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Introducing Blended Learning Environments for Mathematics Instruction: How Does it Affect Student Achievement and Attitudes?

A Project Submitted in Partial Fulfillment
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Abstract

Blended learning is well researched in higher education, but little research exists in the primary and secondary level. This study explored the effects of a blended learning environment on algebra students' achievement and attitudes. Forty-seven eighth grade students participated in this study in two sections of the same course. One section (n = 23) received face-to-face, direct instruction, acting as a control, while the other (n = 24) was immersed in a blended learning environment, a mix of teacher-led and technology-driven instruction through Open Educational Resources (OER). With the use of a quasi-experimental design and quantitative methods, this action research study compared and contrasted the two groups' assessment data and survey results both before and after the unit of study. The results revealed subtle differences in the mean achievement scores. While the blended environment learners had a higher post-test mean, the direct instruction learners exhibited greater gains in achievement because their baseline pre-test mean was lower. The survey results also displayed subtle differences at the completion of the study. Students in the blended learning group expressed higher positive attitudes for the categories of technology-driven mathematics instruction and teacher-led instruction. Implications for teaching, limitations, and recommendations for the future are discussed in this paper.

Keywords: blended learning, mathematics, technology integration, technology in education, student achievement, student attitude, middle school

Chapter One

Introduction

When asked to describe a mathematics classroom, most people would likely picture a teacher-led setting. Students would be sitting in desks arranged in rows, intently listening to instruction from a teacher who is standing at the front of the room. This comes as no surprise since many classrooms across America are using that model daily for teaching math. Moreover, given that the ability of student success relies on their understanding of basic mathematical tools and concepts, many educators may feel that direct, face-to-face teaching is the best instructional delivery method to reach such success. However, students now have access to resources and information at the touch of a button. They can collaborate online more quickly and with greater ease than ever before, so educators no longer need to rely on themselves as the sole information provider to students.

In recent years, access to technology and online resources have increased tremendously giving blended learning a greater chance for success across the United States. Blended learning is an alternate instructional model for the educational setting. Students within these environments learn with online resources and teacher-facilitated lessons for at least part of the time. According to Horn and Staker (2011), in 2000 there were close to 45,000 K-12 students who were enrolled in online courses across the United States. Then only nine years later, that number had grown to well over three million. They reported much of the growth was due to rapid increases to blended learning environments introduced in classrooms. Furthermore, Neuhauser (2002) detailed several studies that found success with online learning courses. Those reports indicated students in cyber-learning environments performed equal to or better on assessments than students instructed in face-to-face environments. Mathematics educators can agree that algebraic understanding is essential in mathematics education, so examining best practices with technology-use seems to be vital in order to ensure success for all students.

Unfortunately, Ross, Morrison, and Lowther (2010) described the declining number of quality experimental studies dealing with educational interventions, especially those involving technology, as a growing concern. Calfee (2006), as cited by Ross et al., urged future researchers to examine educational technology, classifying it as one of the "Really Important Problems" (p 18). For that reason, this project was designed to monitor the effects of blended learning environments on student learning and attitudes for a mathematics course. There is a need to always look for the most effective ways to educate students, and this action research study will test one of those delivery methods by addressing the following questions:

- How does introducing blended learning environments in mathematics instruction affect student achievement in an algebra class?
- In what ways do blended learning environments impact students' attitudes toward mathematics and learning?

The action research study was conducted with a heterogeneous group of middle school students, ranging in age from 13 to 14 and identified as "academically talented" in mathematics. The research took place in two algebra classes in a suburban district in the Midwest. All students enrolled in the algebra classes participated and received the same content instruction but through different instructional methods. Students engaged in the study during November and December of 2014.

This was a descriptive quantitative study comparing the assessment and survey data between two sections of algebra students. Students were given the same assessments in each class, but one class received face-to-face, direct instruction, acting as the control, and the other participated in blended learning which incorporated self-paced, online instruction and periodic small group, teacher-led lessons. The Open Educational Resources (OER) utilized in this environment included *KhanAcademy.org, TenMarks.com, Mangahigh.com,* and *CK12.org.* The means of data collection were pre- and post-assessments and pre- and post-surveys. The surveys contained 25 statements with 5-point Likert-type responses to attitude toward mathematics, general computer use, teacher-led instruction, technology use in the classroom, and technology-driven mathematics instruction and practice.

The control group's assessment scores and survey results were analyzed and compared to those of the blended learning group. The analysis of pre- and post-test data included quantitative procedures, comparing the differences in means of both groups as well as the growth percentages after scores were compiled and calculated. During analysis, the assessment data was used to describe how introducing blended learning environments in mathematics instruction affected student achievement in the algebra class. Subsequently, the pre- and post-survey data was used to describe the ways that blended learning environments impacted student's attitudes toward mathematics and learning. For this part, the 25 statements were analyzed by comparing means for each attitude category from the survey. These scores were then used to recognize how attitudes among students evolved from the beginning of the unit to the end. The evaluation of the findings included the limitations present during the study as well as the differences exposed in the outcomes between the control and treatment groups' data.

Incorporating blended learning into courses could change the U.S. educational system as it is seen today. This type of learning helps to tailor instruction for students, personalize lessons through the use of technology and give students a greater opportunity to discover their true potential. Blended learning seems to challenge the widely-used, traditional model of direct instruction, so there is a need to research it further. The literature review, in the next chapter, will examine several studies showing how blended learning has, thus far, influenced the achievement and attitudes of students at various levels and with various subjects in these nontraditional settings.

Chapter Two

Review of Literature

Picture the ideal classroom environment. Who is leading instruction? What tools are influencing student engagement? Does the setting include technology? How many students are present? These are just a few questions to consider when constructing an exemplary classroom atmosphere. Due to an increased interest in creating students who can compete in a global economy, school districts cannot ignore the importance of technology. Students graduating are now taking jobs that did not exist five years ago, and current students will be looking for careers that do not yet exist (Gasser, 2011). In order to compete with the ever-changing world, districts need to find the most effective methods for educating youth. Integrating technology with face-to-face instructional methods could be the answer. Society has become extremely technology-rich, therefore schools should be looking for the best ways to deliver course content through these technology resources. Since technology can be used to personalize education to meet every child's needs, there is an incredible importance to include it in classrooms across the nation.

This literature review will define blended learning, describe the theory and ideology behind technology integration within education, identify needs within the current educational system, and examine several research studies in the attempt to show how blended learning impacts the achievement and attitudes of students in the nontraditional learning environments. Based on the research findings, the exceptionally rapid growth of technology, and the push of teaching 21st century skills, educators now have to be aware of and skilled in using a multitude of digital resources to teach students how to obtain, develop, evaluate, interpret, and learn from information found online. It only makes sense to assist this process by using a blended learning model within the classroom setting.

Blended Learning

Today, educators have the ability to reach beyond the classroom walls and engage students with social media, online resources, and mobile device applications. By using digital technologies, teachers can create blended learning environments to prepare their students with the necessary 21st century skills required for future success. Blended, or hybrid, learning has been defined in many ways. Staker and Horn (2012) described blended learning as “a formal education program in which a student learns at least in part through online [or digital] delivery of content and instruction with some element of student control over time, place, path, and/or pace *and* at least in part at a supervised brick-and-mortar location away from home” (p. 3). Essentially, blended learning creates personalized learning for students by blending traditional face-to-face instructional delivery with computer-mediated instruction (Graham, 2006). Coursework online is an important element in preparing environments for blended, personalized learning, but blending instruction needs to go beyond that of districts’ “bring your own device” and “one-to-one” initiatives (Imbriale, 2013).

According to Imbriale, the main difference with blended learning models in comparison to sole face-to-face, direct instruction is the amount of student control. These models allow students to choose where to learn and at speeds that grant them an optimal chance for achieving subject mastery. Staker and Horn (2012) described a more in-depth breakdown of different blended learning models found in schools:

1. Rotation model – “Students rotate *on a fixed schedule or at the teacher’s discretion* between learning modalities, at least one of which is online learning” (p. 8).

2. Flex model – “Students move on an *individually customized, fluid schedule* among learning modalities, and the teacher-of-record is on-site” (p. 12). The teacher provides face-to-face support as needed through small group instruction, projects, and possibly individualized tutoring.

3. Self-Blend model – “Students choose to take one or more courses entirely online to supplement their traditional courses and the teacher-of-record is the online teacher” (p. 14).

4. Enriched-Virtual model – “Students divide their time between attending a brick-and-mortar campus and learning remotely using online delivery of content and instruction” (p.15).

One example of the Self-Blend model is in the Quakertown Community School District in Pennsylvania. Horn (2012) summarized their version of self-blended learning, stating, “courses are asynchronous; students can work on their assignments at any time during the day. Many students take advantage of this option in order to work around vocational programs, work schedules, and extracurricular interests” (QSD section, para. 6). These successful online courses allow students the freedom to complete the coursework at their own pace, whether finishing at home or at school during free periods.

When implementing, Evans (2012) pointed out that most elementary schools have found success with the Rotation model, and due to the more independent nature of the Flex and Self-Blend models, secondary schools and higher education seem more successful with those. However, teachers or schools looking to utilize one of these models need to be especially reflective to best meet the needs of the student population in their school or district.

Though blended learning can come in many forms, it ultimately needs to include a mixture of face-to-face instruction and the use of digital technology or digital tools to support learning. Nevertheless, the concept of blended learning is not as simple as just combining online programs with face-to-face learning. To indeed improve achievement of learning objectives with this model, Graham (2006) explained it as needing the application of the “right curriculum” used with the “right technology” matching the “right person” at the “right time”. He indicated that due to the rapid development and availability of technological innovations, traditional face-to-face learning has been impacted. In the past, technology resources and computer access were limited; therefore, they were not regularly used in the classroom and both learning environments remained largely separate. However, since the nature of technology has evolved, more live synchronous, high fidelity applications are available than ever before. Graham predicted that the trend for blended learning would increase and though blended learning may be classified by a different name in the future, this type of learning would be here to stay. This does appear to be true today. Well-educated teachers have and will continue to be a necessary component in customizing education, but the inclusion of digital technology is also an integral aspect in reaching every student’s needs.

Philosophy of Technology Integration

Technological advances happen every day. Educators across the globe use technology resources, computers, and other digital devices in the classroom to enhance their instruction, but why? The answer may be rooted in constructivism. Jean Piaget, the founder of constructivism, claimed that people build and learn knowledge from their own understandings of the world around them (Ackermann, 2001). Based on their experiences and reflections, people can construct new ideas, attaching concepts to previously learned ideas, and from this, they will have learned something new. People are different because they think differently. Because of the environment surrounding them, everyone has had different experiences to construct their understanding of new ideas. Piaget believed that if no one ever challenged a child’s ideas, he or she would stay in an intellectual equilibrium. For this reason, Piaget's cognitive development theory promotes inquiry, a much desired skill in the educational realm.

Scott, Cole, and Engel (1992) argued that the theory may go beyond that of children constructing their own development to more of "a cultural constructivist approach" (p. 191), where not only the child but also an adult is actively present and supportive in educational interactions. Scott et al. continued, "moreover, cultural constructivism emphasizes that all human activity is mediated by cultural artifacts, which themselves have been constructed over the course of human history" (p. 191). From this viewpoint, one influential 20th century, cultural artifact would be the computer. According to Cuban (as cited in Scott et al., 1992), computers aim to bring the world into the classroom, just as radio and film did in the mid-1900s. Cuban predicted that the time would come when computers would be as common in classrooms as chalkboards and instruction with computers would be accepted as a standard educational tool. As early as the 1960s, Marshall McLuhan (as cited in Anderson & Dron, 2011) argued that technologies influenced and defined teaching and learning as much as any other instructional design. Today, with the help of the internet and its vast resources, computers have made their historical mark.

More than ever before, technology now aids in stimulating and exciting students to explore answers to self-generated questions, correct misunderstandings within seconds by the click of a button, and communicate or compete with others across the nation or world. Having access to unlimited resources via digital technology makes questioning or testing a child's thinking easier. Technologies today inspire and produce thought-provoking puzzles that could not have been done as easily in the past. Students may re-watch a video clip online or explore a link to get more information, practice, or help. By blending technology into learning environments, students can obtain real-time feedback, clarify misconceptions, collaborate with peers, and explore their own questions with ease, all without teacher-provided directions or the use of direct instruction. Personalized, blended education is nothing more than students having the reins to control their path of understanding.

The Importance of Technology and Future Needs

Technology is a valuable resource for educators, yet while in school, most students spend the majority of their learning time in traditional direct, face-to-face instructional settings. The nation's children are currently growing up surrounded by technology; the National Postsecondary Education Cooperation (2004) reported that 90% of children from ages five to seventeen were using computers in 2001. Over a decade later, teens are still the most expected users of computers and the internet (Madden, Lenhart, Duggan, Cortesi, & Gasser, 2013). There is no surprise then that blending technology more regularly into education could be an answer as educators begin to explore ways of creating engaging lessons and differentiating instruction. Classrooms without differentiation, Response to Intervention strategies, and technology tools cannot possibly be as effective as classrooms that use any or all three of these instructional designs (Bender, 2011).

The need for customizing student learning. Students, naturally, learn at different paces, have different skills and specialized talents, and come to school with different life experiences and background knowledge. As a result, the United States needs to transform the educational system to tailor instruction for each student and by doing so, students can discover their true capabilities (Evans, 2012). Incorporating technology into instruction can help with personalizing learning. According to Dean (2006), personalized learning means adapting instruction to meet the needs and abilities of each individual student. This occurs when teachers assess the learning needs and learning styles of every student and modify lessons to meet those needs, using a range of teaching approaches and styles. Students in personalized learning environments are encouraged to make decisions about their own learning too. The U.S. Department of Education's top priority in the *Race to the Top-District* competition was creating personalized learning environments; consequently, incorporating technology blended with traditional face-to-face instruction could be the easiest way to create personalized learning environments and improve student achievement and attitudes in classroom settings.

Rae and Samuels (2011) studied and analyzed data from web-based personalized systems of instruction (WPSI) for two different case studies: a large group at Brunel University (BU) and the other a smaller group of "at-risk" students at Coventry University (CU), both in the United Kingdom. Researchers tracked the history of the development of a WPSI from 1983-2005 at BU for a calculus course and then four cohorts at CU from 2006-2010 for an undergraduate discrete mathematics course. Some "at-risk" students at CU were provided an intervention in the form of WPSI. The data gathered included the pass rates of students with and without interventions as well as the average scores earned in both courses. Researchers found that in both cases when instruction was carefully identified and the self-study program was thoroughly supervised with regular formative assessments, personalized learning through online instruction proved to be an extremely effective and successful way of teaching mathematics.

The need for professional development. Since the introduction of "bring your own device" and "one-to-one" initiatives to districts across the nation, teachers in many cases have been left wondering how to best utilize these devices in and out of the classroom. There is a need for administrators to provide professional development opportunities to help teachers successfully incorporate technology resources within their current curriculum. Imbriale (2013) stated,

> To help teachers adjust to the change in the pace and path of learning, principals must be willing to allow teachers and students to experiment, and they must be open to failures. … Investing in high-quality professional development is also essential to the success of blended learning courses. (p. 33-34)

According to Evans (2012), it is imperative to make teachers aware that the move to blended learning is not motivated by a desire to replace them with technology. Like effective educators, many effective computer-assistive instruction (CAI) programs utilize evidence-based approaches (formative assessments, activating prior knowledge, graphic organizers, etc.). Therefore, Ross, Morrison, and Lowther (2010) stressed a consideration, "rather than pitting computers against teachers, a more productive research approach is to investigate strategies for employing CAI efficaciously as a *supplement* to regular classroom instruction" (p. 20). Ross et al. summarized technology use in the classroom in three ways: as a tutor, a teaching aid, and a learning tool. Each of these are important roles in the preparation of students' college and career readiness. Pointing out an area of concern, Ross et al. suggested the obligation for districts is to learn "*how* to use technology reflectively and scientifically to make teachers and curricula more effective" (p. 22).

Educating teachers about these methods of instruction will help to create thriving learning environments. As Lei and Zhao (2007) specified, administrators, teachers, and parents need to pay close attention to how students are utilizing technology and provide guidance to help students use it more efficiently and effectively. This can be achieved when teachers know how to guide students while balancing online and face-to-face instruction, but they first must be familiar with their resources. Professional development opportunities can assist in preparing teachers for effective formative assessment creation as well as preparing them to create the blended, personalized learning environment in their classes (Rae & Samuels, 2011). Ultimately, if administration, teachers, parents, students and the community within districts work together, personalized learning through digital technology has the capability to transform the current education arrangement.

The need for a system change. According to Project Tomorrow (2012), the *Speak Up 2011* survey[1] reported a gap between how students want to use technology in the classroom for learning and how it is actually used. Consequently, students were looking outside of school to meet their personalized learning goals. Project Tomorrow (2012) reported, “almost half of the high school students have sought out information online to help them better understand a topic that is being studied in class” (p. 4). Regarding social networking sites, “1 in 10 high school students have Tweeted about an academic topic… [and] 46 percent of students have used Facebook as a collaboration tool for schoolwork” (p. 4). *Speak Up 2011* even found that parents were behind their children’s personalized learning journeys with 64% of them reporting they would purchase a mobile device for their child’s academic use at school (Project Tomorrow, 2012). Furthermore, 73% of parents identified their biggest concern for their child’s success was whether their child was “learning the right skills to be successful in the future”, which was valued far more than “monetary success” or “getting into a good college” (Project Tomorrow, 2012, p. 1-2). The *Speak Up 2012* survey[2] yielded similar statistics linking the importance of digital technologies to education. Thus, social media and digital resources are emerging strongly

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[1] Sample of 330,117 K-12 students, 44,006 parents, 36,477 teachers, 2,025 librarians, 814 district administrators, 3,319 school administrators, representing 5,616 public and private schools from 1,250 US districts, 24% from urban, 41% suburban, 35% rural communities, and over half of the schools are Title I eligible.

[2] Sample of 364,240 K-12 students, 39,713 parents, 53,947 teachers, 2,399 librarians, 1,564 district administrators, 3,947 school administrators, and 500 technology leaders, representing 8,020 public and private schools from 2,431 districts, 30% urban, 27% suburban and 43% rural communities and over half of the schools are Title I eligible.

as key components of 21st century school-to-home communications. The survey found that 37% of parents wish their child's teacher or school would communicate with them via text messaging when it was just 5% two years ago (Project Tomorrow, 2013). In addition to meeting the needs of students within the current system, technology use and integration has the ability to better student achievement and attitudes in the school setting.

Student Achievement and Perceptions in Blended Learning Environments

A study conducted by Chen (2012) explored the effects of varied blended learning approaches on student learning achievement. The purpose of the study was to compare the effects of the three different learning environments on students' learning achievement in terms of facts, concepts, and understandings using an experimental design. Participants included 93 third-grade students from a middle to high socioeconomic status school district in Tainan City, Taiwan.

All students participating were randomly assigned into the three groups to avoid any sampling bias. Group one was the control group of 30 students who received online only instruction and no peer or teacher interaction, group two was a treatment group of 30 students getting blended learning through online instruction and small group-peer interaction, and group three was a second treatment group of 33 students getting blended learning through online instruction and student-teacher interaction. Students were asked to complete a knowledge test upon finishing their assigned forty-minute mode of instruction.

Although the researcher expected there to be no difference among the three groups, the results showed that students in the two blended learning environments achieved significantly higher scores in the fact portion of the test. There was no evidence, however, to show a difference between the two blended learning groups as there were no statistically significant data among any of the dependent measures: facts, concepts, and understandings. Based on the results, the researcher concluded that the blended learning environments supported students to perform significantly better learning factual knowledge than those in the control getting the online-only instruction.

Though the duration of instruction does seem to be significantly short, their findings seem to suggest that blended learning is a better option compared to that of their online only program. Their results indicated that a blended learning approach can facilitate students' success in terms of remembering factual knowledge, but they also showed online learners still prefer some face-to-face time with teachers and other students. Even still, Chen urges for more research to be done to continue the investigation of the effects of blended learning and online learning environments on students' learning achievement through factual, conceptual, comprehension, and problem-solving practices. The researcher also added that further studies should take into consideration human factors that might affect the study's findings such as individual learning differences, prior knowledge, learning styles, or how students interact with peers and their teacher.

Tempelaar, Rienties, and Giesbers (2009) investigated who benefits most from blended learning environments, taking into consideration student learning styles and subject achievement motivation. These international scholars began their research to study whether adaptive online lessons satisfy the needs of a broad range of learners with different learning styles and preferences. They analyzed the relationships between learners' characteristics and the students' use of an Assessment and Learning in Knowledge Spaces (ALEKS) module, an electronic learning environment. Similar to Chen (2012), this study's results showed positive support for fact-based recall with the digital learning tool.

Tempelaar et al. collected data on over 4,000 students during their first year at Maastricht University in the Netherlands. Six groups of data were gathered, one each academic year from 2003-2004 to 2008-2009. Almost one-third of the students were of Dutch citizenship while the remaining were international students, mainly from Germany. At the beginning of the course, students enrolled in International Economics and International Business Studies completed several self-report questionnaires on learning-related characteristics, including the Inventory of Learning Styles (used to assess preferred learning dispositions) and the Survey of Attitudes Toward Statistics. Each course had a blended learning environment that consisted of the following components: problem-solving tutorials, lectures, independent learning, and an electronic learning environment, ALEKS. The e-learning component in this blended learning environment was used for teaching introductory statistics. Students were able to choose the intensity with which they used each component of the blended learning environment, according to their personal preferences. Due to the large sample size, researchers decided to only analyze the correlations between student learning dispositions and the intensity of their use of ALEKS.

The researchers found on average students spent nearly 24 hours in ALEKS, which was almost a third of the total learning time available for the introductory statistics course. With only 60% of the items in the module relevant to the course, students achieved an average mastery level of 45% in ALEKS. Additionally, researchers found that female students spent more than average time in the e-learning environment and were overrepresented among e-learners. “Stepwise learners”, those who preferred memorizing, rehearsing, and analyzing to relating, structuring, and critical processing, also spent a lot more time in the ALEKS learning environment than other types of learners. In other words, the researchers concluded that students who had a relatively strong disposition to surface learning approaches, identifying themselves as such, seemed to profit most from the availability of e-learning tools.

The researchers determined that even though the ultimate goal was to get students to be deep thinkers, the benefits focused mostly on basic thinking skills and repeated practice. They also mentioned a potential drawback to the study: the intensity of the other components in the blended learning environment was not measured, but if it had been, the results could have provided additional insight into student benefits. Since students were able to access information and interact with the online module at their leisure and convenience, Tempelaar et al. concluded that the availability of a blended learning environment including different components tailored to the various types of learners still seemed to have great benefits.

Similarly, Borman and Sleigh (2011) studied student success and engagement when they used interactive, computer-based elements supporting the lectures from a Civil Engineering course. Two different cohorts were tracked from 2009-2011, with 162 students participating in the group one and 154 participants in the second. Though involvement in the online assessment tool, MyMathlab, is typically around 30-40% for other modules in this school, the first cohort had 62% of students engaging consistently with the program and 91% participated regularly from the second cohort. Surveys were given to students upon completion of the course and students responded to a Likert 5-point scale for a series of statements. The survey results indicated that students felt the interactive elements included with lectures (tablets, online resources, personalized response system) were valuable and useful as an aid to their learning. Another result indicated that nearly 90% of students felt that regular online exercises available through MyMathlab helped with their learning as well; however, the researchers pointed out these were only student perceptions of their increased understanding and were not quantitatively measured in terms of actual gains in student learning.

On the other hand, Lei and Zhao (2007) were able to track student learning gains in their investigation of middle school students during the 2002-2003 school year. Their study investigated how technologies were used by students and what technology uses were most successful for improving student achievement. Indications of achievement were measured by grade point average (GPA). Over 200 students participated in this study, completing pre-test and post-test surveys; ten teachers and nine students were also interviewed to gain a more in-depth perspective of how students used technology. The results revealed that "among students who spent less than 3 hours a day [on computers], the more time they spent on computers, the more they gained on GPA" (p. 288). However, students who indicated more than three hours of computer activity per day showed a loss on their GPA. The researchers explained this phenomenon by suggesting the effect was likely dependent on how students spent their time with specific technologies and with specific activities. In other words, if students were spending excessive amounts of time using computers, it is likely they were not spending the time using the technology tools to contribute to their academic achievement. As a result, time spent with technology that could have positively affected achievement was lost and could have hindered students' overall academic success. Lei and Zhao concluded that the quantity of technology use in education can impact student achievement, but the kind of impact is determined by how technology is used. They suggested that schools providing students with more technology resources and creating blended learning environments would be critically important, though if quality time cannot be ensured, the time spent using technology should be limited.

Some schools throughout the United States seem to be finding that balance. Horn (2012) described several schools using blended learning models that seem to be flourishing. Based in Yuma, Arizona, Carpe Diem is a 6-12 school which uses a blended learning Rotation model. In

2010, their school was ranked first in its county in student performance in math and reading and even ranked among the top 10% of charter schools in Arizona. A K-4 school, KIPP Empower Academy in Los Angeles, also incorporates blended learning using the Rotation model in which students rotate between personalized, online learning and small group stations. The KIPP Empower Academy reported, “though many students…entered kindergarten without basic letter and number recognition skills, by the end of the year, 98 percent were reading and performing math at or above the national average. Not only that, but many students [in kindergarten] were also reading at a ‘2.5’ grade level and performing math almost at the 3rd-grade level” (Horn, 2012, para. 2). Both are exemplar schools in the U.S. successfully implementing blended learning models and obtaining remarkable student achievement gains.

Student Attitudes in Blended Learning Environments

One mixed methods study based in Malaysia, took it a step further and compared the satisfaction levels in nine areas of a blended learning course for urban and rural groups of students. Ling, Siti Rahayah, Saemah, and Lai (2010) examined course content, technicality, flexibility, community learning, motivation, sharing, feedback, complementary learning, personalized learning, and the overall satisfaction level toward a blended learning course. Researchers ultimately hoped to answer the question of whether students in rural areas have the same opportunities in education as those in urban areas while using a blended learning model.

The participants of the study attended three different universities: Open University Malaysia, University of Technology MARA Sarawak, and University Tun Abdul Rahman. All students who were enrolled in the mathematics blended learning course were members in this study. A total of 170 students took part in the quantitative portion, and 16 students were randomly selected for a semi-structured interview where they were asked to give their opinions on satisfaction with the nine components listed above. One hundred five students were identified as living in urban areas while 65 were rural. After the conclusion of the course, all participants completed a 43-item satisfaction survey with a Likert scale from 1 (very unsatisfied) to 5 (very satisfied).

Of the quantitative data, all mean satisfaction levels were over 4.0 for all categories: course content, technicality, flexibility, community learning, motivation, sharing, feedback, complementary learning, personalized learning, and the overall satisfaction level of the course. They also found that there was no statistically significant difference among the rural and urban groups from any area. In fact, the rural group had a higher mean satisfaction level in five of the nine areas (course content, motivation, sharing, complementary learning and personalized learning) in comparison to the urban group. Although the qualitative findings did not add to the overall research or help to answer the research question any differently, Ling et al. (2010) gathered data that supported and was consistent with the quantitative data collected through the surveys. Regardless of their location, all respondents were satisfied with the blended learning course that was offered.

Based on the finding in this study and past studies conducted by Ling and Siti Rahayah, these researchers recommend that blended learning environments should be expanded to elementary and secondary school programs. They suggested that blended learning courses allow all students the same opportunity of education whether they live in a rural environment or urban location (Ling et al., 2010).

Despite the research found by Lin (2009) illustrating a great potential and growing interest in blended learning, research-based evidence still varies on the achievement gains and the environment's effect on student attitudes. This was why Lin developed a study to further investigate student views on blended learning within elementary teacher education courses. Knowing that the research on students' attitudes toward blended learning is limited, the researcher also sought out to find how students view blended learning and what challenges they face in the course of learning in a hybrid environment.

Lin, acting as the researcher and instructor, gathered data from two blended courses taught during two semesters in the academic year 2006-2007: Multicultural Issues in Education and Society and Applied Strategies for the Exceptional Learners, both junior level courses at a small Northeastern college in the United States. Study participants included 27 students in the first course and 24 students in the second. Importantly, there were 21 students in the second course who also experienced the blended learning course the semester before. All students were enrolled in the undergraduate elementary teacher education program. Participants were 90% female, 97% white, and between the ages 21 and 33. Also, it may be important to note that the students' GPA ranged from 2.50 to 4.00 with a median of 2.93 on a 4-point scale.

Using two questionnaires, qualitative and quantitative data were collected. The first questionnaire assessed students' comfortability level with technology and was given on the first day of class; the second gathered student views on hybrid learning using Likert-type questions once the courses were complete. For the instruments, the reliability coefficient of Cronbach's alpha was .81 overall. Therefore, the researcher could expect relatively high internal consistency with data collected.

Although it would have been interesting to see how the attitudes changed between individual students who took the blended learning course in the fall and then in the spring, the results still indicated that there was a generally moderate comfort level with technology between the two groups of students. In addition, since most had experience with the hybrid model once before, there is no surprise that there were more students in the second course who had higher positive views about blended learning than the students in the first course. Almost 85% of students reported wanting to take another course that incorporated blended learning and the item students enjoyed the most about the courses was getting to control the pace of their own learning. Still, according to the results, nearly 15% of the participants did not like the hybrid course or activities. Unfortunately, it is unknown if it was the hybrid course design, instructor, or students within the classes that were the cause for the negative view since those items changed little to not at all from course to course.

Lin set out to discover students' perceptions of the usefulness and outcomes related to blended learning courses in elementary teacher education. What the data revealed was that students generally liked using online course materials and the blended learning environment. The researcher also found that all students could participate equally, which seemed to lead to higher interaction rates and more student engagement in the material presented than in the past without the blended portion of the course. Also, the findings showed that students believed the web-based classwork enhanced their classroom discussions once they met face-to-face. Lastly, Lin argued that online learning that is well-designed also demands students to accept an increased responsibility for their own learning; many participants seemed to like this most about blended learning environments according to the questionnaire. Nevertheless, the researcher recommended the need for future exploration to fully understand how the many factors of teaching and learning in blended learning environments can affect students and teachers.

In another study, middle school-aged students who used web-based mathematics assessment and practice were compared to students exposed to the same material but by traditional practice and assessment (Nguyen, Hsieh, & Allen, 2006). These students completed questionnaires of both a quantitative and qualitative nature before and after the completion of the course. Nguyen et al. found that generally all students believed that using a computer assisted their learning objectives for the day. Students in the web-based program also expressed that working with a computer made learning more enjoyable and stimulating. Of the 31 students randomly placed into the web-based class, a majority either agreed or strongly agreed with enjoying the work on a computer and preferred having more lessons computer-based. Additionally, based on results of this study, researchers concluded that students engaged in web-based assessment and practice were willing to spend more time on comprehension tasks and push themselves for greater success. It was found that since students who participated in the web-based assessments and practice were provided with more opportunities for real-time feedback on their progress, they developed “better self-confidence, self-efficacy, and self-motivation” (Nguyen et al., 2006, p. 275). Although a majority of students did enjoy the technology-based option, there was still one participant who expressed his preference for human interaction over the computer program’s assessment and practice tools. Nevertheless, it is hard to disregard that technology-based applications seem to scaffold students’ learning with an ease and quickness that most teachers are unable to do.

Based in Taiwan, another study gathered data on 24 Institute of Technology students participating in an experimental, computer-networked learning course. Lin, Liu, and Yuan (2008) explained that one of the main advantages of the course included more immediate feedback for students, as the “networked system is more persistent than human beings” (p. 213). Since the program adapted to what a student accurately mastered of the course material, students were able to proceed smoothly, repeating lessons, viewing modules, and persevering until they completely understood the content. Normally, a teacher in a traditional classroom setting may not be able to help a student through remedial catch-up work as a result of time limitations, but due to the web-based nature of this course, students were able to work at their own pace and received instant feedback or hints if ever they provided an incorrect answer. The results of the questionnaire indicated that 85.7% of students stated the system had a positive effect on their learning, and 90.5% indicated having a desire to spend more time on learning through a network learning environment.

In the United States, Horn (2012) described the implementation of Khan Academy at the Los Altos School District in California. In 2012, the math curriculum for students in grades five through eight imbedded Khan tutorials and practice problems with real-time feedback and coaching. By using this online technology resource, the teachers were able to individualize instruction, utilize flexible grouping more frequently, and gather real-time data for continuous targeted interventions, all of which allow students to have more control of what and how they would learn. Since Los Altos was already a high-performing school district, administrators had not seen any significant differences in assessment scores as students began using Khan. However, what they had noticed was an increased enthusiasm for learning from students that was not evident with the use of traditional textbooks (OnlineUniversities, 2012).

Synthesis

Blended learning allows educators the opportunity to develop paths personalized to individual student’s needs and allows students to learn from an assortment of digital resources. The collection of studies and research addressed an importance of blended learning environments for student achievement and attitudes in various educational settings. While some research showed positive gains in student achievement (Chen, 2012; Lei & Zhao, 2007; Horn, 2012; Neuhauser, 2002), there is still limited information about the impact of student achievement in these nontraditional environments. Lei and Zhao (2007) highlighted a need for more research in this realm. Although their findings suggested that spending time in computer-assistive software improved student achievement by increasing GPA, they concluded that too much time with computers could be harmful. They discovered achievement only to be significant if students spent less than three hours on computers each day, while Chen (2012) found achievement gains in blended learning environments for only factual knowledge recall. Furthermore, Horn (2012) described four schools across the United States which have shown academic success since implementing blended models; however, all were in the early stages of implementation and had no real pre- and post-implementation data to support their empirical evidence.

In addition, as Graham (2006) suggested and Tempelaar et al. (2009) exposed, the blended learning environment and contact to online learning options may be more beneficial for certain types of learners or more successful with select curriculum. Tempelaar et al. discovered that much of the success of student achievement within these environments depended on how students learn best.

On the other hand, student perceptions of blended environments seem noteworthy. Ling et al. (2010), Lin (2009), Lin et al. (2008), and Borman and Sleigh (2011) all studied international, college-level students and found relatively high satisfaction with the blended learning courses they took. Most students seemed to have a positive attitude toward online learning and blended learning settings in education. Though these studies focused on student perception of success and had very limited evidence to support the actual impact, each, to some degree, encouraged schools and districts to begin using blended learning models more frequently within classrooms. Each study supported the proposal for offering blended learning environments but suggested an immediate need for more research. Though the qualitative research of Lin et al. (2008) and Lin (2009) were small samples, there is still merit in their findings. Essentially, this, too, supports the need for more technology-based approaches to teaching diverse groups of students in middle school settings.

Although much of the research presented does support the implementation of blended learning approaches in education, there is not ample research targeting achievement and attitudes of students, especially at the middle school level or with students from the United States. It is also important to note that nearly all classroom-based research is quasi-experimental because students are very rarely placed randomly into their assigned classes; consequently, none of the research studies used an experimental design with the traditional classroom setting as a control. Since a majority of U.S. classrooms still use traditional, face-to-face instruction, having a teacher-led control group with limited or no technology interaction would be a more relatable, comparable, and realistic group for research purposes.

The basis of incorporating blended learning environments in a mathematics classroom is to assist in personalizing instruction for each student. By using digital resources, students can be provided with immediate feedback and access to information, help, or more practice as needed while they move through the learning process. Lin et al. (2008), Nguyen et al. (2006), and Horn (2012) expressed the positive impacts on the well-integrated use of technology in learning environments with one major advantage being real-time, adaptive responses. Based on the research and push for teaching 21st century skills, mastery of a subject seems more likely and more easily obtained if students are enrolled in courses that utilize blended learning environments. The next chapter will describe the action research plan for testing this hypothesis.

Chapter Three

Methodology

As is evident from the previous chapter, there is an urgent need for research with blended learning environments, particularly with middle school level education. Very few thorough research studies for K–12 students have been published addressing the effectiveness of online or blended learning (U.S. Department of Education, 2010). As a result, the U.S. Department of Education has little concrete data to support these learning environments' effects on student achievement, though findings from the meta-analysis in this report indicated that "students in online conditions performed modestly better, on average, than those learning the same material through traditional face-to-face instruction…[and] instruction combining online and face-to-face elements had a larger advantage relative to purely face-to-face instruction than did purely online instruction" (p. xiv-xv). The majority of the studies complied in the meta-analysis did not include K–12 students, and since the number of studies involving primary and secondary students was too small, researchers determined a sound conclusion could not be made for this group of learners. Without additional studies investigating online or blended K–12 learning environments, policy-makers lack scientific, research-based evidence of the effectiveness of these emerging alternatives to face-to-face instruction and consequently find it difficult to promote these models at the national level.

Integrating blended learning into schools could change the current educational system, as it challenges the most popular model in schools today. Tailoring instruction for students through personalized lessons can be achieved when using a blended learning setting. Through the use of technology in these environments, students may be granted a greater chance at discovering their true abilities. The number one objective should be to find the most efficient and effective ways to educate students. This project tested one of those instructional methods.

The main goal for this action research project was to monitor the effects of blended learning environments on student learning and attitudes in mathematics. This chapter will describe the participants of study, what experiences each group had during the project, and how the quantitative data was gathered and analyzed from November of 2014 to January of 2015. Students in two middle school algebra classrooms took pre-and post-tests and surveys, which were comparted for the purpose of the research.

Context

The study took place in a Midwest town with a population under 10,000 residents. The suburban district is comprised of eight schools and offers a wide-range of instructional programs. All schools have gifted and talented programs, and in secondary grades a program for “at-risk” children is currently in place to provide students experiencing academic difficulties with extra support. The middle school included approximately 750 seventh and eighth grade students. Two algebra sections from the middle school participated in the study, both taught by the same instructor.

Participants

Participants were a heterogeneous group of 47 middle school students. Their ages ranged from 13 to 14, and these students were identified as “academically talented” (AT) in mathematics. There were 24 female and 23 male participants, with 10 male and 14 female students in the treatment group. Participants were all in a good state of physical and mental health. There was one male participant identified as “at-risk” within the control group and no participants with mathematics learning disabilities. The socioeconomic status for all students ranged from middle to high. Though all participants were minors, the usage of this age group was necessary so relevant and valid research can be gathered on achievement and attitudes of students at the middle school level. Parents were informed by the use of email communication and via an introductory letter of the project (see Appendix A). Within the correspondence, information was provided about the procedures in class, my rationale for the study, and a request for parental consent to use their child's assessment data and survey responses.

Students enrolled in my Algebra 1 classes were the participants. Due to scheduling difficulties, a true random sample did not occur for the placement of students each hour. Every student enrolled in the algebra course participated and received the same content instruction by the same instructor but through different delivery methods. No students in either class opted out of the data collection.

Questions

Based on data collected from middle school algebra students, this action research study investigated the following questions:

- How does introducing blended learning environments in mathematics instruction affect student achievement in an algebra class?
- In what ways do blended learning environments impact students' attitudes toward mathematics and learning?

Students were given the same assessments in each class, but one class received face-to-face, direct instruction, acting as the control, while the treatment group participated in a rotational model of blended learning with Open Educational Resources (OER) and brief teacher-led lessons. OER refers to high-quality, online educational resources "that reside in the public domain or have been released under an intellectual property license that permits their free use or re-purposing by others" (Atkins, Brown, & Hammond, 2007, p. 4). The four resources used were

Khan Academy (Khan Academy, 2014), *TenMarks* (TenMarks Education, 2014), *CK-12* (CK-12 Foundation, 2014), and *Mangahigh* (Blue Duck Education, 2014). In addition, the teacher-led lessons in both classes were enhanced with the use of SMART Board, an interactive whiteboard. The means of data collection were calculated and gathered from pre- and post-assessments and surveys. Like the assessments, the surveys were given at the start of the unit of instruction and upon completion of the unit. They included a 5-point Likert scale to gather data on attitudes of the students toward mathematics, technology, and instruction.

Procedures

Before conducting the research, I trial tested the survey with a few students external to the study. This checked for comprehension and interpretation of the questions. I analyzed the trial survey results and concluded that no revisions to the survey were needed. See Table 3.1 below for the project's timeline.

Prior to the study, all students were notified about the study's purpose and a letter of consent was sent home for parent/guardian approval. All students participated in this study 50 minutes each day for approximately three weeks. The control group was my second period algebra class and my seventh period received the treatment of blended learning. This was largely due to the technology resources availability within my school and the setup required for the treatment group. Both groups of students also took a pre-test assessment to obtain a baseline achievement score as well as a survey to measure attitude prior to the exposure of unit material.

During the study, both groups of students were taught writing linear equations concepts related to the "Chapter 5" learning targets located in *Algebra 1* (Larson, Boswell, Kanold, & Stiff, 2007). With the use of a SMART interactive whiteboard, I instructed students in the control group through traditional, face-to-face lectures. I developed lessons and review activities for each learning target, primarily introducing a new target each day. This was a predetermined schedule and based on the pace previously taken with other algebra courses in the past. These students had access to their textbook, *Algebra 1*, participated in peer interaction partnerships and group work, and completed assigned practice after each day's lesson during the unit.

On the other hand, students in the blended learning treatment group rotated between teacher-led instruction and OER, such as video tutorials, practice exercises, and games. The coursework for the treatment group was shared only to them via *Google Doc* (see Appendix B) to reduce interference between the instructional designs within each class. This document displayed a module for each intended learning target using *Khan Academy, TenMarks, CK-12* and *Mangahigh* resources. These online resources helped to personalize math practice by including video lessons, on demand hints, real-time feedback, access to exercises and flashcards, and math games aimed at middle to high school level students. In addition, nearly all the links within the *Google Doc* required individualized logins and passwords which I provided only to the treatment group participants.

For the treatment group, each day groups of three to eight students received approximately 15 minutes of direct instruction with the aid of a SMART Board interactive lesson. When treatment group students were not participating in the teacher-led rotation, they were working through the assigned tasks of online practice or exploring the online resources linked within the practice. These students' primary source of learning came from online-based resources, although they had access to the course textbook, *Algebra 1*, as well. At the end of each class period, students within the blended learning environment completed a formative assessment to check for understanding of learned material. These four question formative assessments addressed one or two different skills. The achievement scores of these *quick checks* were used to determine the makeup of each small group for the following day; they also helped me determine what the mini-lesson's focus would be. Since students had modules to work through, the blended learning class had a more fluid, individualized pace between the learning targets, while students in the traditional setting moved at my preset pace. However, both classes had a predetermined final assessment date. Students in the blended environment were given this deadline at the unit's commencement and encouraged to pace themselves accordingly.

At the end of the study, both student groups took the post-test assessment and completed the post-survey.

Table 3.1

Project Timeline

Dates	**Description**
Nov. 3	Tested survey with a few students external to the study to check for comprehension and interpretation
Nov. 3	Sent the letter of consent to parents/guardians
Nov. 10	Analyzed trial survey results but revisions were not found necessary
Nov. 17-25	Prepared project materials for students, e.g., lesson plans, copies of directions, assessments and surveys, prepared *Google Doc*, etc.
Nov. 18 – Dec. 23	Implemented project with classes
Nov. 18	Administered pre-test & survey in classes
Nov. 24	Scored pre-test & compiled survey results
Dec. 2	Assigned students for treatment group & began blended learning instruction; Shared OER *Google Doc* of modules with treatment group

Dec. 2	Continued traditional face-to-face instruction for control
Dec. 18	Administered post-test in both classes
Dec. 23	Administered post-survey in both classes
Jan. 5	Scored post-test & compiled survey results
May 26	Calculated means for pre- and post-test and pre- and post-surveys, including differences and growth percentages for assessments
June 22	Analyzed pre- and post-test results and pre- and post-survey results

Instruments for Data Collection

Students took a pre-test (see Appendix C) for writing linear equations that assessed each learning target for this chapter. The scores provided a baseline for each student's achievement. The post-test (see Appendix D) for writing linear equations was the same in structure, size, and concept content, but the numbers used within each question were altered. Since the math department used common assessments for each chapter test, the pre-test was developed from the approved chapter 5 test for algebra. The post-test used was the already-created common assessment for chapter 5 learning targets. Each question of the pre-test was equally matched to the post-test to assess the same concepts, skills, and learning targets presented in the unit.

The pre- and post-surveys were the same questions (see Appendix E). The 25-statement survey was developed to collect information regarding students' attitudes toward: mathematics learning (numbers 1, 3, 4, 6, 11, 12), general computer use (numbers 19, 20, 22, 24), teacher-led instruction (numbers 2, 5, 23, 25), technology use in the classroom (numbers 7, 8, 9, 10, 13, 21), and technology-driven mathematics instruction (numbers 14, 15, 16, 17, 18). The survey was adapted from *Measuring Student Attitude in Mathematics Classrooms* (Brookstein, Hegedus, Dalton, Tapper, & Moniz, 2011) and *Instruments for Assessing Educator Progress in Technology Integration* (Knezek, Christensen, Miyashita, & Ropp, 2000). A 5-point Likert scale ranging from 5-strongly agree, 4-agree, 3-neutral, 2-disagree, and 1-strongly disagree was used to record student responses.

Analysis

The analysis of data included quantitative procedures with data compiled in a *Google Sheet* displaying pre-and post-assessment scores and survey data. The assessment scores were reported in percent for both pre- and post-tests. The survey data was recorded as the frequency of each rating per survey item and then organized by attitude category: mathematics learning, general computer use, teacher-led instruction, technology use in the classroom, and technology-driven mathematics instruction.

During analysis, the assessment score data was used to describe how introducing blended learning environments in mathematics instruction affected student achievement in the algebra class. The scores, reported in percent, allowed me to compare the growth from the beginning to the end of instruction. After calculating the means for pre- and post-tests, I found the difference between the pre- and post-test means and calculated the growth percentages for each student's scores. To calculate the difference in means, I simply subtracted the pre-test score from the post-test result. To calculate the growth percentages, I divided the difference of the pre- and post-test scores by the students' actual pre-test score. I completed this process for all students in both groups. The mean totals, differences, and growth percentages of groups of students, control versus blended learning treatment and boys versus girls, was used to evaluate and compare any differences presented.

Thereafter, the survey data was used to describe the ways blended learning environments impacted students' attitudes toward mathematics and learning. For this part, the Likert-type responses to statements were compiled and analyzed for the 47 students in the study. Most statements were phrased so that agreement with the item would represent a more positive attitude toward the category being measured (see Appendix F). For example, a 5 was awarded to a "strongly agree" opinion, while a 1 was awarded to "strongly disagree". There were three statements (numbers 2, 3, and 10) in which reverse-scoring was used. Numbers 3 and 10 were reversed to account for negatively-keyed items and number 2 was reversed because confidence in one's abilities to solve problems would mean a student does not need teacher-led instruction. Similar to the pre- and post-test scores, means for each category were calculated, totaled, and compared from the control to treatment groups.

Mean data for assessments and surveys was transferred to tables upon completion of the study for simplification. There were no missing data for the pre and post-tests nor the pre- and post-surveys. In the following chapter, the results for this project are listed and described.

Chapter Four

Results

Blending digital technology with the traditional, direct teaching model is not a ground-breaking instructional method. However, since new digital applications and web tools are seemingly launched every day, collecting research about the integration of these technologies does seem to be new. With this ever-changing digital world at educators' and students' fingertips, it is hard not to think maybe there is a better way to teach and learn. This study set out to answer a few questions related to integrating Open Educational Resources (OER) technology within a mathematics classroom. Based on data collected from middle school algebra students in two different instructional settings, one traditional and one blended, I discuss the main results of this study: the effect of blended learning environments in an algebra classroom on student achievement and the impact of blended learning environments on student's attitudes toward mathematics and learning.

There were 47 students who completed this quantitative study, and data was collected from each participant. Findings from the pre- and post-tests and pre- and post-surveys are presented below. To make comparisons and show differences with more ease, the results for both the control and treatment groups have been combined into each table.

Research Question One – *How does introducing blended learning environments in mathematics instruction affect student achievement in an algebra class?*

Students were asked to complete the same assessments in each class, one prior to the exposure of curriculum content and one at the end of the unit. The mean scores for those assessments have been compiled into Table 4.1 below. On average, the post-test score for the treatment group was a greater percent (86.4%) than that of the control group's mean score

(84.2%). This indicated that the blended environment learners showed a slightly higher percentage of understanding with the writing linear equations learning targets at the end of the unit.

On the other hand, the control group's pre-test baseline achievement score was slightly lower on average at 17.1% versus the treatment group at 20.2%. This indicated that the control group had greater ground to cover in terms of achievement. In fact, the differences in the two groups' growth showed that the control actually learned *more.* Both groups exhibited noteworthy gains in their understanding, but students in the face-to-face, teacher-led environment illustrated a 67.1% of growth while the blended environment learners grew about 66.2%. In other words, an average student in the control gained approximately 3.92 times more knowledge acquisition from the baseline score while an average student in the treatment gained about 3.28 times his or her original score.

Table 4.1

Means of Pre- and Post-tests for Control and Treatment Groups

Group	Pre-test (%)	Post-test (%)	Difference (%)
Control (n = 23)	17.1	84.2	67.1
Treatment (n = 24)	20.2	86.4	66.2

When analyzing data based on gender, there were some similarities and differences among both groups (see Table 4.2). The baseline percent for all groups was relatively similar with the exception of the girls in the treatment group. On average, these girls showed a greater understanding of algebra content by about 6% at the beginning of the study. In addition, this subgroup in the blended learning environment showed the highest post-test achievement score (88.1%) but the smallest percentage of knowledge gained at about 2.83 times their baseline score. The group showing the highest gains of concept understanding at the end of the study was the boys in the treatment group with about 4.15 times their baseline achievement scores. The control group girls grew by 69.3%, or 3.98 times their average original scores, and the control group boys showed similar data with a 65.4% difference, or 3.87 times their average pre-test scores.

Table 4.2

Means of Pre- and Post-tests for Control and Treatment Groups by Gender

	Girls[a]			Boys[b]		
Group	Pre-test (%)	Post-test (%)	Diff (%)	Pre-test (%)	Post-test (%)	Diff (%)
Control	17.4	86.7	69.3	16.9	82.3	65.4
Treatment	23.0	88.1	65.1	16.3	83.9	67.6

Note. Diff = Difference between pre-test to post-test percentage
[a] Control group girls (n = 10); Treatment group girls (n = 14) [b] Control group boys (n = 13); Treatment group boys (n = 10)

Overall, knowledge acquisition grew with both instructional designs. The average blended learner showed a greater final understanding through the percentages reported, but the average face-to-face learner displayed greater knowledge gains. Yet, when analyzing data specific to gender, the boys in the blended learning environment had higher final scores and greater knowledge gains in comparison to the boys in the traditional setting. Even though the blended learning environment was positive for both genders, these findings suggested that blending technology with direct instruction was more successful with boys.

Research Question Two – *In what ways do blended learning environments impact students' attitudes toward mathematics and learning?*

Like the assessment data, students were asked to complete surveys at the beginning and end of the study to measure the impact of blended learning environments on students' attitudes toward mathematics and learning. The survey items were scored based on the frequency of ratings for each statement (see Appendix F). There were 47 students who completed the surveys with no missing data. Means scores were calculated and compiled by category into Table 4.3 for simplification.

Table 4.3

Mean Pre- and Post-Survey Results for Control and Treatment Groups by Attitude Category

	Control (n = 23)			Treatment (n = 24)		
Category (Range)	Pre-Survey	Post-Survey	Growth	Pre-Survey	Post-Survey	Growth
Mathematics Learning (6 – 30)	22.61	22.17	–0.44	22.33	22.25	–0.08
Computer Use (4 – 20)	14.65	14.30	–0.35	14.38	13.67	–0.71
Teacher-Led Instruction (4 – 20)	14.52	13.61	–0.91	13.63	14.00	0.37
Classroom Technology Use (6 – 30)	20.00	18.43	–1.57	18.78	17.92	–0.86
Technology-Driven Mathematics Instruction (5 – 25)	17.96	17.83	–0.13	18.08	19.08	1.00

Note. Range = Range of possible mean scores for each category

In general, most of the attitudes in all categories for both groups showed declines in their means. This indicated that regardless of the instructional environment design, the attitudes toward mathematics and learning waned from the beginning to the end of this study. The two exceptions, showing a positive attitude growth, occurred in the treatment group data, while the control's mean attitude levels showed negative growth in each category.

After calculating, compiling, and analyzing the survey data, some suggestive similarities and differences were seen. In the control group data, the greatest dip (–1.57) was seen in student attitudes toward technology use in the classroom; though not as great of a difference, this was also true of the treatment group (–0.86). The second greatest drop for the control group was that of attitudes toward teacher-led instruction (–0.91). However, the blended learning group displayed a slight positive growth in the attitudes toward teacher-led instruction (0.37). Moreover, the treatment group had 1.00 mean growth in their attitudes toward technology-driven mathematics instruction, while the face-to-face, teacher-led students expressed a subtle drop for this category (–0.13).

Overall, the attitude changes from pre- to post-survey are relatively similar and do not seem to suggest that the difference in instructional delivery methods had much bearing on student attitudes. Nevertheless, student attitudes toward technology-driven mathematics instruction and teacher-led instruction for the treatment group were higher than that of the control's attitude mean scores in those categories.

Chapter Five

Conclusions

Today, the United States is extremely dependent on technology, yet it seems, schools are not taking necessary steps toward the integration of online applications, tools, and resources within classrooms (National Postsecondary Education Cooperation, 2004). Children are growing up in a world that is far different than the one previous generations grew up in. The nation's current high school seniors do not know a world without the internet. Now students long for immediate gratification because that is what they have always known through video games, internet use, and cellular phones (Arhin & Johnson-Mallard, 2003). Homework and conceptual practice should be designed with this in mind, but classrooms throughout the U.S. ignore this notion grading homework simply for completion and with little to no feedback (Scriffiny, 2008). Rather than being seen as meaningful practice within the learning process, homework is dismissed as busy work. This traditional routine seems to undermine what educators could actually be providing students through the use of Open Educational Resources (OER) in blended learning environments. Bender (2011) argued, "not utilizing these technologies can drastically impair our overall instructional effectiveness for many students, and in that sense, we owe our students our best, most rigorous efforts in application of these proven technologies and instructional techniques" (p. 125).

Unfortunately, blended learning, like the flipped classroom, carries the risk of being seen as the next *new movement* to hit the educational field (Fulton, 2012). Sometimes when teachers do not immediately experience positive results with a new method of instruction, many may be quick to regard it as ineffective or a useless fad. However, the way in which the instructional model is introduced to students and teachers could change any negative perception. That is why it is important for districts to offer high-quality professional development opportunities to equip teachers with the necessary tools to create successful blended learning settings (Rae & Samuels, 2011; Ross, Morrison, & Lowther, 2010; Imbriale, 2013; Bender, 2011). Teachers cannot expect to be fully effective unless they are given the time to learn how to best use digital technologies and adjust to the new model themselves. In addition, students need time to acclimatize to this different model or they may fail to see how helpful this method of learning can truly be. Regrettably, the research on blended learning carries limited evidence on the impact of student achievement, especially for primary and secondary levels (U.S. Department of Education, 2010). That is why more published research and empirical studies, like this action research, are needed.

Main Conclusions

At the end of the study, both groups showed positive gains in content understanding. Though I expected to see more notable differences between the two groups, I can still draw a few conclusions. Since both showed similar growth, I can definitively conclude that blended learning did not have a negative impact on student achievement. I can also conclude that blended learning and sole direct instruction similarly produce positive student growth in the understanding of writing linear equations. The average post-test mean was slightly higher with the blended learners, which suggests that blended learning does have a greater impact on student achievement than direct instruction. However, the mean percent gains for the teacher-led learners were slightly higher. Essentially, the control had a lower baseline mean, so these students on average had more knowledge to gain. Based on that knowledge, blended learning does not necessary have a more positive impact on student achievement in comparison to teacher-led, direct instruction. Of course, a more sophisticated statistical test accounting for pre-test scores would be needed to determine any true impact on achievement between both groups.

Still, the gender-specific data revealed that for boys the blended learning setting was more beneficial. Not only did the boys in this environment have higher post-test scores, they also exhibited greater gains in knowledge compared to the boys who had only teacher-led instruction. This outcome was not entirely true of the girls since those in the blended environment still produced higher post-test scores than in the traditional classroom setting but smaller growth in overall understanding.

Moreover, the blended learners showed subtle positive attitude shifts toward teacher-led instruction and technology-driven mathematics instruction. This implies that while blended learners enjoyed the self-paced, OER modules, they also became aware of how important the teacher-led lessons were as well. As Evans (2012) pointed out, the push for blended learning is not motivated by the desire to replace teachers with computers; the two should coexist for optimal effectiveness. According to my study, this was exactly what my students desired.

Implications for Teaching

Although I cannot deduce that blended instruction is better than exclusive direct instruction, my data does validate the inclusion of blended environments within classrooms. Based on my research, using digital resources to support instruction does foster mathematics content learning.

However, even though the blended learners did show growth in their overall achievement, those students were continually overwhelmed with the amount of resources I asked them to use since so much of it was new. My students' unfamiliarity with the resources was a constraint. As a result, students need extra time to adjust to the differences presented in this type of environment. There would likely be greater success with blended learning if students were more comfortable with a self-paced workload or just more familiar with how to use each digital resource. Because the blended learners seemed so indoctrinated by the traditional direct instruction model, this seemed to hinder their chance of fully engaging in the environment and experiencing all its value. It would have likely taken more than the one chapter for them to see the benefits, accepting the model, and truly be comfortable in the new setting. For that reason, schools or departments should commit to any changes sticking with them throughout a school year for the initiative to be sufficiently tested (Imbriale, 2013).

Limitations

As with most educational research, there were several limitations within this action research study. Since students could not be placed randomly in either class, I could not have had totally random groupings. Many of the music classes affect student schedules and class placement, so students taking music class may not have been in the control group. This automatically and naturally created a sample bias with ability differences between groups. In addition, the sample size for this study was small with only 23 in the control group and 24 participants in the blended environment.

Other limitations include the lack of a statistical analysis tool and the length of the study. Since data was analyzed using only differences and means, the absence of a statistical procedure to test for significance and account for prior knowledge may have hindered more concrete conclusions from being seen. Moreover, the study was a mere three weeks of implementation and assessed only one unit of algebra.

Also, the survey design had some imperfections. There was not an equal number of positive and negatively worded responses, and there was lack of balance in the number of statements for each attitude category. Since a reliability test was not preformed, there was no information provided to determine if or how the categories relate to one another and therefore, there was no evidence that the items identified within each category actually measured the same construct.

Finally, the assessment results were recorded as percentages of a total score. This did not tell me the specific achievement and understanding of each learning target. In other words, I cannot say for sure that the blended environment promoted conceptual understanding and problem-solving or fact-based recall because the pre- and post-test scores were documented as a total score including questions of both types.

Modifications

If this action research were conducted again, several modifications would be suggested.

1. Introduce all OER (*Google Drive*, *Khan Academy*, *TenMarks*, *CK-12* and *Mangahigh*) to students before expecting them to know how to use them. Most of the resources are very intuitive, but if students had more experience with them prior to the study, they could spend more time with their focus on learning targets and less on understanding how to use the tool.
2. In addition, organize the study allowing for more digital technology time or with multiple units of study in mind. Both would allow students ample opportunity to become comfortable within the new learning environment.
3. If possible, switching the control and treatment groups for an additional chapter should also be an adjustment to the study. After both groups had the chance to experience the blended learning environment, their assessment data would show the achievement and attitude changes more clearly by comparing them to the previous results. There would also be less bias with the two groups if they were both at some point submersed in the blended setting.
4. As was pointed out before, conduct a statistical test of significance of the assessment data and this would help account for prior knowledge understanding.

5. Conduct a reliability test for the survey or restructure the survey and this would provide more confidence in the results.
6. As a final point, collecting qualitative research could help fill in some of the gaps that the quantitative data could not show. Include some open-ended questions on the attitude survey or perform interviews with some of the blended group learners. Possible questions could include:
   - What did you like most about the blended learning environment? Dislike most?
   - Would you enjoy completing another unit with a blended learning classroom structure? Why or why not?
   - Do you feel you learned more, less, or about the same as if you would have with traditional instruction? What makes you say that?
   - What advice would you give students who are learning in a blended environment?

Recommendations for Future

There are several research paths I would recommend related to the inclusion of blended learning environments for mathematics instruction. First, future research should be done to determine the best ways to integrate blended learning with traditional teaching practices. Establishing the foundation for effective implementation would be of great use since I employed several teaching techniques (small group instruction, daily formative checks for understanding, and repositioning desks and seating arrangements) within the blended environment that were not utilized with the other group. For this reason, it would be important to research how to best combine blended learning in the mathematics classroom. Additionally, there is an immediate need for more research addressing the impact of OER on student achievement in the middle school setting. Digital technologies are becoming more readily available and at little to no cost to districts, but blended learning seems to still be in early stages of development and continually evolving. In addition, it is unclear if these environments can consistently reach middle school learners since this style of learning requires more from the student, specifically more responsibility with the self-paced tasks and assignments.

Furthermore, this study has upturned numerous other essential questions: What type of learning, problem-solving, critical thinking, or fact-based recall, is best for blended environments? How does teacher motivation and attitude toward blended learning affect student achievement? How do districts' attitudes toward blended learning impact student achievement? To what extent does familiarity and comfortability with a blended setting affect student achievement and attitudes? Do students' IQ and motivation levels relate to attitudes toward blended learning? Within blended environments, what characteristics are shared by the successful learners? Each of these areas would be beneficial to explore. Future research should seek answers to these questions to help educators teach and students learn in a blended classroom setting.

Technology is a fundamental part of teaching in the 21st century and will only become easier and more available for classroom use. Blended learning seems like a natural addition to what is already being used in classrooms today. This style of instruction can personalize lessons and help to provide students with immediate feedback on their progress, achievements, and misconceptions. Supported by this research, using OER in blended learning can lead to increased student achievement and attitudes. Although this action research could not show that one instructional delivery method was better than the other, there was still evidence to support integrating OER with direct instruction for advantageous results.

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Appendix A: Informed Consent Letter

Monday, November 3, 2014

Dear Parents/Guardians,

Your child has been asked to be a part of an action research project through UW-Whitewater. The purpose of this project is to help me know how well implementing technology in the classroom is working.

If your child chooses to participate, the data from pre-and post-assessments and surveys will be used in the final analysis of the project. If your child chooses not to participate, the data collected from his or her assessments and surveys will not be used in the final results of the project; however, your child will still complete all activities and assessments during the chapter.

Your child's scores and survey results will be kept confidential. The scores and answers will not be linked to your child's name, school, city, or state, nor will answers on the survey affect his or her final grade in this course. There are no risks related to participation in this research.

Please fill out and return the bottom half of this letter. Contact me with any questions or concerns.

Thank you!

Mrs. Lissa Raebel
Algebra Teacher

✂ -

- ❑ I agree to have my child's scores and answers included in the final results of the study.
- ❑ I do not agree to have my child's scores and answers included in the final results.

______________________________	______________________________
Print: Student's Name	Student's Signature
______________________________	______________________________
Print: Parent's Name	Parent's Signature

Appendix B: *Google Doc* of Modules

Chapter 5 – Writing Linear Equations

Unit Learning Targets and Assessment

[redacted]		
5.1 - I can write linear equations in slope-intercept form.	Highlight: I can do this now. I can do this with help. I can’t do this.	
5.2 - I can use linear equations in slope-intercept form.	Highlight: I can do this now. I can do this with help. I can’t do this.	
5.3 - I can write linear equations in point-slope form.	Highlight: I can do this now. I can do this with help. I can’t do this.	
5.4 - I can write linear equations in standard form.	Highlight: I can do this now. I can do this with help. I can’t do this.	
5.5 - I can write equations of parallel and perpendicular lines.	Highlight: I can do this now. I can do this with help. I can’t do this.	
5.6 - I can fit a line to data.	Highlight: I can do this now. I can do this with help. I can’t do this.	
5.7 - I can predict with linear models.	Highlight: I can do this now. I can do this with help. I can’t do this.	

Links to Each Section-

5.1 - Slope Intercept Form
5.2 - Slope-Intercept Form (Cont.)
5.3 - Point-Slope Form
5.4 - Standard Form
5.5 - Parallel and Perpendicular Lines
5.6 - Line of best fit
5.7 - Linear Models
Chapter 5 Review

Notes - Vocabulary

Define and include examples for each word below.
Also, add any other new or unfamiliar terms to the table as needed.

Point-Slope Form		
Standard Form		
Scatter Plot		
Line of Fit		
Negative Correlation		
Positive Correlation		
Relatively No Correlation		
Linear Regression		
Linear Extrapolation		
Linear Interpolation		
Zero of the Function		

5.1 - Slope Intercept Form

5.1- I can write linear equations in slope-intercept form.	Located in the Khan Academy link →	1) Khan Academy - Solving for the y-Intercept 2) TenMarks - Writing Linear Equations Using Slope-Intercept Form	CK12 *(Slope Intercept Form Practice)*

5.2 - Slope-Intercept Form (Cont.)

5.2 - I can use linear equations in slope-intercept form.	Located in the Khan Academy link →	1) Khan Academy - Slope Intercept Form 2) TenMarks - Interpret Slope and y-Intercept in Terms of Context	Mangahigh *(Draw Straight Line Graphs Using y=mx+b)* Mangahigh *(Find the Slope of a Line from Two Points)*

5.3 - Point-Slope Form

5.3 - I can write linear equations in point-slope form.	Located in the Khan Academy links →	1) Khan Academy - Point Slope Form 2) Khan Academy - Converting from Point Slope to Slope Intercept Form	CK12 *(Linear Equations in Point-Slope Form Practice)* Mangahigh *(Find the Equation of a Line Using Point and Slope)*

Assessment Stop - See Mrs. Raebel for 5.1-5.3 Quiz

5.4 - Standard Form

5.4 - I can write linear equations in standard form.	Located in the Khan Academy links →	1) Khan Academy - Converting Between Slope Intercept and Standard Form 2) Khan Academy - Linear Equation Word Problems	CK12 *(Standard Form of Linear Equations Practice)* Mangahigh *(Draw Straight Lines using Alternative Linear Formats)*

5.5 - Parallel and Perpendicular Lines

5.5 - I can write equations of parallel and perpendicular lines.	Located in the Khan Academy link →	1) TenMarks - Identifying Linear Equations 2) Khan Academy - Equations of Parallel and Perpendicular Lines	CK12 *(Comparing Equations of Parallel and Perpendicular Lines Practice)*

5.6 - Line of Best Fit

5.6 - I can fit a line to data.	Located in the Khan Academy link →	1) TenMarks- Line of Best Fit 2) Khan Academy - Estimating Line of Best Fit	Mangahigh *(Lines of Best Fit)*

5.7 - Linear Models

5.7 - I can predict with linear models.	Located in the Khan Academy link →	1) Khan Academy - Linear Models and Bivariate Data 2) TenMarks - Scatter Plots and Line of Best Fit	CK12 *(Applications Using Linear Models Practice)*

Assessment Stop - See Mrs. Raebel for 5.4-5.7 Quiz

Chapter 5 Review

5.1-5.7 Targets	Review any Khan Academy links or “Extras” above.	1) TenMarks - Identifying Equations and Inequalities that Represent a Context	Mangahigh *(Match Together Equations and Lines)*

Assessment Stop - See Mrs. Raebel for Chapter 5 Test

Appendix C: Pre-test

Name: ____ Hour: ________

Algebra Chapter 5 Pre-test: Writing Linear Equations

In 1 and 2, write an equation of the line in <u>slope-intercept form</u> that has the given slope and y-intercept.

1. The slope is –2; the *y*-intercept is 0. 1.____________________

2. The slope is $\frac{3}{4}$; the *y*-intercept is –1. 2.____________________

In 3 and 4, write an equation in <u>slope-intercept form</u> of the line that passes through the given point and has the given slope, *m*.

3. $(-1, 0)$, $m = 2$ 3.____________________

4. $(3, -1)$, $m = \frac{2}{3}$ 4.____________________

In 5 and 6, write an equation in <u>point-slope form</u> of the line that passes through the given points.

5. $(-2, -1)$, $(2, -6)$ 5.____________________

6. $(2, 2)$, $(3, 5)$ 6.____________________

In 7 and 8, write an equation in <u>standard form</u> of the line that passes through the given point and has the given slope, *m*.

7. $(-4, 3)$, $m = \frac{1}{2}$ 7.____________________

8. $(2, -3)$, $m = -4$ 8.____________________

9. **Write an equation of a line that is perpendicular to $2x + 7y = 14$ and passes through $(-4, -1)$.**

9.___________________

10. **Write an equation of a line that is parallel to $y = \frac{1}{2}x - 1$ and passes through $(4, 7)$.**

10.__________________

In 11 and 12, use the following information:

For a school band fundraiser, students are selling seat cushions for $4 each and licenses plate holders for $6 each. One student raises $304.

11. Write an equation in **standard form** of the line that models the possible combinations of seat cushions and license plate holders the student sold.

11.__________________

12. List two of these possible combinations.

12.___________________

____

In 13 and 14, use the following information:

A delivery service charges a base price for an overnight delivery of a package plus an extra charge for each pound the package weighs. A customer is billed $22.85 for shipping a 3-pound package and $40 for shipping a 10-pound package.

13. Write an equation that gives the total cost of shipping a package as a function of the weight of the package.

13.___________________

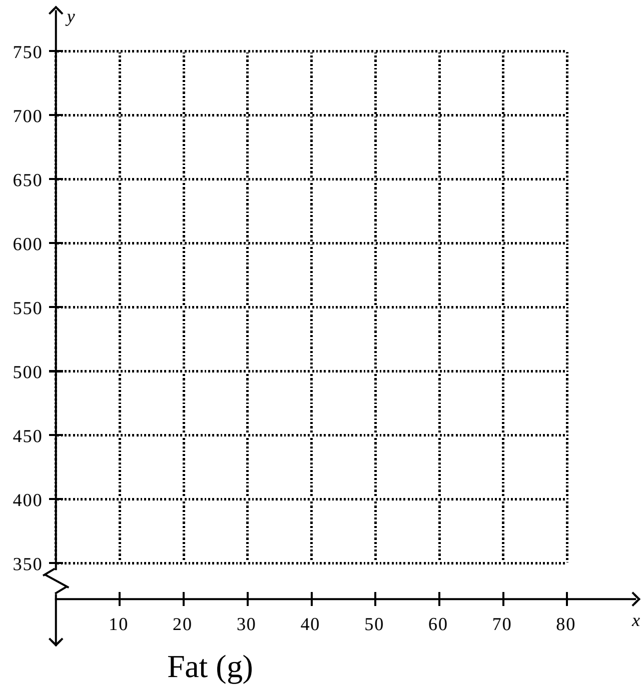
14. Find the cost of shipping a 15-pound package.

14.___________________

In 15-18, use the table that shows the number of calories in grams of fat.

Fat (g)	31	39	19	34	43	39	35
Calories	580	680	410	590	660	640	570

15. Make a scatter plot of the data.



16. Describe the correlation. 16.____________________

____

17. **<u>Draw</u> a best fit line for the data.**

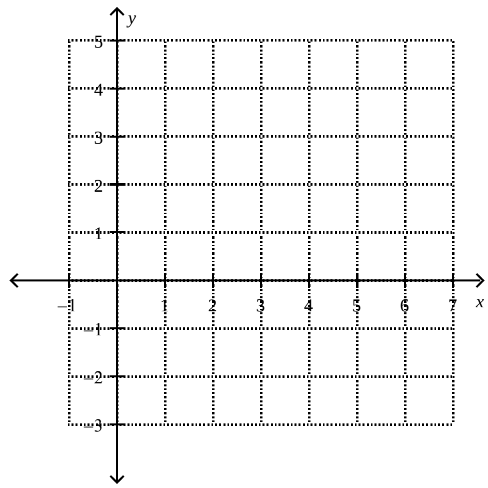
18. Use the line of fit from Question 17 to predict the number of calories in a hamburger that contains 28 grams of fat. 18.____________________

Find the zero of the function.

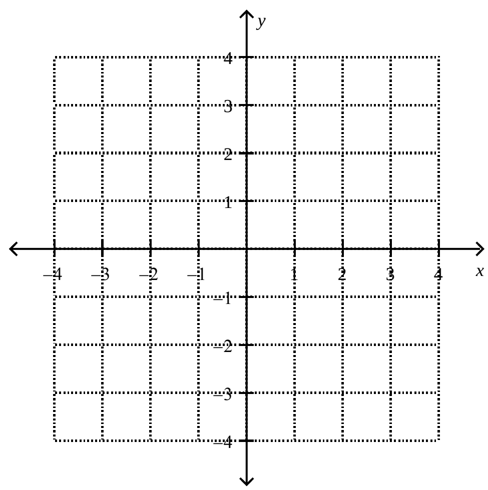
19. $f(x) = \frac{1}{2}x - 1$ 19.____________________

In 20 and 21, graph each equation.

20. $y - 1 = 2(x - 4)$



21. $y + 2 = -(x - 1)$



Appendix D: Post-test

Name: ____ Hour: ________

Algebra Chapter 5 Post-test: Writing Linear Equations

In 1 and 2, write an equation of the line in slope-intercept form that has the given slope and y-intercept.

1. The slope is –9; the *y*-intercept is 0. 1.____________________

2. The slope is $\frac{2}{5}$; the *y*-intercept is –2. 2.____________________

In 3 and 4, write an equation in slope-intercept form of the line that passes through the given point and has the given slope, *m*.

3. (–2, 0), $m = 6$ 3.____________________

4. (–3, 9), $m = 9$ 4.____________________

In 5 and 6, write an equation in point-slope form of the line that passes through the given points.

5. (–7, –4), (–5, 3) 5.____________________

6. (1, 8), (5, –4) 6.____________________

In 7 and 8, write an equation in standard form of the line that passes through the given point and has the given slope, *m*.

7. (–8, 3), $m = \frac{3}{4}$ 7.____________________

8. (2, –3), $m = –5$ 8.____________________

9. **Write an equation of a line that is <u>perpendicular</u> to** $3x + 8y = 20$ **and passes through (**–3, –10).

9.___________________

10. **Write an equation of a line that is <u>parallel</u> to** $y = \frac{1}{4}x - 5$ **and passes through** (4, –7).

10._______________

In 11 and 12, use the following information:

For a school band fundraiser, students are selling seat cushions for $3 each and licenses plate holders for $8 each. One student raises $204.

11. Write an equation in **<u>standard form</u>** of the line that models the possible combinations of seat cushions and license plate holders the student sold.

11.__________________

12. List two of these possible combinations.

12.___________________

____

In 13 and 14, use the following information:

A delivery service charges a base price for an overnight delivery of a package plus an extra charge for each pound the package weighs. A customer is billed $16.75 for shipping a 3-pound package and $29 for shipping a 10-pound package.

13. Write an equation that gives the total cost of shipping a package as a function of the weight of the package.

13.___________________

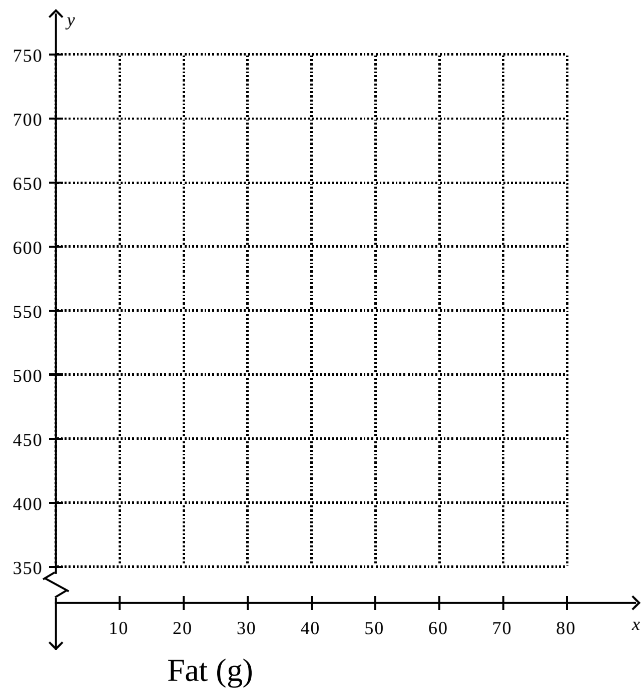
14. Find the cost of shipping a 15-pound package.

14.___________________

In 15-18, use the table that shows the number of calories in grams of fat.

Fat (g)	**30**	**37**	**19**	**32**	**45**	**41**	**37**
Calories	**590**	**680**	**430**	**610**	**680**	**630**	**550**

15. Make a scatter plot of the data.



16. Describe the correlation. 16.____________________

____

17. **<u>Draw</u> a best fit line for the data.**

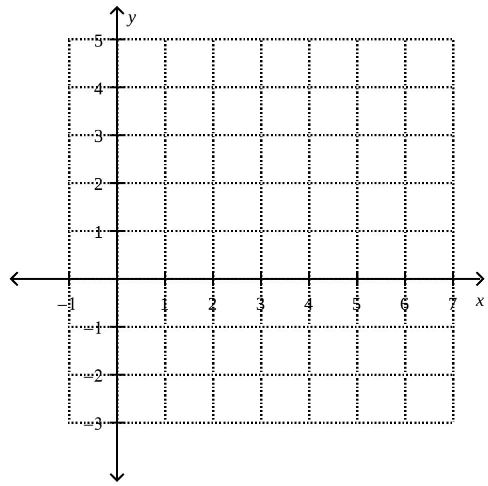
18. Use the line of fit from Question 17 to predict the number of calories in a hamburger that contains 28 grams of fat. 18.____________________

Find the zero of the function.

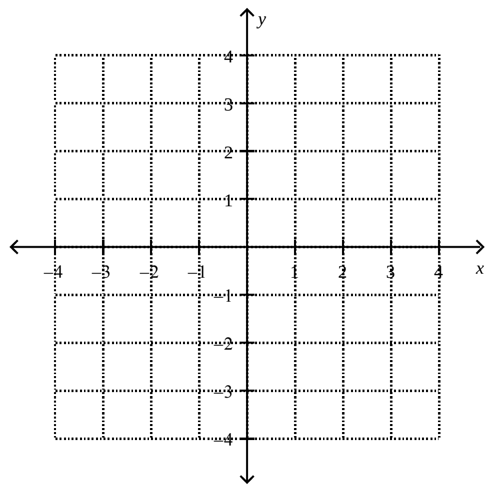
19. $f(x) = \frac{1}{2}x - 4$ 19.____________________

In 20 and 21, graph each equation.

20. $y - 1 = 3(x - 3)$



21. $y - 2 = -(x + 1)$



Appendix E: Pre- and Post-Survey

Name: ____

Directions: Place an "x" in the box that best supports your opinion.

Statement	**5-strongly agree**	**4-agree**	**3-neutral**	**2-disagree**	**1-strongly disagree**
1. I think mathematics is important in my life.					
2. I feel confident in my abilities to solve mathematics problems.					
3. In the past, I have not enjoyed math class.					
4. I enjoy this mathematics course.					
5. My math teacher listens carefully to what I have to say.					
6. I enjoy mathematics problem solving.					
7. I like to do math on the computer.					
8. I enjoy using a computer when learning math.					
9. Technology can make mathematics easier to understand.					
10. I am not comfortable using technology in math class.					
11. I know I can do well in math.					
12. I think I can handle more difficult math.					
13. Computer-based math tasks are clear and easy to read.					
14. I like to receive immediate scores on my math practice from the computer.					
15. Immediate scores help me to be aware of my performance.					
16. I like the help and suggestions on my math homework from the computer.					
17. Computer-based math homework gives me more chance to practice.					
18. Computer-based math instruction helps me to review mathematics concepts.					
19. I like using a computer and other technology devices.					
20. I enjoy lessons on the computer.					
21. I believe that the more teachers use computers, the more I will enjoy school.					
22. I have a lot of confidence when it comes to working with computers.					
23. Lessons in a large group help me learn better.					
24. I enjoy doing things on a computer.					
25. I like teacher-led lessons most.					

Appendix F: Pre- and Post-Survey Key

Attitude toward: Mathematics learning.
General computer use.
Teacher-led instruction.
Technology use in the classroom.
Technology-driven mathematics instruction.

Statement	**5-strongly agree**	**4-agree**	**3-neutral**	**2-disagree**	**1-strongly disagree**
1. I think mathematics is important in my life.	5	4	3	2	1
2. I feel confident in my abilities to solve mathematics problems.	1	2	3	4	5
3. In the past, I have not enjoyed math class.	1	2	3	4	5
4. I enjoy this mathematics course.	5	4	3	2	1
5. My math teacher listens carefully to what I have to say.	5	4	3	2	1
6. I enjoy mathematics problem solving.	5	4	3	2	1
7. I like to do math on the computer.	5	4	3	2	1
8. I enjoy using a computer when learning math.	5	4	3	2	1
9. Technology can make mathematics easier to understand.	5	4	3	2	1
10. I am not comfortable using technology in math class.	1	2	3	4	5
11. I know I can do well in math.	5	4	3	2	1
12. I think I can handle more difficult math.	5	4	3	2	1
13. Computer-based math tasks are clear and easy to read.	5	4	3	2	1
14. I like to receive immediate scores on my math practice from the computer.	5	4	3	2	1
15. Immediate scores help me to be aware of my performance.	5	4	3	2	1
16. I like the help and suggestions on my math homework from the computer.	5	4	3	2	1
17. Computer-based math homework gives me more chance to practice.	5	4	3	2	1
18. Computer-based math instruction helps me to review mathematics concepts.	5	4	3	2	1
19. I like using a computer and other technology devices.	5	4	3	2	1
20. I enjoy lessons on the computer.	5	4	3	2	1
21. I believe that the more teachers use computers, the more I will enjoy school.	5	4	3	2	1
22. I have a lot of confidence when it comes to working with computers.	5	4	3	2	1
23. Lessons in a large group help me learn better.	5	4	3	2	1
24. I enjoy doing things on a computer.	5	4	3	2	1
25. I like teacher-led lessons most.	5	4	3	2	1