significant when compared to the classroom where technology was at odds with the teaching philosophy of the classroom (Connell, 1998).

**Teaching mathematics content using the interactive whiteboard.**

A specific technological device that requires noting is the interactive whiteboard (IWB). The IWB when connected to a computer with special software while also connected to a projector can be integrated into the classroom to enhance curriculum and engage students. There are many advantages to using the IWB over a regular whiteboard. The IWB allows teachers to demonstrate and illustrate mathematical concepts; the software that accompanies an IWB allows the teacher to record problems that she has modeled on the whiteboard, creating a video for later playback by students. This unique feature provides a differentiating tool for students that require multiple examples (Mounce, 2008).

In other research, a teacher was observed using the IWB to enhance the learning experience and appeal to a larger group of students through multisensory presentations as well as
the ease of replaying examples modeled on the IWB (Wood & Ashfield, 2008). In an article entitled, “Teaching and Learning Mathematics with an Interactive Whiteboard”, in face to face discussions students expressed for themselves a belief that math was easier to understand after using the IWB (Ball, 2003). Some students believed that they learned more and that the lessons were more advanced (Ball, 2003).

Teaching and learning using student response systems (SRS).

As Socrates realized over two thousand years ago, people understand more on a subject if asked questions than when simply given the answer (Abrahamson, 1999). The National Science Foundation (NSF) funded the development of a teaching tool that would facilitate communication between the teacher and the students (Abrahamson, 1999). The main idea behind a communication system is to bridge the gap that exists between the teacher and the necessity to impart information in a manner that engages students (Abrahamson, 1999).

SRSs provide privacy and anonymity for students responding to questions in the classroom, while engaging students and allowing for all students to give teachers feedback on what they understand (Ferriter, 2009). Students have the ability to monitor their own learning through the immediate feedback provided by the hand-helds or by the graphic presentation on the board (Ferriter, 2009). All results are collected and recorded onto a computer where the teacher receives immediate formative feedback on concept acquisition and understanding before continuing on to the next lesson (Ferriter, 2009).

Brain-Based Learning

Neuroscience and brain-based research exploded during the decade of the nineties. Many studies have investigated how the knowledge learned from neuroscience can be applied in education and more specifically, the classroom. Brain and educational studies and learning styles models have centered their attention on the complexity of the learner and their differences,
in conjunction with and relating to the constructivist approach (Gulpinar, 2005). These studies have given way to the understanding of how the brain is designed and how it functions.

The brain constantly searches for and integrates new information into existing structures known as schemata (Roberts, 2002). It takes the information and organizes it into meaningful categories of information (Roberts, 2002). Research of the brain’s ability to store real-life experiences in a different and more meaningful way than it does a fabricated story has provided proof for the success of traditional teaching approaches in career and technical education as they have made use of the brain’s natural predisposition to learning (Kaufman, E., Robinson, J., Bellah, K., Akers, C., Haase-Wittler, P., & Martindale, L., 2008). From the current information we have regarding brain-based learning, educators are utilizing power point presentations to implement teaching-learning models founded on brain-based learning (Shapiro, 2006). The same models used to teach children are being used to teach adults. Research has shown that it is equally important when teaching adults, to incorporate social learning in order to ensure that cognitive gains have founded meaningful learning experiences (Dwyer, 2002).

Marshall (2005) believes that our current level of knowledge and understanding of neuroscience maybe be incomplete and inaccurate. A lack of information and or understanding has led to misrepresentations of neuroscience (Goswami, 2006). He also argues that it is too early in the research process to bridge the gap between research and practice (Goswami, 2006).

**Learning Styles**

One cannot discuss technology and brain-based learning and not discuss learning styles. In a study researching the effects that learning styles had on education and teaching it was noted that students who had previous experience with learning styles as a process and an approach to learning would be more successful (Kazu, 2009). A similar study suggested that there are significant relationships between a student’s learning styles and the use of technology preference (Saeed, 2009).
One study investigated how students would behave when placed in courses that were directly mismatched with their learning styles Tzu-Chien (2009). The researchers concluded that those students required more help in understanding and in order to master concepts in mismatched courses (Tzu-Chien, 2009). Additional studies were conducted specifically for business students, computer programming, and microeconomics. Each researcher concluded that there appeared significant evidence that learning styles do play a part in a student’s ability to perform and achieve as well as preferences correlated to gender, also, (Lau, 2009; Ramayah, 2009; Terregrossa, 2009).

Summary

Issues to consider in the foundation of this research design are mathematical literacy, motivating students, engaging students, best practices, and integrating technology. Existing literature provided insight into the interconnectedness of technology usage in teaching and learning, and its ability to increase mathematical literacy, differentiate instruction, as well as motivate and engage students. Using best practices such as incorporating technology, provides a necessary remediation for at-risk or low-achieving students. Technology becomes personified when described in some literature.

While learning styles will be evaluated, time will not allow for in-depth study of learning styles and their correlation to the study. Additionally while brain-based research is fascinating to research, it appears too controversial and not well-founded enough to present substantial arguments for its incorporation in this study.
CHAPTER THREE: METHODOLOGY

The problem as presented was two existent classes of geometry students that had exhibited gaps in mathematics content knowledge on recent exams and required differentiated instruction to close achievement gaps. The differentiated instruction chosen was the Qwizdom system. This study ascertained the efficacy of the Qwizdom system in closing gaps in mathematical content knowledge. This study sought to describe and characterize the following research questions:

Do students make greater gains towards closing achievement gaps in mathematics content knowledge when teachers integrate technology into instruction and acquisition?

Does using technology affect a student’s ability to acquire math concepts and apply them in everyday situations?

Does using technology increase participation, motivation, or transform attitudes about mathematics and the use of technology?

Does technology have the potential to become the language of meaningful interaction between students and teachers?

The hypothesis of this researcher stated that students in a technology-integrated geometry class who were instructed using a wireless interactive learning and student response system with standards-based instructional and assessment curriculum would make greater gains towards closing achievement gaps in mathematics content knowledge as measured by assessments used for pre- and post-exams, than students who received traditional instruction.

Participants

The participants in this study had exhibited gaps in mathematics content knowledge on recent exams. There were two existent groups. The participants were of varying skill levels and educational experiences.
Demographics

Participants.

There were forty-eight total participants. Breakdown by grade classification were: five as ninth grade, forty as tenth grade, and three as eleventh grade. There were twenty females, twenty-eight males, seven Hispanic, one Hispanic/African-American, seven African-American, and thirty-three White participants.

In the experimental group, there were twenty-four participants. By classification there were two as ninth grade, twenty as tenth grade, and two as eleventh grade. There were thirteen females, eleven males, four Hispanic, two African-American, and eighteen White participants.

In the control group, there were twenty-four participants. By classification there were three as ninth grade, twenty as tenth grade, and one as eleventh grade. There were seven females, seventeen males, three Hispanic, one Hispanic/African-American, five African-American, and fifteen White participants.

District.

In this suburban school district, there were 3,117 students, with 892 students in the high school. The district employed 196 teachers with thirteen average years of experience and 15.9 students to every teacher. The ethnic distribution for the district was 13.5% African-American, 22.8% Hispanic, 62.7% White, 0.4% Native American, and 0.6% Asian/Pacific Islander. The district recorded 48.9% of its students were economically disadvantaged, 4.0% Limited English Proficient, and 46.2% were classified as at-risk. Student enrollment by program broke down to 3.3% of the students in Bilingual or English as a Second Language, 4.1% were Gifted and Talented, and 10.8% were Special Education.

Research Design

The research approach implemented was a quantitative, quasi-experimental, non-equivalent control group research design. There was at least one independent variable that
observed. The participants selected were divided into two groups having similar numbers and characteristics at the onset of the research experiment. One group received the designed treatment and one group was the control. Pre- and post-exams were used to collect data regarding overall changes in the two research groups. Field observations and feedback were collected, and surveys were administered to provide explanation and understanding.

**Rationale for Design**

The research approach chosen was an appropriate choice to study the cause and effect outcomes regarding the use of technology as prescribed differentiation to effectively close achievement gaps in mathematics content knowledge. In this proposal, a quantitative approach and quasi-experimental research design was chosen to collect and analyze numerical data regarding acquisition and application of mathematical content knowledge.

A quasi-experimental research design using nonequivalent control group design was much like the pretest-posttest control group design. It used random assignment of intact groups instead of random assignment of individuals and allowed for the use of analysis of covariance to statistically equate the groups if required. Using existent groups precluded effects from reactive arrangement; however, regression and interactions between testing were validity threats of the design.

**Methods**

The efficacy of the wireless interactive learning and student response system with standards-based instructional and assessment curriculum was ascertained by comparing the scores of the pre- and post-exams for math content achievement of the experimental and the control groups. In the event the pre-exams revealed an inequality existed in the measures of the participant performance between the two groups, an existent Algebra II pre-exam from the standards-based assessment curriculum would have been administered and the results would have served as a covariate to adjust post-exams for the pre-exam discrepancies.
A pre- and post-affective survey identified participants’ perceived abilities, and attitudes and motivations toward math and using technology in the experimental group. The pre- and post-surveys were identical.

A pre- and post-affective survey identified the participants’ perceived abilities, and attitudes and motivations toward math in the control group. The pre- and post-surveys were identical. A learning styles evaluation and a demographic survey were administered to all participants.

A feedback form allowed participants in the experimental group to share their ideas and feelings regarding geometry class, the use of technology in geometry, technology’s part in their understanding of geometry, and whether they would choose a class that integrated technology.

**Instruments**

**Qwizdom Student Response System (SRS)**

The interactive learning system consisted of Qwizom Connect (proprietary software), a USB host, wireless hand-held participant remotes, and a wireless presenter. The software ran the interactive instruction and assessment Actionpoint presentations and collected, recorded, analyzed, and reported the participant’s answers. It was used to collect all data from the experimental group with the exception of the pre- and post-exams. This data was quantitative in nature.

**Pre- and Post-Exam**

The pre-exam (Appendix A) and post-exam (Appendix B) for math content achievement were the 2009 released mathematics TAKS (Texas Assessment of Knowledge and Skills) exam. Each exam consisted of sixteen multiple-choice problems; each problem was worth five points for a possible score of ninety-six. The exams were designed to assess the mastery of objectives four, six, seven, and eight: formulating and using linear equations and inequalities, demonstrating an understanding of geometric relationships and spatial reasoning, demonstrating
and understanding of two- and three-dimensional representations of geometric relationships and shapes, and demonstrating an understanding of the concepts and uses of measurement and similarity. The pre-exam provided information on the participant’s previously attained knowledge and was used to establish the ability levels of the experimental and the control groups in order to establish equality or inequality of participant performance. The post-exam measured the outcome after the time of treatment and identified the mastery of assessed grade-level standards. The pre- and post-exams were multiple objective tests, quantitative in nature, and provided internal variables.

While the exams were paper-based, the Qwizdom SRS were used by the participants in the experimental group to collect and grade their responses. For the control group, the exams were distributed and answers were graded in the traditional manner.

**Covariate Adjustment**

Had the pre-exam revealed an inequality in the measures of the ability levels of the experimental and the control groups, the Algebra II pre-exam would have been used as a covariate between the two groups. Covariate analysis was a statistical method whereby the covariance would have adjusted the scores of the post-exam to compensate for the pre-exam differences in measurements.

**Pre- and Post-Affective Surveys**

Pre- and post-affective surveys (Appendix C) for the experimental group were divided into three sections to identify the participant’s perceived abilities, attitudes and motivations toward math, and attitudes toward the use of technology. Pre- and post-affective surveys for the control group (Appendix D) were divided into two sections to identify the participants’ perceived abilities, and attitudes and motivations toward math. The pre- and post-surveys were identical and created by me. The surveys were designed using a five-point Likert scale and provided ordinal variables and were therefore quantitative in nature.
The surveys for the experimental group were distributed using Actionpoint presentations and the Qwizdom SRS collected and score the participants’ responses. The surveys for the control group were paper-based and distributed and scored in the traditional manner.

**Demographic Survey**

The demographic survey (Appendix E) was administered directly following the affective surveys and in the same manner as was required for each perspective group. It provided basic information regarding each individual participant. The data was qualitative and produced nominal variables.

**Learning Styles Evaluation**

The learning styles evaluation (Appendix F) was administered to all participants. Understanding the learner’s specific needs allowed the researcher to make every effort to differentiate instruction within the prescribed definition of this research design. The data collected was used to draw a correlation between the participant’s responsiveness to technology as it related to their learning style and his or her feedback. The evaluation was qualitative in nature and produced nominal variables.

**Feedback**

Feedback was collected using open-ended prompts that guided participants in sharing their feelings and ideas. Prompts aided participants in sharing their feelings on topics such as what they liked or disliked about geometry class, how they felt about the conclusion of the research project, how they felt about using technology in geometry, and whether they felt it helped them understand geometry. One question was asked of participants, if given the choice, would he or she choose a class that used technology?

Feedback prompts (Appendix G) were paper-based and were administered to the experimental group at the conclusion of the project, following every exam, affective survey, and evaluation.
Observations

I observed the control group using the Nonparticipant Observation Form (Appendix H) to record necessary information. Other math department teachers, counselors, and administrators also observed the control group and the experimental group which provided pertinent qualitative data. The resultant data provided nominal variables categorizing participation by nature of conversation, types of interactions, and roles of people. The data was qualitative in nature.

Materials

The materials required to complete this research project were categorized as technology both hardware (Table 1) and software (Table 2), and documents and Actionpoints. Integrating multiple forms of technology required software to drive the perspective hardware. When using one computer to drive all technology, a specific protocol was necessary for startup. If possible, a second computer was recommended for driving the IWB due to the large requirements of the IWB software and drivers.

Most documents for this project were created on the computer. Actionpoint presentations were interactive slides that were designed to lead participants through the lesson. Questions asked during modeling were collected, graded, and recorded using the Qwizdom SRS. Class responses were then graphically presented and discussed. The IWB and its software allowed participants to use technology in shaping their understanding of the geometry concepts that were presented.
### Table 1

**Technology Hardware**

<table>
<thead>
<tr>
<th>Material</th>
<th>Used by</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qwizdom Q7 Presenter</td>
<td>Teacher</td>
<td>To wirelessly manipulate the interactive software with Qwizdom, the IWB, and the laptop</td>
</tr>
<tr>
<td>Qwizdom Q4 Student Remotes</td>
<td>Students</td>
<td>To respond to questions posed during modeling and guided practice. They will also be used to record daily work.</td>
</tr>
<tr>
<td>Interactive Whiteboard (IWB)</td>
<td>Teacher</td>
<td>To present lesson</td>
</tr>
<tr>
<td></td>
<td>Students</td>
<td>To acquire and apply math concepts</td>
</tr>
<tr>
<td>Laptop</td>
<td>Teacher</td>
<td>To run the software for IWB, lesson presentation, as well as data collection, analysis, and reporting.</td>
</tr>
<tr>
<td>Projector</td>
<td>Used to project onto the IWB.</td>
<td></td>
</tr>
<tr>
<td>Graphing Calculators</td>
<td>Students</td>
<td>To construct understanding of math using representationally-rich examples.</td>
</tr>
</tbody>
</table>

Table 1 Technology Hardware
<table>
<thead>
<tr>
<th>Material</th>
<th>Used by</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connect ®</td>
<td>Qwizdom</td>
<td>To run interactive Power Point presentations and for all data collecting, recording, analyzing, and reporting within the Qwizdom system.</td>
</tr>
<tr>
<td>WizTeach ®</td>
<td>Qwizdom</td>
<td>Dynamic manipulatives used during lesson presentation.</td>
</tr>
<tr>
<td>Actionpoint ®</td>
<td>Qwizdom</td>
<td>To create the interactive presentations and the answer keys used to input daily work.</td>
</tr>
<tr>
<td>VBoard ®</td>
<td>IWB</td>
<td>To manipulate the projections on the IWB.</td>
</tr>
<tr>
<td>GeoGebra</td>
<td>Teacher and Students</td>
<td>Free, open source, dynamic software with geometric, algebraic, and statistical capabilities used for creation and exploration of mathematical concepts.</td>
</tr>
<tr>
<td>Virtual Classroom</td>
<td>Teacher</td>
<td>To extend the classroom learning to the home where the day’s lesson, interactive presentations, videos recorded from the IWB, and dynamic constructions captured from GeoGebra are posted. Accessed from home by students where they can view materials posted from class. Helpful content specific how-to video links will also be posted.</td>
</tr>
<tr>
<td></td>
<td>Students</td>
<td></td>
</tr>
</tbody>
</table>

Table 2 Technology Software
Documents and Actionpoints

In addition to the instruments already described, the instructor needed

- Record of Participants,
- TAKS Mathematics Chart,
- Actionpoints,
- Activity Notes,
- Nonparticipant Observation Form,
- Teacher Instructions,
- Individual Dry Erase Boards,
- and Dry Erase Markers.

Research Procedure

Forty-eight geometry students were chosen to participate in this study where technology was used to differentiate instruction. The students exhibited gaps in mathematics content knowledge on recent exams. Twenty-four students were in the first class and twenty-four students were in the second class. A coin was flipped to determine whether the first class would be the control group (heads) or the experimental group (tails). The coin landed tails up and the first class was the experimental group and the second class was the control group.

Administration of Pre-Instruments

One week prior to the commencement of the study, each participant took an Informed Consent form (Appendix J) home to be read and signed by the participants and their legal guardians, and then returned to their teacher. The Record of Participants form (Appendix K) was used to assign a participant number to each student as they returned the Informed Consent form. The participant number was used on all exams, surveys, written work, and feedback prompts.

Three days prior to instruction, participants were given the Pre-Exam (Appendix A) to establish the mastery of objectives four, six, seven, and eight. It provided information on the
participant’s previously attained knowledge and established the ability levels of the experimental and control groups in order to determine equality or inequality of participant performance. All scores were recorded in the computer as quantitative data.

Two days prior to instruction, the Learning Styles Evaluation (Appendix F) and the Pre-Affective Survey for the control group (Appendix D) were given to each participant in the control group. Likewise, the Learning Styles Evaluation (Appendix F) and the Pre-Affective Survey for the experimental group (Appendix C) were given to each participant in the experimental group. The scores from the surveys were recorded in the computer as quantitative data. The learning styles determined from the evaluation were categorized and recorded in the computer as qualitative data.

In the event the data collected from the pre-exam revealed an inequality existed in the measures of the participant performance, then an existent Algebra II pre-exam would have been given to all participants and would have served as a covariate to adjust post-exam scores for the pre-exam discrepancy in scores.

**Instruction Geometric Formulas and Spatial Reasoning**

This study in the efficacy of the wireless interactive learning and student-response system entailed eleven days of instruction on Developing and Applying Geometric Formulas and Spatial Reasoning using the integrated technology for the experimental group. For the control group, this study consisted of eleven days of traditional instruction on Developing and Applying Geometric Formulas and Spatial Reasoning. Traditional instruction in this project consisted of the teacher projecting worksheets onto the dry erase board and working each problem with the class.

I observed the control group as a nonparticipant recording participation data. It was categorized and recorded in the computer as qualitative data. For the experimental group, the
participation data recorded by the Qwizdom system was exported to analyzing software as quantitative data.

**Administering Post-Exam and Post-Affective Survey**

On the day following the completion of instruction, all participants were administered the Post-Exam (Appendix B) to measure the outcome after the time of treatment. Mastery of objectives four, six, seven, and eight were assessed. The exam scores were recorded in the computer as quantitative data.

On the final day, the Post-Affective Surveys (Appendix C and D) were administered to the perspective groups. The scores were recorded in the computer as quantitative data. The Feedback prompts (Appendix G) were given to the experimental group to allow participants to respond in their own words. The data was organized as qualitative data. All data was prepared for analysis and interpretation of results.

**Data Analysis**

Due to the complexity of the research questions driving this study, both quantitative and qualitative data was collected. Consequently, multiple techniques were required for data analysis.

**Descriptive Statistics**

Descriptive statistics were techniques to analyze data and were usually the first step used in describing many pieces of data with a numerical index. The Measure of Central Tendency was determined using the interval data produced by the pre- and post-exams to determine the mean scores for the pre-exams and the post-exams for the treatment and the control groups. The Measure of Variability determined the standard deviation which indicated how scattered or how clustered the scores were that existed from the pre- and post-exams. While the central tendency determined the equality of the means, the variability referred to the distributions of the scores. The standard deviation or the square root of the variance and the mean of a normal distribution
used to compute the percentile rank that correlated to any score. Typically, in a normal
distribution, about sixty-eight percent of the scores were within one standard deviation of the
mean and about ninety-five percent of the scores were within two standard deviations of the
mean.

**Inferential Statistics**

*Analyzing pre- and post-exams.*

Inferential statistics were techniques used to analyze data to determine how likely it was
that results collected from a sample would be the same results collected for the entire population.
In analyzing the data, an appropriate Test of Significance such as a $t$ test was used to determine
whether there was a significant difference between the mean scores of the pre- and post-exams.

The mean scores from the pre-exam were used to run a $t$ test for independent samples to
determine equality or inequality in the measures of the ability levels of the experimental and the
control groups.

If the $t$ test had revealed a significant inequality in the measures of the ability levels of
the two groups, then the Algebra II pre-exam mean scores would have been used to run an
analysis of covariance (ANCOVA) on the post-exam mean scores.

When the initial $t$ test established equality in the ability levels of the experimental and the
control groups, then three additional $t$ tests were run. The first $t$ test for nonindependent samples
determined there was a significant difference between the mean scores of the pre- and post-
exams of the experimental group. The second $t$ test for nonindependent samples determined
there was a significant difference between the mean scores of the pre- and post-exams of the
control group. The third $t$ test, that one for independent samples, determined there was a
significant difference between the mean scores of the post-exams of the experimental and the
control groups.
Analyzing pre- and post-affective surveys.

The pre- and post-affective surveys rendered non-independent and ordinal data and therefore required a nonparametric test for paired data. The Wilcoxon Signed-Rank test was an appropriate Test of Significance used to rank and analyze the scores for the pre- and post-affective surveys for the experimental group and the control group.

Inductive Analysis

Upon conclusion of the data collection, field observations were organized. The process of induction began with the mass of data as a whole and reduced it to manageable forms that provided depth and understanding to the study.

Insights gained through data interpretation were compared or triangulated with other forms of data to further investigate its reliability. The results of the learning styles evaluations, post-exam scores, and feedback were investigated to compare effectiveness of different instructional methods for different learning styles.

Rationale for the Analysis Chosen

The t test was an appropriate test to determine whether there was a significant difference between the mean scores of the pre- and post-exams. The t test was a parametric test used when the variable measured was normally distributed in the population, when the data represented an interval or ratio scale, and when the participants were selected independently. A t test also made adjustments for small samples of scores.

The Wilcoxon Signed-Rank test was a non-parametric test used as an alternative to the popular t test when the data used was ordinal data. Because the affective surveys were scored using a five-point Likert scale, the scores produced were arbitrary. The score of two was not twice as positive as the score of one and was meaningless to establish a ratio.
Description of Results Interpretation as It Pertains to Research Questions

The results of the pre-exam were used to establish the ability levels of the experimental and the control groups. Because the exams were designed to assess participant ability on objectives four, six, seven, and eight, results delineated achievement gaps in mathematical content knowledge.

The results of the post-exam measured the outcome after the time of treatment. When the post-exam scores of the experimental group were compared to their scores on the pre-exam, a significant increase in scores were interpreted as making gains in closing gaps on mathematic content knowledge.

The results of the pre- and post-affective surveys, feedback, and the learning styles evaluation for the experimental group identified participant’s learning styles, overall changes in perceived abilities, and changes in attitudes and motivations toward mathematics and the use of technology. The results of the pre- and post-affective surveys and the learning styles evaluation for the control group identified participant’s learning styles, overall changes in perceived abilities, and changes in attitudes and motivations toward mathematics.

Furthermore, this study sought to determine additional and correlational phenomena of interest as it pertained to how and why technology affected certain outcomes. Using a combination of quantitative and qualitative data determined and defined whether a relationship existed between technology and naturally occurring social structures and did it transform the social space of the connected classroom and become a language of meaningful interaction?
CHAPTER FOUR: RESULTS

Mean scores from both groups were calculated, recorded, and then analyzed. Since the gain scores for participants in the two groups were of primary interest, a repeated measures of analysis of variance was used to test whether gains were significant at the .05 alpha level ($\alpha < .05$). Surveys, observations, interviews, feedback and evaluations were organized and analyzed, looking for patterns and explanations that supported other findings.

The two existent geometry groups were originally equal class sizes of twenty-four participants each. By the end of the study, three participants had withdrawn from the experimental group and one had withdrawn from the control group. The control group also had two participants removed to the Alternative Education Program (AEP) and the experimental and the control group each had two participants disqualified from the study due to incomplete exam data. The experimental group completed the time of treatment with nineteen participants and the control group completed the study with twenty.

Statement of Results

In Table 3, the experimental group had a mean score of 58 on the pre-exam with a standard deviation of 15.56; whereas the control group had a mean score of 61 on the pre-exam with a standard deviation of 18.40. The pre-exam scores of the experimental group were closer to the mean than those of the control group; yet, on the post-exam it was the control group’s scores that were closer to the mean. On the post-exam, the experimental group had a mean score of 77 with a standard deviation of 16.75; for the control group they had a mean score of 59 with a standard deviation of 13.23. In Figure 1 and Figure 2 the scores for the pre-exam and for the post-exam had been compiled into histograms in order to better see the distributions of the scores and to expand knowledge about these distributions.

The mean scores for the pre-exam for each group were analyzed using a $t$ test for independent samples. The $p$ value of 0.2914369 obtained from the $t$ test determined there to be
no significant difference ($p<.05$) in the measure of ability levels of the experimental and the control groups. Equal ability levels assured simple inferential statistics.

After establishing the equality of the mean scores of the pre-exam, three additional $t$ tests were run. The first $t$ test for nonindependent samples returned a $p$ value of 0.0000436 which determined there to be a significant difference ($p<.05$) between the mean scores of the pre- and post-exams of the experimental group. The second $t$ test for nonindependent samples returned a $p$ value of 0.6703631 which determined there to be no significant difference ($p<.05$) between the mean scores of the pre- and post-exams of the control group. The third $t$ test, this one for independent samples, returned a $p$ value of 0.0009738 which determined there to be a significant difference ($p<.05$) between the mean scores of the post-exam of the experimental and the control groups. An additional $t$ test for independent samples was run to determine whether the difference in the gain-scores was significant. The resultant $p$ value of 0.0014222 confirmed the significant difference ($p<.05$) in the comparison of the gain-scores between the experimental and the control groups.
### Data

Table 3

*Mean score, t test, and Gain-score Comparison for Experimental and Control Groups*

<table>
<thead>
<tr>
<th></th>
<th>Experimental (n = 19)</th>
<th>Control (n = 20)</th>
<th>P value</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-exam Mean</td>
<td>58</td>
<td>61</td>
<td>0.2914369</td>
<td>No</td>
</tr>
<tr>
<td>Standard Deviation Of the Pre-exam</td>
<td>15.56</td>
<td>18.40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-exam Mean</td>
<td>77</td>
<td>59</td>
<td>0.0009738</td>
<td>Yes</td>
</tr>
<tr>
<td>Standard Deviation Of the Post-exam</td>
<td>16.75</td>
<td>13.23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gain-score Comparison</td>
<td>19</td>
<td>-2</td>
<td>0.0014222</td>
<td>Yes</td>
</tr>
</tbody>
</table>

*P value* 0.0000436 0.6703631  
*Significance* Yes No

Note: Passing score was 70.
Figure 1. Pre-exam score distributions for the experimental group and for the control group.

Figure 2. Post-exam score distributions for the experimental group and for the control group.
**Pre and Post Survey Results**

The results from the pre- and post-affective surveys determined that on the Perceived Abilities Survey the experimental group participants’ $z$ score of 0.3296 showed no significant increase or decrease ($z_{critical}=1.645$) when analyzed using a Wilcoxon Signed Rank test. For the control group, the participants’ $z$ score of -0.21301 showed a change in the negative direction. On the Attitudes and Motivations Survey, however, the experimental participants’ $z$ score of 1.8035 showed a significant difference ($z_{critical}=1.645$) from the pre- to post-survey after using technology as a tool in mathematics and the $z$ score of -1.51204 for the control group showed an almost equal change in the negative direction again. Once more, a significant change ($z_{critical}=1.645$) in the experimental participants’ $z$ score of 3.7123 on the Technology Survey was recorded in Table 4 after data was analyzed using a Wilcoxon Signed Rank test. For the control group, there was no significant change in the participants’ $z$ scores on either the Perceived Abilities Survey or the Attitudes and Motivations Survey.

<table>
<thead>
<tr>
<th>Table 4</th>
</tr>
</thead>
</table>

**Wilcoxon Signed Rank Test Results for Experimental and Control Groups**

<table>
<thead>
<tr>
<th></th>
<th>Experimental</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$(n = 19)$</td>
<td>$(n = 20)$</td>
</tr>
<tr>
<td><strong>Z score</strong></td>
<td><strong>Significance</strong></td>
<td><strong>Z score</strong></td>
</tr>
<tr>
<td>Perceived Abilities Survey</td>
<td>0.3296</td>
<td>No</td>
</tr>
<tr>
<td>Attitudes and Motivations</td>
<td>1.8035</td>
<td>Yes</td>
</tr>
<tr>
<td>Attitudes Toward Technology</td>
<td>3.7123</td>
<td>Yes</td>
</tr>
</tbody>
</table>

A $z_{critical} = 1.645$ is needed for a score to be significant.
Student Feedback

At the conclusion of the treatment, the experimental group was given an open-ended feedback form. The prompts: “what I liked or disliked about the geometry class”, “how I feel about the conclusion of the research project”, “how I feel about using the technology in geometry”, and “I feel the technology helped or did not help me understand the geometry” were all answered by the participants in their own words. On each question, 82% of the participants were positive in their comments while only 18% were negative. Some quotes have been included.

One tenth grade female stated, “I liked how I learned about geometry stuff in a different way.”

A tenth grade male wrote, “I liked using all different types of technology. It made me anticipate geometry, and I never anticipated geometry before. It got me interested.”

A tenth grade female stated, “It is fun to interact.”

“I loved using technology to help me learn,” a tenth grade male.

“I liked it, I would like to see more,” written by a tenth grade male.

A tenth grade female stated, “Technology didn’t help anymore than using a regular white board.”

Observations

Observations of the experimental group were compiled through feedback from other teachers, at-risk facilitator, counselors, principals, and the district’s curriculum director. In each observation, the observer noted multiple levels of participation, from students answering the teacher’s questions, to students working on the interactive white board with classmates’ supporting them, to students working quietly in collaborative groups where students were explaining concepts and answering questions of their classmates. Observers noted the student directed learning environment of the classroom. Observers especially liked how the technology
provided instant feedback to students whether they were answering questions during the modeling section of the lesson or they were submitting their answers into the technology.

Other statements noted the bell to bell instruction and participation of the students; as well, students were noted to be engaged and supportive of their classmates. Participants were seen writing the titles “right” and “wrong” on their tests and quizzes and using tally marks to keep track of how many answers the student response remotes recorded as correct and how many were incorrect. The participants began to expect that instant feedback on all of their work.

The observations of the control group stated that the teacher worked through problems from the lesson on the white board, asking students for answers in the next progressive step of the problem. The teacher rarely turned around to look at the students and seemed oblivious to what the students were doing. Only a few students would answer questions. Repeatedly mentioned in the observations was that students were sleeping, talking about work or driving, or reading books. Most students were not engaged nor were they ever redirected to the lesson. After a limited presentation of the concept, the teacher would hand out the worksheet for homework and would sit at the desk.

**Triangulation of Data**

The qualitative data was organized by affective surveys, observations, interviews, and student feedback. After analyzing the quantitative data, I looked to the qualitative data for patterns that would provide explanation to the questions that arose before, during, and after the research.

The research questions that drove this study were of prime importance; however, there were a number of questions noted during the research that deserved review and explanation. In preparation for the study, technology was introduced to the participants to alleviate the novelty affect as a possible bias toward the study. The first question came within two days of its introduction to the experimental group; “why were the participants so anxious to use the
technology?” Students were concerned about the new format of their class as well as the use of the technology and whether they would be successful in class. Students were voicing concerns to their counselors and to their parents. Parents were in turn calling the counselors concerned about this new technology being used in their child’s class.

After multiple observations as well as discussions with the participants, the counselors decided that there were numerous reasons. Students who had not been expected to participate in class were now expected and monitored as the student response remotes recorded every response by every student. Students were being held accountable to the material being presented in class. No more could students sleep or talk in class without accountability. Another explanation for the anxiety was the lack of exposure students had to technology. The only technology used in their classrooms was the teacher’s computer, calculators and the Elmo, digital projector.

Another question noted was, “why don’t they teach simplifying radicals?” During the lesson on special right triangles, when questioned during the modeling portion of the lesson, the participants stated that they did not know how to simplify radicals at which point I began to teach that necessary prerequisite skill in order to close that particular content gap. The teacher in the class said that they do not teach that. When I asked why, I was told that the students cannot do it so they do not teach it. I decided to inquire from other math teachers within the department and administrators that had also been math teachers. Other teachers in the department concurred that students could not simplify radicals so they were taught to use their calculators and guess at the answer that was closest. The two administrators that had previously taught math both declared that they had indeed taught the concept.

During the study some participant remarks were also noted and incorporated into the qualitative data. One female participant of the experimental group said that she really liked using the technology but it was making her homework grades go down. Since that statement seemed implausible I searched the affective surveys, the learning style evaluations, and her
grades. There was no evidence of the technology making her grades go down; instead, her grades were consistent with the previous three six-week reporting periods. What I did find was that she had a high rate of absences. This particular student had been absent 27% of the time of treatment and had not returned her makeup assignments.

The significant increases in affective survey scores definitely supported the findings from the analysis of the pre- and post-exam that that the technology had been used by the participants to close math achievement gaps as well as to create a deeper understanding of the concepts and been able to apply those concepts on real-life problems. Participants’ statements: “it made me anticipate geometry class”; “it got me interested in math; it helped by making it more fun and making me wanna learn”; all supported the beliefs of this researcher that when students are engaged, participating and interested, they are learning.

During reflection I again questioned why the scores on the Perceived Abilities surveys almost showed a decline. When I returned to the surveys and the observations, and then the student feedback, I realized that as participants’ answers were corrected on quizzes and exams, so were their perceptions of their own abilities. They reported positive feedback about using technology and its ability to help them learn, and yet, they corrected their previous survey answers to show that maybe math was not easy and for some, maybe they did not work hard in math.

Answering the Research Questions

Do students make greater gains towards closing achievement gaps in mathematics content knowledge when teachers integrate technology into instruction and acquisition? As shown in Table 3, results from the pre and post-exams have shown a significant increase in scores in the experimental group after time of treatment as compared to the control group which showed no increase but actually a decline in the mean score. As stated in the Description of Results Interpretation, a significant increase in scores will be interpreted as making gains in
closing gaps on mathematic content knowledge; therefore, in regards to answering the first question, yes, students did make greater gains towards closing achievement gaps in mathematics content knowledge when teachers integrated technology into instruction and acquisition.

Does using technology affect a student’s ability to acquire math concepts and apply them in everyday situations? On the attitude toward technology survey, the statement, “Technology helps me understand math” received a total score of 47 on the pre-survey; and on the post-survey, the same question received a total score of 61. Participants (n=19) also demonstrated an increase in total score on the statement, “Technology makes math fun”, from 48 on the pre-survey to a total score of 75 on the post-exam. Those results coupled with the gain in the mean scores from the pre-exam to the post-exam suggested that technology did affect a student’s ability to acquire math concepts and apply them in everyday situations.

Does using technology increase participation, motivation, or transform attitudes about mathematics and the use of technology? The results in Table 4 showed a significant change in the attitudes and motivations of the participants in the experimental group. Likewise, their attitudes toward using technology in mathematics also showed a significant change. The significant increase in the experimental group’s survey scores suggested, yes; technology did increase motivation and transform attitudes. Regarding increased participation, there were observations and letters from counselors and administrators that strongly stated that they witnessed increased student participation with the technology. One counselor wrote, “I feel there was a complete change in attitude with students from the beginning to the end of the test group.”

Does technology have the potential to become the language of meaningful interaction between students and teachers? While there was some evidence in the observations to show that technology was used as an alternative means of meaningful interaction between students and teachers, there is still much research required to fully understand this metamorphosis. One counselor wrote, “I saw students begin to direct each other in how to set up problems… The
technology that was considered difficult and a little scary at the beginning was shown to improve student participation, give immediate feedback on student success and encourage students to direct each other on problem solving.” These individuals had no previous knowledge of the research questions or the dynamics that would be investigated, so these observations were intriguing.

Another observer noted, “Because the answers could be anonymous, I saw some of the quiet, shy students, become much more comfortable in classroom discussions and in working problems.” The research question was still answered in the positive as the question asked was, “does technology have the potential to become the language of meaningful interaction between students and teachers” and there was definitely a potential demonstrated.

Discussion

This study did provide some evidence that the Qwizdom SRS when used in a technology rich environment did close achievement gaps in mathematics. There was also some evidence that the use of technology where participants were provided instant feedback transformed the environment and the social space of the classroom. Although there were a number of struggles and hurdles to overcome, the benefits far outweighed the added stresses.

Integrating technology into an existent class of students that had before been allowed to merely coexist in the space caused an unusual amount of anxiety with students and their parents. Taking the time before beginning treatment to introduce the technology and provide some experience seemed to make sense. It was expected that the students would embrace it from the beginning, and see this as a unique opportunity. The accountability that the technology provided, however, had numerous adversaries. The technology now became the reason that a student did not understand the material. The technology was also blamed for falling grades.

Deeper reflection on the study revealed through the observations and eventually through the Perceived Abilities survey that participants actually self-corrected their perceived abilities.
The immediate feedback actually provided the accountability that caused participants to correct their previous perceptions of how they felt about math and their abilities in math. This was a frightening ordeal for many who believing they understood the material and the concepts were now receiving instant grading on a quiz or an exam and knowing that they were not doing well.

When asking the question, “how could they have been so skewed in their beliefs?,” I recalled that these students were not accustomed to receiving immediate feedback on homework assignments, quizzes or even exams, but instead might wait for two weeks. By the time the work was returned those red Xs meant nothing and the students were happy that they had moved on to new material.

It was easy to report that the analysis of the Attitudes and Motivations survey and the Attitudes toward Technology survey showed there to be a significant difference from the pre- to post-survey. What was interesting and bared noting was that beyond attitudes being change for the positive, participants held true to themselves and reported honestly on the Perceived Abilities survey making adjustments to their previously recorded statements. Without the use of the Qwizdom SRS, participants did not have accurate data to rate their own abilities.

Through the observations, technology was reported to be the catalyst to the transformation of the social space of the classroom. As participants were observed reaching out to answer their classmate’s questions or to assist in setting up a particular problem, the confidence exuded came from the immediate responses received through the technology. It was also reported that a quiet participant from the experimental group was observed taking to the whiteboard during another totally separate class to work out a problem for the class. Participants reported to counselors and administrators that the technology was “helping them to understand math”.

Change is difficult and technology is scary, but this study holds strong evidence that there can be many positives attributed to technology. When within a short period of time the dynamic of a group can be so changed it is imperative that further investigation be undertaken.

**Implications**

This study can be used by educators, counselors and administrators when researching and evaluating technology purchases and professional development. The same anxieties experienced by the participants when the technology was introduced into their classroom environment will almost assuredly be felt by the educators that are being asked to use it. Beyond that, this study should provide a framework of hope and encouragement to closing the mathematics achievement gaps that so many educators and districts are facing. This study also provides some knowledge and understanding to parents and the community of the doors that may be opened when technology is integrated into education.

**Limitations**

There were immediate limitations such as integrating technology into a class that had no experience utilizing technology for learning; and working in and with an existent group. While students are label “digital learners” because of the era of technology in which they have grown up, as educators we must remember that not all students arrive with the same experiences and that includes experiences with technology.

Using an existent class was a limitation in that these students were unaccustomed to working, engaging, participating, and to being meaningfully evaluated. To thrust so much accountability onto a group limited the full potential that the technology may have provided. Although the quantitative and qualitative data rendered positive results, the full impact of using technology in every aspect of the presentation, acquisition, application and evaluation remains a question.
The most reported limitation was always the cost of the technology itself. I desired to set my goals on a star and only reached the moon. My next project, I will surely reach that star.

**Critique**

My master’s degree experience has been almost as much of a whirlwind as my undergraduate experience but in a strangely different way. While my undergraduate time was all-out all the time and race to the finish, my master’s degree experience has been much slower paced but extremely fulfilling.

I have already implemented everything I originally prescribed in this research with my class this year and I am on my way to the star. My students continue to persevere through each new challenge I lay before them. The students enjoy using the technology and the word has spread. I have had to close three classes as I am limited by the number of SRS remotes that I purchased. Students arise to the expectations that we hold before them and their goals and achievements will not be squelched.

The district has made my classroom the prototype and I have already established a consulting firm to help districts and educators integrate technology in a meaningful way. The success I have achieved is due in part to Western Governors University; however, I could never have accomplished all that I have without my dear friend and mentor, Mary Owen.
References


Saeed, N. Y. (2009). Emerging web technologies in higher education: A case of incorporating blogs, podcasts, and social bookmarks in a web programming course based on students'


Appendix A

Pre-exam.

1. The drawings below show the left-side, front, and top views of a three-dimensional structure built with identical cubes.

Which of the following 3-dimensional structures is best represented by these views?

2. Which point on the grid below best represents \((-4 \frac{1}{2}, 7)\)?
3. Dante has 5 times as many marbles as Kenny. Juan has 1/3 as many marbles as Dante. If Kenny has 30 marbles, how many marbles does Juan have?

   A 6  
   B 50  
   C 2  
   D 18

4. A sphere with a diameter of 6x centimeters is shown here. Which of the following expressions best represents the volume of this sphere in cubic centimeters in terms of \( \pi \)?

   - A \( \frac{4}{3} \pi (3x)^3 \)
   - B \( \frac{4}{3} \pi (6x)^3 \)
   - C \( 4\pi(3x)^2 \)
   - D \( 4\pi(6x)^2 \)

5. Josh earns money by washing cars in his neighborhood. He spent $215 on supplies and changes $15 for each car washed. Josh’s profit, \( p \), can be represented by the function \( p = 15n - 215 \), where \( n \) represents the number of cars that Josh washes. What is the minimum number of cars Josh must wash to make a profit?

   A 14  
   B 29  
   C 15  
   D Not here
6. Kara explains that the expression \( x^2 + 1 \) results in an even number for all integer values of \( x \). Which value of \( x \) shows that Kara’s claim is incorrect?

- A \( x = 5 \)
- B \( x = -3 \)
- C \( x = 0 \)
- D \( x = -1 \)

7. Trapezoid \( PQRS \) is similar to trapezoid \( TUVW \). What is the height of the larger trapezoid?

- A \( 19 \frac{1}{5} \text{ ft} \)
- B \( 16 \text{ ft} \)
- C \( 12 \frac{4}{5} \text{ ft} \)
- D \( 20 \text{ ft} \)

8. The graph of \( \triangle RST \) is shown here. If \( \triangle RST \) is reflected across the line \( y = 3 \), which of the following ordered pairs best represents point \( T' \)?

- A \((-4, 8)\)
- B \((-4, 2)\)
- C \((10, -2)\)
- D \((4, -2)\)
9. In the equation $6.5x + 1.4y = 59$, what is the value of $x$ when $y = 5$?

A 13  
B 8  
C 12.5

10. If the diameter of a circle is dilated by a scale factor of 0.6, what will be the effect on the circle's circumference?

A The circumference will be 0.3 times as large.  
B The circumference will be 0.36 times as large.  
C The circumference will be 1.88 times as large.  
D The circumference will be 0.6 times as large.

11. Martina designed a painting for art class, as shown in the drawing below. Her design contains 4 circles on a square canvas. Each circle has a radius of 6 inches. The circles touch the edges of the canvas and each other, as shown. The shaded section of Marina's design will be painted black. Which is closest to the area that will be painted black?

A $124\text{ in.}^2$  
B $463\text{ in.}^2$  
C $308\text{ in.}^2$  
D $116\text{ in.}^2$
12. The net of a rectangular prism is shown. What is the total surface area of the rectangular prism represented by the net?

![Net of a rectangular prism]

A 114.70 cm²  
B 150.88 cm²  
C 105.00 cm²  
D 119.88 cm²

13. Use the ruler on the Mathematics Chart to measure the side lengths of rectangle PQRS and rectangle P'Q'R'S' to the nearest 0.1 centimeter. Which of the following is closest to the scale factor used to dilate rectangle PQRS to create rectangle

![Diagram of rectangles PQRS and P'Q'R'S']

A 0.625  
B 1.6  
C 0.525  
D 2.0

14. Desmond wants to take guitar lessons. The one-time registration fee is $60, and each lesson costs $40. Which of the following inequalities can Desmond use to determine \( x \), the number of lessons he can take if he wants to spend no more than \( c \) dollars?

![Diagram of inequalities]

A \( 60x + 40x \leq c \)  
B \( 60 + 40x \leq c \)  
C \( 60x + 40x \geq c \)  
D \( 60 + 40x \geq c \)
15. A company designed a new label to completely cover the lateral surface area of a cylindrical can without any overlap. The can is 5 1/2 inches tall and 3 inches in diameter. Which of the following is closest to the area of this new label?

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A 52 in.$^2$
B 160 in.$^2$
C 104 in.$^2$
D 66 in.$^2$

16. What is the value of $x$?

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A 169
B 17.2
C 13
D 119.2

17. The table on the right shows the relationship between $x$ and $f(x)$.

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Appendix B

Post-exam.

1. The drawings below show the left-side, front, and top views of a three-dimensional structure built with identical cubes.

   ![Left-side view](image1) ![Front view](image2) ![Top view](image3)

   Which of the following 3-dimensional structures is best represented by these views?

   ![Option A](image4) ![Option C](image5) ![Option B](image6) ![Option D](image7)

2. Which point on the grid below best represents \((-4 \frac{1}{2}, 7)\)?

   ![Grid with points](image8)

   A. Point R  
   B. Point S  
   C. Point T  
   D. Point U
3. Dante has 5 times as many marbles as Kenny. Juan has 1/3 as many marbles as Dante. If Kenny has 30 marbles, how many marbles does Juan have?

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A 6  
B 50  
C 2  
D 18

4. A sphere with a diameter of 6x centimeters is shown here. Which of the following expressions best represents the volume of this sphere in cubic centimeters in terms of \( \pi \)?

\[ \frac{4}{3} \pi (3x)^3 \]

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A  
B  
C  
D

5. Josh earns money by washing cars in his neighborhood. He spent $215 on supplies and changes $15 for each car washed. Josh’s profit, \( p \), can be represented by the function \( p = 15n - 215 \), where \( n \) represents the number of cars that Josh washes. What is the minimum number of cars Josh must wash to make a profit?

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14. Desmond wants to take guitar lessons. The one-time registration fee is $60, and each lesson costs $40. Which of the following inequalities can Desmond use to determine x, the number of lessons he can take if he wants to spend no more than c dollars?
15. A company designed a new label to completely cover the lateral surface area of a cylindrical can without any overlap. The can is 5 1/2 inches tall and 3 inches in diameter. Which of the following is closest to the area of this new label?

   A 52 in.$^2$
   B 160 in.$^2$
   C 104 in.$^2$
   D 66 in.$^2$

16. What is the value of $x$?

   A 169    C 13
   B 17.2   D 119.2

17. The table to the right shows the relationship between $x$ and $f(x)$.

   A $f(x) = 2x$
   B $f(x) = -2x$
   C $f(x) = -x - 2$
   D $f(x) = x + 6$

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Appendix C

Affective survey for the experimental group.

Perceived Abilities  1 – SD  2 – D  3 – U  4 – A  5 – SA

1. Math is easy.
2. I do very well in school.
3. I can learn anything if it is explained to me.
4. I work hard in math.

Attitudes and Motivation

1. I like math.
2. When I see a math problem, I feel nervous.
3. I do not like to talk out loud about math.
4. My teacher always explains math so that I can understand it.
5. Word problems are difficult for me.

Technology

1. I like using technology.
2. Technology helps me understand math.
3. I enjoy using a computer to help me with math.
4. I am not comfortable using technology.
5. Technology makes math fun.
Appendix D

Affective survey for the control group.

<table>
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<th>Perceived Abilities</th>
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<th>2 – D</th>
<th>3 – U</th>
<th>4 – A</th>
<th>5 - SA</th>
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<td>2. I do very well in school.</td>
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<td>3. I can learn anything if it is explained to me.</td>
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<td>4. I work hard in math.</td>
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Attitudes and Motivations

1. I like math.
2. When I see a math problem, I feel nervous.
3. I do not like to talk out loud about math.
4. My teacher always explains math so that I can understand it.
5. Word problems are difficult for me.
Appendix E

Demographics for experimental group.

1. Sex
2. Age
3. Race
4. Language spoken at home
5. Do you have a computer at home?
6. Do you have internet at home?

Demographics for control group.

1. Sex
2. Age
3. Race
4. Language spoken at home
Appendix F

Learning styles evaluation.

<table>
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<th>Visual</th>
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<th>3 – U</th>
<th>4 – A</th>
<th>5 - SA</th>
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<tbody>
<tr>
<td>1. I learn better by reading what the teacher writes on the board.</td>
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<td>2. When I read instructions, I remember them better.</td>
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<td>3. I learn better by reading than by listening to someone.</td>
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<td>4. I learn more by reading textbooks than by listening to lectures.</td>
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<td>5. I understand better when I read instructions.</td>
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Tactile

1. I learn more when I can make a model of something. |
2. I learn more when I make something for a class project. |
3. I learn better when I make drawings as I study. |
4. When I build something, I remember what I have learned better. |
5. I enjoy making something for a class project. |

Auditory

1. When the teacher tells me the instructions, I understand better. |
2. I learn better when someone tells me how to do something. |
3. I learn better when I listen to someone. |
4. I learn better when the teacher gives a lecture. |
5. I remember things I have heard, better than things I have read. |

Kinesthetic

1. I prefer to learn by doing something in class. |
2. When I do things, I learn better. |
3. I enjoy learning in class by doing experiments. |
4. I understand things better when I participate in role-playing. |
5. I learn best when I can participate in related activities.
Appendix G

Feedback prompts.

Feedback for “Math Turned On”

What I liked or disliked about the Geometry class…

How I feel about the conclusion of the research project…

How I feel about using the technology in Geometry…

I feel the technology helped or did not help me understand Geometry…

Would I choose a math class that uses technology such as the IWB, the Qwizdom, or the Technology Lab?
Appendix H

Nonparticipant observation form.

<table>
<thead>
<tr>
<th>Nonparticipant Observation Form</th>
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<tbody>
<tr>
<td>Teacher</td>
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<tr>
<td>Participants</td>
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<td>Participants Absent:</td>
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<tr>
<td>Instructional Materials:</td>
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<tr>
<td>Nature of Conversations:</td>
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<tr>
<td>Interactions:</td>
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<tr>
<td>Roles of Teacher/Students: Lead, Follow, Decisive, Indecisive</td>
</tr>
</tbody>
</table>


Appendix J

Informed consent.

INFORMED CONSENT

Western Governors University

Master of Arts, Mathematics Education (5-12)
Using an Interactive Student Response System in a Technology-Rich Classroom
to Determine the Efficacy on the Acquisition and Application
of Mathematical Content Knowledge
Mrs. Kimberly Benien

INTRODUCTION: You are being invited to participate in a quasi-experimental research project being conducted by a graduate student from Western Governors University. Mrs. Kimberly Benien is conducting research to determine the efficacy of using the Qwizdom interactive student response system as a part of a connected classroom.

DESCRIPTION OF THE PROJECT:

• Students in one group will experience learning in a connected classroom using an interactive hand-held student response remote integrated with a laptop, projector, interactive white board, and interactive software and curriculum. Students in another group will continue learning in their traditional classroom. The effects of technology on the acquisition and application of mathematics will be measured.
• The lessons are innovative and written to Texas state standards. Every lesson is representationally-rich and correlates to state objectives and student expectations.
• The research will be conducted at school during the fourth six weeks. The entire project will consist of fifteen days of instruction and four days for assessments and surveys.
• Students are expected to participate fully in all classroom activities. There will be a daily lesson with activity notes, modeling, guided practice, and individual work.
• In addition to the daily lessons, all students will be required to complete a twenty statement learning styles evaluation, a twenty statement pre- and post-survey, and a twenty-two question pre- and post-exam.

BENEFITS OF THIS STUDY: Using the Qwizdom system has proven to be a highly effective teaching and learning tool promoting participation and enthusiasm. Studies have shown that when students are enthusiastic and participate in classroom discussions, they learn more and have shown greater achievement on exams.
**CONFIDENTIALITY:** It is my promise that complete confidentiality and anonymity of all participants will be maintained. Students will be given a participant number that will be used when recording, reporting, and aggregating all data. Data will only be seen by the classroom teacher and me.

**Voluntary participation and withdrawal:** While all participants are expected to participate in any regular classroom instruction, participation in classroom video and audio taping are voluntary. Participants may withdraw at any time from non-regular classroom instruction and will not be penalized for non-participation.

**Questions, Rights and Complaints:** Participants or legal guardians may contact me, Mrs. Kimberly Benien, researcher, at: 979-345-3511 or benien@my.wgu.edu

It is the right of the participants or legal guardians to request a copy of the data collected from their student. For requests, please contact me at the conclusion of the project.

**Consent statement:**

By signing this Informed Consent, we, the undersigned, agree to participate in the above referenced research project.

________________________  _______________________
Signature of Participant   Signature of Legal Guardian

_________________________  _______________________
Typed/printed Name   Typed/printed Name

__________________________  ________________________
Date      Date
Appendix K

Record of participants.

<table>
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<tr>
<th>Period</th>
<th>Control Group</th>
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**Record of Participants**

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Appendix L

Lessons.

Day one of instruction: Developing Formulas for Triangles & Quadrilaterals Using Tangrams and GeoGebra

Objectives: Develop and apply the formulas for the areas of triangles and special quadrilaterals. Solve problems involving perimeters and areas of triangles and special quadrilaterals.

Day two of instruction: Developing Formulas for Circles and Regular Polygons – Develop $\pi$

Objectives: Develop and apply the formulas for the area and circumference of a circle.

Develop and apply the formula for the area of a regular polygon.

Day three of instruction: Composite Figures

Objectives: Use the Area Addition Postulate to find the areas of composite figures. Use composite figures to estimate the areas of irregular shapes.

Day four of instruction: Effects of Changing Dimensions Proportionally

Objectives: Describe the effect on perimeter and area when one or more dimensions of a figure are changed. Apply the relationship between perimeter and area in problem solving.

Day five of instruction: Review


Objectives: Classify three-dimensional figures according to their properties. Use nets and cross sections to analyze three-dimensional figures.

Day seven of instruction: Representations of 3-Dimensions – Constructing Isometric and Orthographic Views
Objectives: Draw representations of three-dimensional figures. Recognize a three-dimensional figure from a given representation.

Day eight of instruction: Developing Formulas in 3-Dimensions – Using Euler’s Formula and Pythagoras’ Theorem in 3-Dimensions

Objectives: Apply Euler’s formula to find the number of vertices, edges, and faces of a polyhedron. Develop and apply the Distance and Midpoint Formulas in three dimensions.

Day nine of instruction: Surface Area of Prisms and Cylinders – Using Nets

Objectives: Learn and apply the formula for the surface area of a prism. Learn and apply the formula for the surface area of a cylinder.

Day ten of instruction: Surface Area of Pyramids and Cones – Using Nets

Objectives: Learn and apply the formula for the volume of a pyramid. Learn and apply the formula for the volume of a cone.

Day eleven of instruction: Review