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Comparing middle school students' learning and attitudes in face-to-face and online mathematics lessons

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COMPARING MIDDLE SCHOOL STUDENTS' LEARNING AND ATTITUDES IN FACE-TO-FACE AND ONLINE MATHEMATICS LESSONS

An Abstract of a Dissertation

Submitted

in Partial Fulfillment

of the Requirements for the Degree

Doctor of Education

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ABSTRACT

Online learning has become a staple within education for college students, and has started to enter high schools. While this instructional delivery system has been shown to work for older students, few studies have involved middle school students. If this trend toward online teaching of younger students continues, online learning could become a large part of education for middle school students, making research in this area important.

Multiple positive and negative aspects have been identified for online learning. Positive characteristics include individualized pacing, electronic resources, and the opportunity for rapid or personalized feedback, while negative aspects address increased student responsibility and technological ability. Online communication may be viewed as an asset and detriment, depending upon the emotional needs of middle school students that differ from the older online student.

This study examined sixth grade students' academic performance in face-to-face and online mathematics units. Research participants included 46 sixth grade students attending a rural middle school in a Midwestern state. The counterbalanced, repeated measures study compared pretest and posttest scores on unit tests addressing mathematical content learned under two instructional conditions. Students alternated between online and face-to-face units, completing ten units during the school year. No statistically significant differences in overall student performance between the two conditions were found. A Two One-Sided T-Test indicated that student performance in the online and face-to-face learning in this study could be called equivalent.

Students also responded to surveys in which they rated perceived learning and enjoyment of the learning condition. No significant difference in perceived learning between the conditions was found. Student-reported enjoyment was significantly higher for online learning, but that enthusiasm decreased a small but significant amount during the year, probably because of loss of novelty. Student responses concerning their reasons for preferences for instructional condition paralleled characteristics reported in the professional literature.

This investigation demonstrated the equivalency of both conditions; however, additional studies with a greater number and diversity of students are warranted. Future research studies will need to determine if a blend of both instructional approaches is optimal.

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CHAPTER 1

INTRODUCTION

Delivery methods within education are always evolving, but depending on the year an individual receives instruction, the method experienced varies. For most adults, the school experience is remembered with a teacher, front and center, in a four-walled classroom passing on knowledge to the student through a lecture format that may or may not have included visuals, manipulatives, or an occasional discussion. The probability of a technology-rich lesson was small. The Internet as we think about it today was not implemented until the late 1970s (Strickland, 2008), and the World Wide Web did not make an appearance until 1992 (Harasim, 2000). Without these two inventions, student learning was often synchronous, text-dependent, teacher-directed, and limited to the visuals and information contained in the classroom.

Those individuals who found themselves beyond the high school level after 1996 were able to break out of the four walls and experience online learning (Harasim, 2000). The increased availability of online learning provided new opportunities for specific types of learners, such as distance and non-traditional students (Huang, 1996). The content being taught was nearly the same, but the convenience of accessing this information increased (Ramaswami, 2009). Online learning was mostly restricted to colleges in its early stages (Harasim, 2000). Although online learning may be convenient and expedient, does this format of instruction nurture student academic achievement when compared to traditional educational methods?

Researcher's Personal Interest in the Topic

Having completed seven years of teaching middle school mathematics, I have provided and have been a part of many educational experiences that have shaped my views and opinions in the field. During my teacher-preparation years, I attended two out of the three public universities in the state of Iowa. Part of my undergraduate degree, as well as my complete Master's Degree in Middle School Mathematics, was completed at the University of Northern Iowa. Iowa State University also served as a learning opportunity where I received my undergraduate degree in Elementary Education with an emphasis in mathematics.

As a student, I have always enjoyed mathematics because of the multiple ways of approaching problems and the fact that I was able to understand this subject when so many other classmates and family members did not. Mathematics is challenging. I chose to become a mathematics teacher because I wanted to assist others in learning mathematics in a meaningful way.

When I was a middle school student, many resources were present to aid in mathematical understanding. These items included improved textbooks with digital resources for support, overhead projectors with transparencies on which teachers could write and use translucent manipulatives, and the use of computer technology through simplistic games that addressed individual skills, like finding multiples and solving computation problems. Some of these innovations helped students more than others, but no matter the level of support, they currently have been replaced with new or updated devices.

One of the updates to education was online learning. Growing up in the era that I did, I have been immersed in the beginnings of online learning. I have taken many online classes throughout my post-secondary education years, and, for the most part, have been successful. However, all of these experiences have occurred in college, and not in my teaching-interest area of middle school. My goal as a middle school mathematics teacher is simple. I want to help students understand mathematics as best they can by using the most effective methods. If I have to get up in front of the class and do a mathematical dance to enable students to understand, I will. That being said, not every method of teaching mathematics works to the same degree and some students learn better using one method as opposed to another. Wanting what is best for my students, I am interested in knowing whether online learning is appropriate and effective for teaching mathematics to middle school students.

Today's Generation Z middle school students, as described by Dillon (2007), are generally known for their technology skills and experience, and not their analog reading abilities or for patience towards listening to a lecture when other materials like video learning and content driven games are at their fingertips. Generation Z is a group of individuals born post 2000 who have grown up with televisions, computers, cell phones, and everything digital (Dillon, 2007). Generation Z is arguably the most influential party in creating a need for online learning. All the traits of my Generation Z middle school students point to online learning in my mathematics classroom being a success, but will academic results follow?

Statement of the Problem

A majority of colleges have moved toward online classes, with many offering exclusively online degree programs (Bejerano, 2008; Harasim, 2000; Lorenzetti, 2008). High schools now regularly feature online opportunities for advanced subjects or language coursework with online-specific high schools becoming more commonplace (Young, Birtolo, & McElman, 2009). The state of Michigan even mandates that students experience a virtual learning course as part of a high school graduation requirement (DiPietro, Ferdig, Black, & Preston, 2010). These actions paint a clear picture of what is to come within education (Starkman, 2007). With this push towards online activity, where does this leave middle school students?

Noted later in this dissertation, research studies have illuminated the differences between online and traditional learning experiences. However, most of these studies investigated college and high school learners, not middle school students. Experimental studies are needed to determine if the successes of online learning can be effectively transferred to middle school students and if prior technological familiarity plays a part in a student's success. This research has the potential to impact many educational stakeholders including teachers, students, parents, administrators, and school districts, as well as the business community as employers and manufacturers of texts, hardware, and software (Huang, 1996).

The purpose of the research investigation is to provide empirical evidence of online instruction for middle school students learning mathematical concepts. Student academic achievement from pretest to posttest on several different mathematical topics taught online or face-to-face will be compared. The role of computer proficiency as measured by home computer use will be examined to determine its effect on online learning of mathematics. Student perceptions of mathematical understandings and attitudes toward the face-to-face or online environment will also be considered in this study.

Research Questions

This study will examine the following research questions:

1. How does students' academic achievement compare between face-to-face and online mathematics classes for middle school sixth graders?
2. How does students' perceived understanding compare between face-to-face and online mathematics classes for middle school sixth graders?
3. How does students' enjoyment of learning compare between face-to-face and online mathematics classes for middle school sixth graders?
4. Do students with more technology experience (as measured by home computer use) differ in their achievements in an online learning environment?
5. What factors do students report for preference of online or face-to-face learning of mathematics?

Limitations

While this study describes some benefits and shortcomings of online learning for middle school students, limiting factors of this research are present. First, this study addresses only two classes of students and takes place in a rural Iowa school district with middle to upper middle class Caucasian participants. Therefore, the study results may not be generalizable to all middle school groups such as diverse urban or socio-economic populations.

Another limitation of the study is the amount of technology resources needed to accomplish online learning. The school district in this study provided a laptop computer for every student. The district's network is wired for maximum efficiency and speed. The procedures employed in this study may not be replicable in a school district with very few computers or a slow connection speed.

Even though the researcher who conducted this study acted professionally and put every effort into teaching both conditions well, he did have an expectation that the online lessons would be successful. He had previously used technology in his classroom and found it a useful tool in education. He had also participated in numerous online classes with success. He had not, however, conducted his classroom in a completely online manner previous to the implementation of this study and so did not know whether this method would be viable with middle school students. The researcher's ultimate goal was to ensure that all students learn mathematics well, regardless of whether the teaching is face-to-face or online. He therefore made every effort under both conditions to ensure that students learned the information well.

Relevant Terms Defined

1. Asynchronous. (n.d.). Learning in which there is no timing requirement.

2. Counterbalanced. (n.d.). Research that uses a force or influence that offsets or checks an opposing force. In the counterbalanced design, each participant is tested under each condition. The subjects are divided into two groups and one is tested with condition

A and then condition B, while the other group is tested with condition B, then condition A, and so forth. In this way, student performance of the same subjects can be compared between conditions, and performance under the same condition can be compared between subjects.

3. Face-to-face learning. (n.d.). Students attending class in the same room within sight of each other and interacting through direct contact.

4. Internet. (n.d.). The Internet is an electronic communications network that connects computer networks and organizational computer facilities around the world.

5. Online Learning (e-learning). (Cohen & Nycz, 2006, p. 24). The delivery of education (all activities relevant to instructing, teaching, and learning) through various electronic media. The electronic medium could be the Internet, intranets, extranets, satellite TV, video/audio tape, and/or CD ROM.

6. Repeated Measures. (n.d.). A research design where the same experimental unit is subjected to the different treatments under consideration at different points in time.

7. Synchronous. (n.d.). Student learning within the classroom is happening, existing, or arising at precisely the same time.

Now that study-related terms have been defined, the next chapter focuses on the literature related to the topic. The literature review features studies comparing online learning and traditional experiences throughout high school and college. Other areas of focus include student attitudes and proficiencies towards technology, advantages and disadvantages of online learning, and the impact of middle school students' social relationships on learning.

Chapter 3 offers a discussion of the design of the study. Chapter 4 presents the collected data of the study, while Chapter 5 provides analysis and interpretation of the results of the research.

CHAPTER 2

LITERATURE REVIEW

The following review of the professional literature will assist in answering the research questions concerning student achievement, technological attitudes, and technological proficiency in comparison to the two delivery styles. The first part of the literature review will examine the results of recent studies comparing online to face-to-face learning, first at the college, next at the high school level, and finally the small pool of available research studies for the middle grades. This is followed by a consideration of the impact student attitudes and skills related to technology have on online learning. Next, the advantages and disadvantages of online learning are documented in the literature. Finally, middle school student relationships will be examined.

Collegiate Comparisons of Online and Face-to-Face Learning

Face-to-Face Advantage

The first study that shows an advantage in learning to the face-to-face condition was done by Carbanaro, Dawber, and Arav (2006) at a Canadian community college. This research investigation examined the nursing program and its mandatory microbiology course. While prospective nurses were expected to complete a specific course to enable them to be accredited, the way they took the course was optional. Carbanaro et al. (2006) indicated that the number of traditional students in this study totaled 245, and included both full time and part time students. Attending the course at a distance, 54 students participated in the online side of the experiment. Although instructors differed among the groups, all of the materials and information provided by the instructors were the same, leaving the focus on the two paper and pencil multiple-choice assessments and a final test to determine whether there were any academic differences between the online group and the traditional group. Students scored equally well on the second assessment, but the first and third assessments showed a statistical advantage for the traditional, face-to-face condition by way of ANOVA (Carbanaro et al., 2006).

The researcher of another investigation (Kirtman, 2009) decided to use already completed courses in an attempt to remove as much bias as possible. The study also assigned the same instructor for every class, and the same evaluator of essays and tests to further the reliability. In this study focused on students pursuing their Masters in Science Education, six classroom sections were analyzed. Kirtman (2009) indicated that out of the six classes, three were face-to-face with 71 participants, and three were online containing 69 participants. All classes used the same curriculum and materials throughout, and assessed the following: a 25 point mini-literature review, a 50 point literature review, a 40 point midterm test, and a cumulative 50 point final test (Kirtman, 2009). The results showed that students in traditional classroom settings scored higher in all four assessment pieces. Although the outcomes favored face-to-face learning, the highest mean difference between any of the scores was less than two points. This indicates that there was little difference between methods, and the results as assessed by a t-test were not significant (Kirtman, 2009).

Online Advantage

Researchers (Lim, Kim, Chen, & Ryder, 2008) in another study investigated a health and wellness course offered as an online or face-to-face class at a university located in the middle of the United States. A total of 153 undergraduates participated in this research. The Lim et al. study (2008) controlled variables by making materials and curriculum of the course as similar as possible in both online and face-to-face formats. The instructors for each of the class types were also the same. To see which mode of instruction produced the best academic results, the researchers compared pretest and posttest scores. The improvement for the face-to-face group was 11.4% while the improvement of the online section was 17.3%. Results were significant as indicated by analysis of variance (ANOVA; Lim et al., 2008).

A broader study (Schulman & Sims, 1999) examined student performance in five classes: Organization Behavior, Personal Finance, Managerial Accounting, Sociological Foundations of Education, and Environmental Studies, and featured 40 undergraduate online students and 59 undergraduate traditional students. Pretests and posttests in the research done by Schulman and Simms (1999) were administered for each of the five courses to gauge how much knowledge was attained from the beginning of the class to the conclusion. Each test was worth 100 points. The results of the posttest and follow-up t-test showed that average scores did not vary enough to be a significant discovery. However, the online group's pretest scores started out on an average of thirteen points lower than the traditional group meaning that they started at a disadvantage and achieved similar results to the traditional group (Schulman & Sims, 1999).

Another comparison of online versus traditional learning at the college level examined a class designed to help prospective teachers aid their future students in the communication of the English language as part of an English as a Second Language Endorsement (Thirunarayanan & Perez-Prado, 2001). The class was taught in face-to-face sessions, or completely over the computer. Thirunarayanan and Perez-Prado (2001) stated that the participants in each group numbered approximately 30. The same instructor taught both sections of the class. Students were also unaware of which section they were signing up for, as the decision for an online course by students was made after registration. Much like the outcome of the Schulman and Simms project (1999), the results of student achievement on a final test, compared to a pretest (both taken though the online course management software WebCT), showed no difference between the teaching methods, but the online students started lower, thus closing the gap while facing a significantly larger deficit (Thirunarayanan & Perez-Prado, 2001).

In another example, a study examined student achievement in a 16-week business statistics course at Thailand's Suan Dusit Rajabhat University (Suanpang & Petocz, 2006). Information on course grades was taken from both online and traditional participants in this class of 269 participants. Final grades were determined through a combination of a midterm, a final exam, homework, and participation. The online group outscored the face-to-face group in this particular business statistics class with statistically significant results as indicated by a t-test (Suanpang & Petocz, 2006).

No Advantage

In a study (Neuhauser, 2002) at a small Michigan university, an undergraduate business principles course was used as a comparison piece between face-to-face and online conditions. The face-to face group contained 25 students, while 37 participated as online learners. Neuhauser's (2002) data focused on two major course grades: the final test and the final overall grade. The final test showed student averages of the two groups as not being significantly different. Online learners held a slight advantage over their counterparts with percentages of 88.1% versus 86.2% respectively. Final grade point average comparisons were also not significantly different, with online receiving a 3.5 compared to traditional at 3.35. Again, while not statistically significant, both of these results show that online learning can compete with traditional methods in achievement within education (Neuhauser, 2002).

Another study (Ryan, 2002) taking place at an Ohio community college had results similar to the findings of the Neuhauser (2002) example. In the 1999-2000 school year, students took an introduction to statistics course via online or through traditional methods. When final course grades were compared, once again, there was no significant statistical difference between the two delivery methods (Ryan, 2002).

The research discussed to this point has indicated that two distinctly different classroom setups can both yield acceptable and comparable results. In almost every case discussed above, the online class produced similar, if not better results than the traditional class (Carbanaro et al., 2006; Kirtman, 2009; Lim et al., 2008; Neuhauser, 2002; Ryan, 2002; Schulman & Sims, 1999; Suanpang & Petocz, 2006; Thirunarayanan & Perez-

Prado, 2001). While the results do not prove the superiority of online classes, they do state that they are on par with what has been done traditionally, making them a valid form of education.

To echo these remarks on the comparative nature of online and traditional experiences, Sunal, Sunal, Odell, and Sundberg (2003) conducted a major research study comparing online learning and traditional learning at colleges across the United States and Canada. They examined 10 different studies of online learning compared to traditional learning. In all cases, academic results were indistinguishable when similar online and face-to-face classes were compared. The authors concluded that it was difficult to generate a conclusion of which method is better, but did acknowledge that online learning was a viable way to conduct a class. Sunal et al. (2003) also noted that the deciding factor for success for any college level instruction was the course setup and pedagogical decisions being made rather than the online or traditional format.

High School Research

While online learning started out primarily in higher education, a significant trickledown effect over the past decade to high school has occurred (Barbour & Reeves, 2009). The movement originated in Canada primarily because of the great distances between rural areas. Barbour and Reeves (2009) indicated that students had such unusually long commutes to travel for an education that this method made sense. Since its inception in the late 1990s, online educational expansion has been a priority for Canada. From 2001 to 2005, the Newfoundland virtual high school enrollments jumped from 200 students to 1500 students. Alberta garnered around 7000 online students, while

Northern Ontario touted a 2001 population of more than 11,000 students. Many other Canadian areas have seen a boost in online learning as well (Barbour & Reeves, 2009).

The late 1990s also saw the birth of virtual high schools in the United States. Florida housed the first two digital schools in the United States (Young et al., 2009). In just five short years, close to 50,000 students in over thirty states took part in virtual schooling. As of 2006, that number had almost tripled to 139,000. More than 10 other countries also use the virtual schools housed in the United States to educate their students (Young et al., 2009).

One might assume that high school and college online classes are similar, but it is hard to be sure without proven research featuring high school students. Unfortunately, most studies compare face-to-face and online learning occurs in the college setting. In one qualitative study (Corey & Bower, 2005), the researchers examined a class of high school students and their experiences with Algebra One. Unlike the previously mentioned college studies, the students split their time between an online environment and a traditional setting. Corey and Bower's (2005) main focus was on one particular male student who generally performed below average in mathematics. This individual indicated that based on his experiences he perceived that he did much better with the online version because of the ability to work at his own pace, because of the practice afforded by the different online math programs available to him, and because of the online message boards where he could communicate with other students with similar questions (Corey & Bower, 2005). To make conclusions, the authors used a variety of qualitative techniques such as classroom observations, online observations, interviews, and questionnaires incorporating both field notes and videotapes. While Corey and Bower's (2005) study did not divulge specific grades or other forms of quantitative data, the researchers concluded that students felt more confident and comfortable with their online surroundings, cultivating higher achievement levels.

Middle School Students Learning Online

Even though a small number of studies have been conducted with middle school mathematics students to analyze the comparisons of online and face-to-face classrooms, most have addressed semi-online environments and not full immersion. These studies do not encompass the full online experience that this dissertation will show, but it is a glimpse of what research is available for middle school students related to online learning. Web-Based Learning Tools (WBLT) are similar to an online environment in a few categories. Students finish work online through participating in tutorials and answering questions. Students are assessed by the program, and advanced or taken back to previous instruction until their understanding is at an acceptable level (Kay, 2011). In a study by Kay (2011), students who used this type of environment in a mathematics and science classroom were given questions that were sorted by the Bloom's Taxonomy hierarchy. A pretest was given to provide initial data. After the posttest was assessed, students using the WBLT made significant strides in each of Bloom's levels except analysis. At the very least, this study shows that middle school students can make learning improvements by participating in a form of online instruction.

In a similar study, Nguyen and Kulm (2005) looked at the differences in online mathematics practice problems versus paper-and-pencil work related to fraction and decimal concepts of 95 randomly assigned middle school students. While the initial pretest showed no significant difference between the groups, the posttest showed a sizable gain score advantage for the online group significant at the $p<0.01$ level, which was credited to multiple practice questions and immediate adapted feedback. While this example does not address standard online learning, it shows that an online alternative can produce favorable results.

A final example of a middle school using online learning for mathematics took place in Arizona, and featured approximately 900 students (Gulley, 2009). This study randomly assigned students in the school to one of two mathematics learning methods: the traditional classroom, or the Computer-Based Education (CBE) experience. CBE uses a variety of videos and online practice opportunities to allow students to work independently and at their own paces. Both groups were required to take the Arizona Instrument to Measure Standards (AIMS). Results of both groups were very similar, with no significant difference between the traditional classroom and the CBE classroom.

Technology Attitudes and Skills

Another aspect of the current research is the investigation of a possible connection between a student's experiences with technology, both attitudinal and skills-wise, and academic performance. While little research is available for middle school students in an online environment, an even smaller number of research studies have been conducted in relation to student attitudes towards online learning (Hughes, Mcleod, Brown, Maeda, & Choi, 2007). Adults often have a hard time adapting to online learning environments because of a lack of experience with technology as well as their overall feelings towards technology (Huang, 1996; Miller & Lu, 2002). A non-traditional learner may struggle with achievement in an online environment (Carbanaro et al., 2006). Middle school students tend to be thought of as superior technology users (Harris, 2009). Will a middle school student's perceived comfort with technology be overly beneficial in an educational setting, or will that prior knowledge of technology end up not being a factor?

In a previously discussed study that compared traditional and online achievement, Carbanaro et al. (2006) noted that the online group of participants in this research was split into a younger student (25 or younger) category and an older student (26 and above) category. Non-traditional learners often avoid online classes because they are not as comfortable with the technology, thus do not perform as well (Miller & Lu, 2002). This study supported this finding because the final overall scores for the younger online group were a few percentage points higher than for the older online group (Carbanaro et al., 2006).

Another age comparison of the study authored by Carbanaro et al. (2006) focused on only younger students, comparing online and traditional settings. In two out of the three assessments, the younger online students performed better than the younger traditional students indicating the possible advantage of online learning for those who feel comfortable with technology.

While technology seems to be a strength of younger students (Harris, 2009), a study done by Rule, Barrera, and Dockstader (2002) showed that sixth graders in a typical classroom may vary greatly in technological ability. The researchers gave a pretest addressing certain technology skills including Internet usage, word processing skills, and overall file management. The mean score for one of the classes was 18.5 percent while the mean of the other class was 4.1 percent. These numbers not only show a great difference between technology skills amongst peers, but also show that neither group started out with the core knowledge that most individuals assume from students of this age (Rule et al., 2002).

The notion that technology alone can improve learning has also been shown to be faulty through past research. In a study by Wang and O'Dwyer (2011), the amount of technology was studied in comparison to the Trends in International Math and Science Study (TIMSS) throughout nine countries. The amount of technology various schools used did not have an effect of scores on this test. Therefore, it is possible that online learning, which is delivered through technology, may not produce equal or greater student performance even though Generation Z students are familiar with it.

A survey of 645 college students split up between two universities in Taiwan (Sun, Tsai, Finger, Chen, & Yeh, 2008) addressed student feelings or attitudes toward different aspects of online learning. One of the major roadblocks seen by the 295 respondents to online learning success was lack of skills and anxiety towards computers, which the Sun et al. (2008) consider as an example of technology anxiety. These results are particularly interesting because the sample consisted of both traditional and non-traditional students. Using a stepwise regression, the study found that computer anxiety did have a negative effect on eLearning satisfaction. Even digital learners who are considered proficient with technology can express negative attitudes that impede their academic success (Sun et al., 2008).

In a research endeavor, Barkatsas, Kasimatis, and Gialamas (2009) investigated connections between technology attitudes and proficiencies with student achievement of over 1000 upper middle school/lower high school aged students in urban Athens, Greece. While this study did not specifically address online learning, different applications of technology were used on a daily basis. Students were surveyed about their thoughts and feelings towards technology. Using a cluster analysis, the final classroom grading results in the Barkatsas et al. (2009) study showed that the students who received A's indicated a very high penchant for technology. Students earning F's tended to have very negative attitudes towards technology as indicated by the survey. Students given a B, C, or D grade had mixed ranges on the technology survey. While previous student performance was a key predictor in this experiment, the results did indicate a strong correlation between technology comfort or attitude, and academic success (Barkatsas et al., 2009).

To further examine the idea of individual students' attitudes and proficiency levels when using technology, Blocher, Sujo de Montes, Willis, and Tucker (2002) suggested that technology is not fair to everyone involved no matter the age bracket or gender. Unlike an instructor who presumably will treat his or her students fairly, technology rewards the proficient, and frustrates the inexperienced. Using an online classroom format can cause even the most academically capable student to falter, making previous experience with technology paramount to success within the class (Blocher et al., 2002).

Published research also suggests a more general viewpoint that whether students are using technology or not, having a positive attitude toward technology can impact learning in the classroom, as well as performance on standardized assessments (Esposito, 1999; Garrison, 2004). This information can be used to make an assumption that students who have negative dispositions towards school in general or toward technology will not perform as well academically. Negativity towards technology may possibly connect directly with a lack of skills. In any case, a positive student is quite often a successful student (Plucker, 1998).

As a final component of a review of the research associated with attitudes and technology, the work of Lim et al. (2008) is discussed. They instituted a satisfaction survey to 153 undergraduates, which was previously discussed in this dissertation. The query was based on a five-point scale. The results indicated that the overall satisfaction level for the online learning was 3.9 while face-to-face was only 3.3. This indicates an online format could produce a higher satisfactory level when compared to a traditional environment (Lim et al., 2008).

The research presented on attitudes and performance toward technology shows that negative feelings towards online learning or technology may be a hindrance to academic performance for students of any age. While student attitude and skill-level regarding technology is not the main focus in this research investigation, it could play an important role. With so many unseen variables within any given educational setting, choosing one delivery method as superior to another may be difficult. Insights into students' thoughts and feelings may illuminate subtle factors regarding which classroom style is most effective.

Advantages of Online Learning

The switch to online learning has not come about for the sake of change. There are advantages to online learning that a face-to-face classroom cannot duplicate (Sher, 2009). One of those features is the convenience (Serhan, 2010). Today's students are busy with extracurricular activities, and being part of an online community makes getting an education more manageable. In discussing the flexibility of online learning, Serhan (2010) stated that class materials do not have to be accessed only during class time, but any time an individual's schedule allows. Some classes do not have timelines, allowing students to truly work at their own paces and turn in materials as completed. This convenience factor provides opportunities for many who, in the past, would not have had a chance to participate (Serhan, 2010). These individuals do not just include nontraditional students returning to school, but also students who began work immediately after graduating from high school, or students who originally did not intend to attend college. In this way, online learning can provide many new and exciting opportunities for a wide range of people (Rodriguez, Ooms, & Montañez 2008; Serhan, 2010).

With flexibility also comes pacing (Serhan, 2010). Self-pacing is effective on two levels. First, students who often struggle to keep up in the traditional classroom can work at their own speed, and go back and relook at any material they desire to help better understand the concepts. Without the ability to work at a suitable pace, students often do not fully understand the concepts, but move on anyway further complicating future learning opportunities. Pacing can also aid the more advanced student. Instead of waiting for everyone to be in the same spot, these students can push ahead, and gain additional learning opportunities that they would not have had if they waited for their peers (Oliver, Kellogg, & Patel, 2010; Serhan, 2010).

Another advantage of online learning concerns the materials available to students (Sagheb-Tehrani, 2008). In most lecture–focused classrooms, the main resources are the instructor and text. While both of those options are still a vital part of online learning, a plethora of resources are left untapped or are unavailable. The traditional lecture can now be recorded and put in an online environment for viewing and replaying. Supplements to textbooks include online videos, interactive simulations, Internet information, and content blogs (Sagheb-Tehrani, 2008).

Communication is possible in a lecture or face-to-face style classroom, but it is only feasible if class sizes are manageable (Barcelona, 2009; Duemer et al., 2002). Unfortunately, many college classes contain hundreds of students, and even high school and middle school classes are sometimes overflowing because of budget deficits. Online learning can help alleviate this problem by dividing the class into smaller groups, and allowing them to communicate through online message boards, wikis, instant messages, and other forms of online communication as long as the setup of the communication is user friendly (Gadanidis, Graham, Mcdougall, & Roulet, 2002). Communicating in this way allows students to voice what they need to say without having to wait for the one-at-a-time turn-based system of a traditional classroom. Online communication can also be helpful to the more shy audience member who would otherwise go unheard. Online communication has been found to encourage users to curb harsh words because of the visibility of what is being written and the time for thought to occur before communicating (Barcelona, 2009; Duemer et al., 2002).

Along with communication comes the feeling of community. The real world is an experience shared by many, and quite often the classroom fails to get students to be a part of something bigger, even if they are communicating (Duemer et al., 2002; Fottland, 2002; McLellan, 1997). In most traditional classes, group work happens during random periods throughout the year, without much consistency. Online learning allows students to be key members in their online community, and share their experiences every step of the way in components such as peer feedback, the sharing of documents and ideas, and helping to answer one another's questions about the learning. Students also get a sense of familiarity with the other community members through postings of pictures and biographies about themselves (Duemer et al., 2002; Fottland, 2002; McLellan, 1997).

Cost is a significant factor in the staffing and delivery of educational programs (Nelson, 2008). Considering the current recovering economic climate, and the high expectations for student performance related to the No Child Left Behind Act (Au, 2007), online learning could be used to lower cost and keep outcomes acceptable. When an online course is presented, schools save money on building space, materials, and staff. Students may also be the beneficiaries of the savings. Two economic advantages that would affect students include less gas to get to school, and fewer books to purchase. In the current uncertain economy, who is not seeking for ways to reduce costs (Nelson, 2008)?

Prompt and more precise feedback is an additional advantage of online learning (Jewett, 1998). Instructors can personally comment at a greater speed using online learning environments as opposed to the traditional one on one communication or writing prolonged notes on handed-back assignments (Jewett, 1998). The more responsive feedback allows students to know quickly what they are doing well, and what aspects of their performance they might improve. Jewett (1998) determined that many online games, tests, and quizzes give immediate results to students so they no longer have to wait to know what they achieved.

Disadvantages of Online Learning

While there are numerous advantages to online learning, one cannot ignore the potential negative aspects as well. The first negative facet involves communication. While communication through online learning can be a positive experience, the lack of body language and facial expressions can make fully understanding a person's intentions difficult (El Mansour & Mupinga, 2007). Although interaction occurs, not being able to gauge a person's reactions through visual cues can leave a conversation generic and without much meaning. In a study conducted by El Mansour and Mupinga (2007) that attempted to identify the positives and negatives of online learning, students taking an online class voiced a concern for the lack of visual language within conversations. Concerns included lack of body language and facial expression, which led to a negative experience due to a lack of meaningful conversation. Feelings can also be ambiguous. To combat this lack of visuals during a conversation, etiquette specific to online communication is expected, but not always used. These online etiquette examples involve lower case lettering to avoid the illusion of yelling, not using shortened forms of words to prevent confusion, and understanding audience (Scheuermann & Taylor, 1997).

In continuing the discussion on the negatives of online communication, many students find the interactive nature of face-to-face communication more meaningful, especially when discussing school related topics with teachers and peers. In a study of North Carolina Virtual Public Schools, students were asked to answer questions to help determine if mathematics instruction online was seen as being different than other online subjects (Oliver et al., 2010). The mathematics participants in this study ranged from students enrolled in Algebra 1 up to Advanced Calculus. Open-response questions were used to determine students' individual attitudes toward online learning of mathematics. Of the negative results recorded, most of the responses focused on communication, specifically the lack of teacher explanations and the difficulty communicating with peers in an online setting.

From the perspective of high school students, a major negative aspect of online learning is self-discipline. Valtonen, Kukkonen, Dillon, and Väisänen (2009) conducted a study on Finnish teens about online learning, and found that within an online learning environment, students have no one to personally remind them that an assignment is due or to read a particular chapter. Students who lack the drive to learn or the organization skills to stay on top of their learning could end up falling behind. This lack of discipline could result in a lower grade or score than usual, but more importantly, students may not make the needed connections that result in learning (Song & Hill, 2007; Valtonen et al., 2009).

Another possible negative component is the technology used during online learning (Blocher et al., 2002; Cheurprakobkit, Hale, & Olson, 2002). In most other forms of instruction, something can be done if the learner needs a different form of presentation. That is not the case in online learning. The presentation style is exclusively online. If a person is comfortable with technology, then he or she can focus solely on the learning. If a student struggles with technology, the focus may be on getting the technology to work instead of the actual content material from the class (Blocher et al., 2002). Thompson and Lynch (2003) found that students who did not have acceptable access to the technology needed for the online learning experience, or lacked experience with the technology developed a loss of confidence and therefore a negative attitude toward online instruction.

Middle School Student Relationships

Middle school students are often caught between the childlike behavior of elementary school and the more mature expectations of high school (Buchanan & Bowen, 2008). Because students differ in both physical and mental development, finding something that suits everyone in a middle school classroom can be a challenge (Buchanan & Bowen, 2008). At the top of Buchanan and Bowen's (2008) list of middle school concerns are relationships. The most evident relationships within school walls are the teacher-to-student relationship and the student-to-student relationships.

Middle school is a time when some students lose intrinsic motivation towards learning, and may even lose the academic success that they had experienced in elementary school (Buchanan & Bowen, 2008). While the relationship between teacher and student is usually very strong throughout elementary school, this relationship tends to deteriorate once the next level of schooling begins (Anderson, Christenson, Sinclair, & Lehr, 2004). This is particularly unfortunate because research states that a middle school teacher who can successfully foster a positive relationship with a middle school student can drastically affect that student's academic successes, as well as increase motivation and attitudes towards school (Anderson et al., 2004). Online learning is seen as effective in colleges and high schools, but considering the importance of a strong, positive relationship between teacher and student, will a reduced teacher role turn out to be a negative component in the educational process?

The relationship amongst peers is another area that can affect middle school students in a variety of ways (Johnson, Johnson, & Roseth, 2010). Anyone who has ever worked with middle school students knows that two individuals can be best friends when they get to school, but by lunch, they may be bitter enemies. The unpredictability of middle school student emotions can be overwhelming for both students and their teachers.

During middle school, students feel increased pressure to belong and fit in a group. Not establishing a sense of acceptance and belonging can severely damage a student's psyche to the point where the student can no longer function in a classroom setting (Buchanan & Bowen, 2008). Online learning is interesting in that students get a chance to communicate without spoken words. From a relationship standpoint, a student with limited functionality among peers may be able to engage in a faceless conversation and feel comfortable doing so. Collaboration in a community setting is also thought to have positive effects on students' levels of academic achievement, as well as helping to create more positive relationships between middle school students (Johnson et al., 2010).

Although more than a third of academic success of middle school students could be attributed to positive peer relationships (Johnson et al., 2010), opening the lines of communication through various forms of online learning may provide opportunities for students to talk about information or topics that take them off the academic task. The unpredictability of middle school student relationships adds another dimension of complexity to online learning, which has shown to work for many college and high school students, who are generally more emotionally mature than their middle school counterparts.

The professional literature shows that one of the most important aspects, both positive and negative, to the academic success of a middle school student is the quality of the relationship that the student has with teachers and peers (Anderson et al., 2004; Johnson et al., 2010). Because middle school students possess such a wide range of developmental levels, the value of relationships within the school is even more important (Buchanan & Bowen, 2008). The normal school relationships are altered in an online situation because of the lack of face-to-face contact. This could also be both positive and negative depending on the student's previous involvements in specific relationships. No matter the previous relationships, online learning will surely affect middle school students more than the average adult who would normally participate in an online class. Any type of communication used during online learning needs to support this important teacher to student, and student to peer relationship if success is to be possible (DiPietro et al., 2010).

Summary

After reviewing the literature, a few particularly important ideas from previous work that are pertinent to the current investigation can be identified. First, there are multiple situations where online learning has been shown to be the more effective method of instruction when compared to a face-to-face condition. However, various examples of face-to-face learning being the more valuable choice also exist. A few studies even show no discernable difference between the two conditions. This leads to the conclusion that other variables than the delivery format, including characteristics of the learner, have an important impact.

Another key point is that there are many strengths and weaknesses to both online, and face-to-face instruction. Oftentimes a positive characteristic of online learning turns out to be a negative trait of face-to-face instruction and vice versa.

Finally, student to student and teacher to student relationships are even more important due to the unstable emotional place most middle school aged students experience at this time in their lives. How online instruction strengthens or weakens that relationship needs to be investigated.

The following chapter will explain the methodology of this study, including the characteristics of participants, the design of the research, and an outline of how the research questions will be analyzed.

CHAPTER 3

METHODOLOGY

The purpose of this study was to compare sixth grade student learning and attitudes in traditional and online mathematics activities. This chapter describes the study participants, the set-up of the study, data collection procedures, and methods of data analysis.

This study examined the following research questions:

1. How does students' academic achievement compare between face-to-face and online mathematics classes for middle school sixth graders?
2. How does students' perceived understanding compare between face-to-face and online mathematics classes for middle school sixth graders?
3. How does students' enjoyment of learning compare between face-to-face and online mathematics classes for middle school sixth graders?
4. Do students with more technology experience (as measured by home computer use) differ in their achievements in an online learning environment?
5. What factors do students report for preference of online or face-to-face learning of mathematics?

These five research questions were addressed through the collection of data in this research project. The specific types of data collected and how this information will be analyzed are discussed in the final section of this chapter.

Participants

The participants in this research consisted of 46 Caucasian sixth graders, 25 male, and 21 female, from the same Iowa rural community, divided into two classroom groups. Each group consisted of more than fifteen students, which according to Plano Clark and Creswell (2010), is an acceptable number to initiate quasi-experimental research. Middle school students are not only important to the study for informing the researcher's personal teaching practice, but also to add to the professional literature on effective teaching practices in mathematics for middle school students.

Participant recruitment began with the researcher describing the study to students and sending home a letter explaining the research study for parents to consider. Students returned the letter regardless of their choice of participation or non-participation. The forms were sealed in envelopes so the researcher had no knowledge of who agreed to or refused participation. The researcher's faculty advisor collected the sealed letters and selected student data to be included in the study for those who had provided permission. All students participated in the lessons because the regular school curriculum was being taught during the study.

Study Design

This quantitative research project was conducted using the quasi-experimental design with an existing sample of two sections of sixth graders. The sixth graders were divided into two mixed-ability sections of students based mostly on social relationships by the previous fifth grade instructors, who had no knowledge of this research project. Groups consisted of 22 and 24 students respectively. Class A of 22 contained 11 male and 11 female students. Class B of 24 consisted of 13 males and 11 females. This is a form of non-probability sampling. As in a quasi-experimental research design, conclusions were drawn on the variables implemented (Plano Clark & Creswell, 2010). In this case, the independent variables consisted of the types of instruction within the classroom: online or traditional. The dependent variables were the student academic performance shown by pretest and posttest gain scores, the technology experience as measured by home computer use, the attitudes towards online and traditional learning, and the perceived understanding of mathematics.

The study took place in two phases, with each phase corresponding to a trimester of sixth grade education. At the school where the study took place, students attended mathematics class only two of the three trimesters of sixth grade: first and third trimesters. During the first trimester, four topics were included in the study, and during the third trimester, six additional topics were part of the study. Other mathematics topics that were not part of the study were taught during these trimesters in a blended fashion, both online and traditional. Data were not collected on these topics.

Each section of students experienced both independent variables: online learning and face-to-face instruction a total of five times each during the two trimesters. While one group learned online, the other group learned in a traditional manner, making this a counterbalanced design. The 10 topics that were presented within this format included decimal concepts, statistics, probability, algebra functions, measurement, symmetry, geometry concepts, polygons, perimeter, and standard area. A timeline of the mathematics topics is given in Table 1.

Table 1.

Design of Study

Math Topic	Duration in Weeks	Instructional Condition: Traditional	Instructional Condition: Online	Trimester	Approximate Dates
Number Sense	2	Not Part of Study		1st	Mid to Late August
Fraction Concepts	2	Not Part of Study		1st	Early to Mid September
Decimals	1.5	Class A	Class B	1st	Mid to Late September
Decimal Operations	1	Not Part of Study		1st	Early October to Mid October
Statistics	1	Class B	Class A	1st	Mid October
Probability	1	Class B	Class A	1st	Late October
Algebra Concepts	1	Class A	Class B	1st	Late October to Early November
Fraction Operations	2	Not Part of Study		1st	Early November to Mid November
Measurement	1.5	Class B	Class A	3rd	Early to Mid March
Symmetry	1.5	Class A	Class B	3rd	Mid to Late March
Geometry Concepts	2	Class A	Class B	3rd	Late March to Mid April
Polygons	2	Class B	Class A	3rd	Mid April to Late April
Perimeter	1	Class B	Class A	3rd	Late April to Early May
Standard Area	1	Class A	Class B	3rd	Early May
Area of Complex Figures	1	Not Part of Study		3rd	Mid May

The research design included both counterbalanced and repeated measures. All students were pretested at the start of the trimester and posttested two weeks after the last study unit was taught. The pretests and posttests were identical instruments and were arranged so that there were exactly 10 questions related to each of the four mathematical units. Student gain scores on each topic learned through traditional methods were compared to scores learned through online methods. Each student experienced five of the 10 topics in each method.

A pretest of the trimester's material was given first. This information was used as a comparison to see which of the delivery methods helped improve students' academic achievement the most. The pretest contained 40 questions during the first trimester and 60 questions during the third trimester from the *Middle School Math Course One* sixth grade textbook used in the school district (Charles, Dossey, Leinwand, Seeley, & Vonder Embse, 1999). Each of the sections had 10 questions each. Each section of the test contained four basic questions, three middle level questions, and three advanced questions. This text mirrors state and local standards to help ensure that what is being taught is also what is being assessed.

At the same time, a survey containing questions about technology use was given to the students to ascertain abilities of the classroom. This was used later to help identify relationships between technology usage and online learning success.

At the end of each instructional unit, students completed a short attitude survey to express their feelings towards the type of learning experienced. These surveys tied in with the technology experience surveys because they too were closely analyzed in comparison to student achievement to find out if various connections exist.

At the end of the trimester, students took an identical posttest covering the same units taught in the first part of this study. The students concluded with a posttest on both attitudes towards the different methods of learning and their own personal preferences now that they have had a chance to experience both online and face-to-face multiple times. During the third trimester, the entire process was repeated. An entire list of test questions and survey questions can be found in the appendix of this dissertation. Table 2 outlines the study as a whole, and when each piece of data was collected.

Table 2.

Timing of Collected Data

Time	Data Collection
First Trimester August through November	
Early September	Pretest of Mathematics Pretest Technology Experience Survey
After the completion of each of the 4 instructional units	Post-Unit Attitude Survey
End of Trimester – Mid November	Posttest of Mathematics Posttest Instructional Preference Survey
Third Trimester March through May	
March	Pretest of Mathematics
After the completion of each of the 4 instructional units	Post-Unit Attitude Survey
End of Trimester – Late May	Posttest of Mathematics Posttest Instructional Preference Survey

Controlled Variables

As with any education study, the process of working with human subjects always adds variability to the research. Therefore, every attempt was made to control as many variables as much as possible. First, both environments were overseen by a single instructor with the same concepts being taught. The instructor was also in the classroom for both conditions for safety purposes. No homework was given, thereby giving the students an equal amount of time in class to complete their work. Classroom materials also remained consistent as far as textbooks (Charles et al., 1999) and manipulatives. The only difference with the manipulatives was that the online setting used manipulatives on the computer (virtual manipulatives) whereas the traditional classroom used actual objects. Studies by Namukasa, Stanley, and Tuchtie (2010), as well as an article by Suh and Heo (2005) have shown that virtual manipulatives can be just as effective as physical manipulatives.

The practice opportunities also differed in delivery, but not concept. Face-to-face students often had whole class practice, while online students used a variety of games and online activities that provided feedback, much like a teacher would. A study by Ritzhaupt, Higgins, and Allred (2010) has shown that these types of games and sites can have a positive effect on student achievement as well. For data collection purposes, the same instrument was used as pretest and posttest with both groups. Overall, the instructor, to the best of his ability, has replicated similarities throughout both conditions as much as possible.

Classroom Setup

Both the traditional and online classroom functioned within the same room, but had differences to differentiate between the two methods. The traditional classroom had the instructor at the front giving a lecture presentation about the topic. Students had opportunities to raise their hands and ask questions or comment when appropriate. The class concluded with an assignment providing practice with the particular topic which the students completed and turned in. The instructor walked around the room to answer any individual questions that were raised. Students could collaborate together in a face-to-face manner on any work they needed to accomplish in class. When students finished, they could choose to expand on their learning through extra mathematical opportunities such as premade sheets with additional topics being covered, do other schoolwork, or have free reading time. They did not have the option to go on to the next day's topic.

The online learning environment started with each student picking up a laptop from the provided cart and going to the instructor's website, which contained all the materials and instructions for the unit as a whole. Students could choose to work ahead or stick to a day-to-day schedule, but the same amount of time was given for each individual piece of the unit when compared to the traditional method. No communication took place verbally or visually in the physical classroom. All communication was facilitated through an online chat in which students were free to post comments and questions as they occurred. Both the teacher and the students could see all of the discussion in this chat interface. All assignment submission was accomplished through the student's school email, on the chat, or posted directly on the website. Students within this environment also had the same choices when they were finished with an assignment as the traditional situation, but with the added factor of being able to work ahead. An entire list of differences in activities for each condition listed by topic can be found in the appendix of this dissertation.

Data Analysis

Each of the following research questions, which were presented in Chapter 1, was investigated through data collection and analysis. The types of data and the method of analysis are described in this section.

The first research question was, "How does students' academic achievement compare between face-to-face and online mathematics classes for middle school sixth graders?" Student achievement was measured through pretest-posttest gain scores and overall posttest scores on the sets of 10 questions addressing concepts taught during the individual mathematics units. Mean scores of students for individual units were compared across conditions. A t-test provided information on the statistical significance of the results to see if any differences were by chance, or as a product of the method. Two One-Sided T-Test (TOST) was also use to show equivalence between the conditions.

The second and third questions were, "How does students' perceived understanding compare between face-to-face and online mathematics classes for middle school sixth graders?" and "How does students' enjoyment of learning compare between face-to-face and online mathematics classes for middle school sixth graders?" Student ratings for perceived understanding and enjoyment (numerical values on a rating scale of 1-10 reported by students) were averaged and looked at focusing on the comparison of each of the two trimesters of face-to-face instruction, each of the two trimesters of online learning, both online and face-to-face instruction combined comparing each of the two trimesters, and both trimesters combined, looking at online learning versus face-to-face learning. Paired t-tests were used in all cases, determining if the mean scores show differences in student perceived understanding through the use of a specific method of instruction (face-to-face or online) and differences in enjoyment due to the actual method (face-to-face or online), or if differences are just by happenstance.

The fourth research question was, "Do students with more technology experience (as measured by home computer use) differ in their achievements in an online learning environment? Student responses to the questions about home computer use guided the sorting of students into two groups of more proficient/experienced computer users (15 students stating more than an hour of computer use each night) and less proficient/experienced computer users (15 students stating less than an hour of computer use each night). A non-paired t-test was conducted to determine if the difference between the mean gain scores for the online units of the more proficient computer group is significantly different than the less proficient computer group, or vice versa.

The fifth and final research question was, "What factors do students report for preference of online or face-to-face learning of mathematics?" A list of all reported factors affecting preference for each condition was tabulated and reported with the frequency of occurrence. The reported factors were summarized and discussed.

CHAPTER 4

RESULTS

Chapter 4 addresses each research question, and analyzes the results of each individual test calculated from the data of the various instruments. A review of the research questions follows.

1. How does students' academic achievement compare between face-to-face and online mathematics classes for middle school sixth graders?
2. How does students' perceived understanding compare between face-to-face and online mathematics classes for middle school sixth graders?
3. How does students' enjoyment of learning compare between face-to-face and online mathematics classes for middle school sixth graders?
4. Do students with more technology experience (as measured by home computer use) differ in their achievements in an online learning environment?
5. What factors do students report for preference of online or face-to-face learning of mathematics?

Research Question 1

How does students' academic achievement compare between face-to-face and online mathematics classes for middle school sixth graders?

To help answer this question, students took part in pretests at the beginning of the first and third trimester that addressed the units they would participate in during those trimesters. The results of these pretests showed that the students were similar in their beginning knowledge of these topics. The average difference on the pretests combined for group A when compared to group B was 0.27. Each pretest contained 10 questions, meaning that the difference was less than one-third of a point per 10-question pretest.

Students approximately started from the same spot and alternated between face-to-face instruction and online learning throughout the year. Students took 10-question assessments following each of the 10 units. A gain score was derived for each unit by taking the posttest score and subtracting the pretest score for each unit.

Once all of the pretest scores, posttest scores, and gain scores were collected, paired t-tests were conducted to see if the differences between conditions for each of the topics were statistically significant. In the first round of t-tests, the counterbalanced nature of the study was exploited to compare learning between conditions. The final posttest scores for the group of students learning each of the 10 topics under one condition were compared to the final posttest scores for each topic for the group of students who were instructed in the other condition. The final results showed that the biggest difference in posttest scores was 0.87 points out of 10 (on the topic of perimeter). A majority of the differences were less than 0.50 points out of 10. The t-tests indicated that none of the results of the 10 posttest comparisons were statistically significant at a 0.05 level. Overall, half of the online units resulted in better final posttest scores as compared to the face-to-face units. A detailed listing of all 10 math topics, posttest means, standard deviations, and t-test results can be found in Table 3.

Table 3.

Posttest Scores for each Separate Topic

Order	Mathematics Topic	Trimester Taught	Class Group	n	Mean Posttest Score Online	Face to Face	SD	*t*	*p*
1st	Decimals	1	A	22		6.46	1.50	-.77	.45
			B	24	6.96		2.71		
2nd	Statistics	1	A	22	4.02		2.61	-.83	.41
			B	24		4.69	2.83		
3rd	Probability	1	A	22	5.64		1.97	-.28	.78
			B	24		5.73	2.24		
4th	Algebra	1	A	22		6.00	2.31	-	.60
			B	24	6.23		3.19	.52 3	
5th	Measuremen t	3	A	22	6.27		1.83	.82	.42
			B	24		5.71	2.73		
6th	Symmetry	3	A	22		7.77	1.69	.05	.96
			B	24	7.75		1.51		
7th	Geometry	3	A	22		5.82	2.24	.60	.55
			B	24	5.38		2.70		
8th	Polygons	3	A	22	7.23		1.72	.57	.57
			B	24		6.88	2.36		
9th	Perimeter	3	A	22	6.41		1.89	1.8	.07
			B	24		5.54	1.18	8	
10th	Area	3	A	22		4.86	2.25	1.0	.30
			B	24	4.08		2.76	4	

When using the same method to compare the gain scores, similar results were discovered as found in the posttest scores. Differences in gain scores indicated the perimeter unit's gain score again showed the biggest difference in means when comparing face-to-face learning with online learning. The difference in the perimeter test was an average of 1.53 points out of 10. This result was found to be statistically significant ($p = 0.007$). Another large difference between conditions occurred in gain scores as well. Student performance on the topic of measurement showed a gain score difference of 1.33, while area resulted in a gain score difference of 0.91. However, none of these gain score values showed statistically significant differences between the two conditions. For five of the units, the higher gain score was found to be in the face-to-face condition, but for the other five, it occurred in the online condition. Refer to Table 4 to acquire a more extensive view of the statistical results of the gain scores for all 10 math topics.

Table 4.

Gain Scores for each Separate Topic

Order	Mathematics Topic	Trimester Taught	Class Group	n	Mean Gain Score Online	Mean Gain Score Face to Face	SD	*t*	*p*
1st	Decimals	1	A	22		4.23	1.77	-1.01	.32
			B	24	4.92		2.80		
2nd	Statistics	1	A	22	3.89		2.58	-.90	.37
			B	24		4.60	2.80		
3rd	Probability	1	A	22	4.50		1.90	-1.20	.24
			B	24		5.15	1.74		
4th	Algebra	1	A	22		4.41	1.63	-.523	.60
			B	24	4.78		2.93		
5th	Measurement	3	A	22	4.50		2.28	2.0	.052
			B	24		3.17	2.24		
6th	Symmetry	3	A	22		5.95	2.26	.13	.90
			B	24	5.88		1.80		
7th	Geometry	3	A	22		5.14	2.17	.44	.66
			B	24	4.83		2.48		
8th	Polygons	3	A	22	5.77		1.80	.74	.47
			B	24		5.38	1.86		
9th	Perimeter	3	A	22	5.32		1.89	2.83	.007
			B	24		3.79	1.77		
10th	Area	3	A	22		4.41	2.20	1.30	.20
			B	24	3.50		2.50		

While both of the previous tests showed scores that were relatively close in regard to the online and face-to-face conditions, whether these two instructional methods are equivalent cannot be determined through the lack of statistical significance of differences; a test of equivalence was needed to make that determination. Dr. Robert Boody of the University of Northern Iowa assisted in performing an equivalence test procedure known as the Two One-Sided T-Test for equivalence (TOST; Hoenig & Heisey, 2001). Dr. Boody specializes in statistical analysis, and was a welcome addition to this part of the study. An example of the TOST can be found in the article written by Chen, Rathore, Ji, and Germansderfer (2010). A more detailed description of the results from the TOST in this study are located in a manuscript in the *Journal of Computers in Mathematics and Science Teaching* by Edwards, Rule, and Boody (In Press).

In a portion of this test (TOST), the teacher must select a range of scores that the teacher considers to represent essentially the same level of proficiency. Out of the 50 points possible from each of the posttest from both conditions in the study, the "zone of indifference" was determined to be ± 2.5 points by the classroom teacher. In explaining this thinking, the teacher determined a score of 30 to be essentially the same as a 27.5 or a 32.5. The range of equivalence of student scores in the teacher's eyes was 5 points (on a 50 point assessment).

This study had a zone of indifference of 1.17 points ± 2.5 points, or -1.33 to 3.67 on the 50 point assemblage of assessments for each condition. A Two One-Sided T-Test (TOST) was conducted by developing a 90% confidence band around the mean of the difference scores. Gain scores had a range of $-.14 \leq 1.17 \leq 2.48$ (the mean of the differences (1.17) ± 1.31 (which is the standard error of the mean (.78) x .90CI $t(45)$ (1.68)). For the posttest scores, the range was $-1.01 \leq 0.15 \leq 1.16$ (the mean of the differences (.15) ±1.13 (which is the standard error of the mean (.69) x .90CI $t(45)$

(1.68)). The full confidence interval in both situations (gain and posttest scores) is housed within the zone of indifference, therefore the achievement of the gain scores and posttest scores from the online and the traditional instructional conditions may be considered as equivalent at the .05 level of significance. This means that online and face-to-face instruction for sixth graders in this experiment can be considered equivalent.

Research Question 2

How does students' perceived understanding compare between face-to-face and online mathematics classes for middle school sixth graders?

This research question was investigated through the student surveys taken at the end of each unit. One of the questions on the survey asked for the students' perceived level of understanding of the mathematical topic. These responses were used to compare the instructional methods for that topic (face-to-face or online). The students were asked to answer this question on a scale of 1 to 10, with 10 meaning they understood the topic completely.

The preliminary t-tests were used to show that there was not a significant difference during the year in the students' perceived understanding of mathematics taught through face-to-face instruction, as compared to online learning. The reported understanding for face-to-face instruction stayed similar throughout the year with students giving a rating of 9.0 the first trimester, and 8.7 for the third trimester. Online learning was also seen as consistent throughout the year, as 8.6 was the average for mathematical understanding both first and third trimester. The average overall mathematical understanding was also uniform for both trimester warranting an 8.8 (first trimester) and an 8.7 (second trimester).

The last test conducted pertained to the student perspective on mathematical understanding comparing online learning with face-to-face directly. Considering the entire year (five units apiece), students in the online condition averaged an understanding of 8.6, and students in the face-to-face condition answered at a nearly equal mark of 8.8. Neither of these results was found to be statistically significant ($p = 0.24$). The full results of the tests concerning a student's understanding under the conditions of face-to-face and online instruction can be found in Table 5.

Table 5.

Rating of Mathematical Understanding

Condition	Trials & Timing	Mean Rating of Understanding of Mathematics (SD)	*p*-Value from t-test
Face to Face	2 Trials 1st trimester	9.0 (1.3)	0.08
	3 Trials 3rd trimester	8.7 (0.9)	
Online	2 Trials 1st trimester	8.6 (1.3)	0.93
	3 Trials 3rd trimester	8.6 (1.0)	
Both Conditions Combined	4 Trials 1st trimester	8.8 (1.1)	0.34
	6 Trials 3rd trimester	8.7 (0.8)	
Face to Face	5 Trials through year	8.8 (0.9)	0.24
Online	5 Trials through year	8.6 (1.0)	

Research Question 3

How does students' enjoyment of learning compare between face-to-face and online mathematics classes for middle school sixth graders?

This question was answered in a similar fashion to the previous question by investigating the students' perceived understanding of the mathematics topic due to the condition of instruction for the unit (online or face-to-face). Using the same survey utilizing a 10-point scale, the students each chose a number signifying how much they enjoyed the particular condition of instruction. This did not have to do with the mathematical topic itself, but the instructional method presented.

Multiple t-tests were conducted to compare different times of the school year, as well as the different conditions of the study (online and face-to-face). The first test showed that students rated face-to-face enjoyment slightly higher after the third trimester (8.1) when compared to the first trimester (7.8). These differences were not found to be statistically significant ($p = 0.30$). When the same test was run comparing online learning at different trimester points during the year, the enthusiasm towards online instruction was consistently higher than face-to-face, but the rating did drop by a half a point over this time period (9.2 for first trimester; 8.7 for third trimester). This change was statistically significant at a 0.01 level ($p = 0.003$) with a small to medium effect size. When both conditions were combined, the enjoyment did not vary much throughout the year. Combined statistics indicate that all students, no matter the condition enjoyed their method first trimester giving a rating of 8.5. Students rated their third trimester experience at an average of 8.4.

The largest difference is shown when all five face-to-face units were combined, and compared to all five online units. Students throughout the entire year rated the enjoyment of face-to-face instruction with an average of 8.0 out of 10. The student-rated enjoyment of the full year in the online condition was almost a full point higher at 8.9. This final t-test was statistically significant at a 0.01 level ($p = 0.001$) with a medium to large effect size, indicating that students did enjoy online learning more than face-to-face learning. The full results of the tests relating to a student's enjoyment under the conditions of face-to-face and online instruction can be found in Table 6.

Table 6.

Rating of Method Enjoyment

Condition	Trials & Timing	Mean Rating of Enjoyment of Condition of Instruction (SD)	*p*-Value from t-test	Cohen's *d* Effect Size and Interpretation for Significant Differences
Face to Face	2 Trials 1st trimester	7.8 (2.2)	0.30	-
	3 Trials 3rd trimester	8.1 (1.4)		
Online	2 Trials 1st trimester	9.2 (1.2)	0.003	0.40 Small to Medium
	3 Trials 3rd trimester	8.7 (1.3)		
Both Conditions Combined	4 Trials 1st trimester	8.5 (1.2)	0.67	-
	6 Trials 3rd trimester	8.4 (1.0)		
Face to Face	5 Trials through year	8.0 (1.4)	0.001	0.71 Medium to Large
Online	5 Trials through year	8.9 (1.1)		

Research Question 4

Do students with more technology experience (as measured by home computer use) differ in their achievements in an online learning environment?

To help identify the statistical answer to this question, two sets of data were used. The first data set was a survey taken by the students in which they indicated how much time they spend on the computer at home on an average school night. Times ranged from no computer usage up to six hours each night. In order to better use this data, the students were split into three categorical groups that each contained nearly the same number of students. The first group consisted of 15 students who reported less than one hour of computer usage per night. The middle group was represented by 16 students who reported exactly one hour of computer use per night. The final group had 15 members, and reported more than one hour of computer use each night.

Gain scores at the ends of the first and third trimesters from these computer usage groups were separated and compared with a t-test. During this process, the middle computer usage group was not considered, and only the high and the low computer usage groups were used.

During trimester one, the low computer usage group averaged 4.47 points improvement on a 10-point assessment, while the high computer usage group averaged 4.67 points improvement. The differences of these two means were not statistically significant ($p = 0.72$).

Considering the entire year as a whole, the results did not vary greatly from the first trimester data. The low computer usage group averaged 4.61 points of improvement on a 10-point assessment. The high computer usage group averaged a slightly higher amount of growth at 4.96 points of improvement per 10-point assessment. Again, these values were not statistically significant ($p = 0.32$). A listing of these values can be found in Table 7.

Table 7.

Mean Gain of Higher and Lower Computer Usage Groups

Time Period	Higher Computer Usage Group Mean Gain (SD)	Lower Computer Usage Group Mean Gain (SD)	*p*-Value from t-test
1st Trimester 2 Online Units	4.67 (1.5)	4.47 (1.5)	0.72
Full Year 5 Online Units	4.96 (1.0)	4.60 (0.8)	0.32

Research Question 5

What factors do students report for preference of online or face-to-face learning of mathematics?

Following both the first trimester and the third trimester, students were given an open-ended survey asking them to select either face-to-face learning or online instruction for the following questions:

1. Which of the instructional methods (online or face-to-face) did you find most beneficial to your mathematical learning?

2. Which of the instructional methods (online or face-to-face) did you find most beneficial to your classroom enjoyment?

Students could choose the same method for both questions, or select one of each depending on their feelings. After students made a selection for each question, they were asked to create a list of up to three reasons why they selected the method they did for both questions. The students were not given suggestions on what these reasons might be. These results were sorted into different categories, and tallied to see how many times each reason was answered.

At the conclusion of the first trimester, 29 students stated that they preferred the online condition for mathematical learning, while the other 17 students thought face-to-face instruction helped the most. After the third trimester, the results were exactly the same with 29 students answering for online learning, and 17 preferring the face-to-face condition.

The results were somewhat different for student ratings of enjoyment of learning under the two conditions. Thirty-seven students reported they enjoyed the online experience, leaving nine students to select face-to-face instruction. While the results of the mathematical understanding remained identical, the enjoyment for online learning dropped during the school year. Following the third trimester survey, 30 students said they favored online learning in terms of enjoyment. The number of students enjoying the face-to-face method rose to 16, indicating that seven students switched their preference. Refer to Table 8 and Table 9 for an organized list of these results.

Table 8.

Student Choice of Method of Learning Mathematics for Understanding (n = 46)

Time	Number of students choosing online instruction as the preferred condition of learning for understanding	Number of students choosing face to face instruction as the preferred condition of learning for understanding
After 4 units	29	17
After 10 units	29	17

Table 9.

Student Choice of Method of Learning that was the Most Enjoyable (n = 46)

Time	Number of students choosing online instruction as most enjoyable	Number of students choosing face to face instruction as most enjoyable
After 4 units	37	9
After 10 units	30	16

The responses students gave as to why they thought the instructional method worked best for them in either a mathematical understanding sense, or from an enjoyment standpoint were sorted into groups of similar ideas, and counted to gain the number of responses for each category. A similar process was done during first trimester, as well as third trimester.

Students who cited the online method as being most helpful to their mathematical learning mentioned ideas such as self-paced learning, computers in general, instructional videos, and the noise level of the room as advantages. During the third trimester, students answered similarly, but also included various other responses including the ability to use a web search. Students who thought face-to-face instruction aided their learning the most wrote down face-to-face questioning with teachers, and teacher explanations as being the biggest positives. An ease of peer grouping was also listed multiple times for the third trimester.

Those students preferring online learning for enjoyment responded with computers in general, pacing, online chatting, and online videos as being the most helpful. Students who enjoyed the face-to-face method more so than online learning listed face-to-face group work with peers, and the ability to talk one on one as ways to increase satisfaction. Most of these selections for face-to-face enjoyment were listed for third trimester as students started to change their affiliation. A full breakdown of student responses to both question at different time periods in the year can be found in Tables 10, 11, 12, and 13.

Table 10.

Reasons for Preferring Online Condition for Understanding

Reason	Number of students giving this reason after 4 units	Number of students giving this reason after 10 units
Go at own pace	10	10
Quiet	7	4
Computers help me learn	7	5
Videos helpful	7	7
Can ask questions anytime	5	4
It is something new	4	0
Visual learner	4	0
Educational games	3	0
Teach myself	2	0
I could help others	2	0
Increased responsibility/freedom	2	3
Helped focus	2	0
No writing	1	1
More active learner	1	0
Infinite wait time	1	0
Look up info on Google	0	5
Links helpful	0	2
Easier to differentiate	0	1
More challenging online	0	1
Good with technology	0	1
More tools to use	0	1
Less book work	0	1

Table 11.

Reasons for Preferring the Face-to-Face Condition for Understanding

Reason	Number of students giving this reason after 4 units	Number of students giving this reason after 10 units
I liked asking questions face-to-face	10	7
Teacher explanations	8	6
Teacher interaction	3	5
Disliked online communication	2	6
Focused better without computer	2	1
Did not like watching videos	1	0
Easier to work with peers	0	8
Understand better face-to-face	0	3
Don't like everything to be on computer	0	1
Less confusing	0	1
Like taking notes the regular way	0	1

Table 12.

Reasons for Preferring Online Condition for Enjoyment

Reason	Number of students giving this reason after 4 units	Number of students giving this reason after 10 units
Computers	18	9
Pacing	13	11
Videos	12	4
Talking online	9	7
Quiet	5	2
Technology in general	4	0
Games	4	4
It is something new	2	1
Everything laid out	2	1
Clear directions	1	1
Relaxed	1	0
Less writing	1	3
Quick feedback	1	3
No worksheets	1	
Look up info on Google	0	4
Less book work	0	3
Less waiting time	0	2
Organization	1	1
More variety	1	1
Helps us learn how to use technology	1	1
Easier to concentrate	1	1

Table 13.

Reasons for Preferring the Face-to-Face Condition for Enjoyment

Reason	Number of students giving this reason after 4 units	Number of students giving this reason after 10 units
Talking to people in person	4	9
Teacher interaction	3	0
Teacher explanations	2	0
Dislike online communication	1	3
Focused better without the computer	1	0
Disliked videos	1	2
Online wastes time	1	0
Like whole class examples	1	0
Could work in groups easier	0	9
Less confusing	0	3
Not good with computers	0	1
Don't like everything to be on computer	0	1

The data have now been explained and analyzed. Chapter 5 will provide a summarizing interpretation of the results, as well as recommendations for implementation and further research.

CHAPTER 5

CONCLUSIONS

Chapter 5 presents the implications of each finding noted in Chapter 4. The following is a review of the research questions that have been discussed in this dissertation:

1. How does students' academic achievement compare between face-to-face and online mathematics classes for middle school sixth graders?
2. How does students' perceived understanding compare between face-to-face and online mathematics classes for middle school sixth graders?
3. How does students' enjoyment of learning compare between face-to-face and online mathematics classes for middle school sixth graders?
4. Do students with more technology experience (as measured by home computer use) differ in their achievements in an online learning environment?
5. What factors do students report for preference of online or face-to-face learning of mathematics?

Research Question 1

How does students' academic achievement compare between face-to-face and online mathematics classes for middle school sixth graders?

The t-tests conducted on the pretest, posttest, and gain scores showed no statistically significant differences between online learning and face-to-face instruction. The data showed online learning having the higher gain score or higher overall posttest score half the time. If one of the two modes of lesson delivery would have evidenced consistently higher means, a case might be made for superiority. However, because the data showed no such advantage, and little statistical significance of differences, a conclusion as to a better method of instruction cannot be made.

A few of the individual t-tests were found to be statistically significant. At a 0.05 level ($p = 0.05$), student work in the measurement unit showed a difference in gain scores of 4.50 for the online group, and 3.17 for the face-to-face class. This was one of the larger disparities in gain score of any of the units. Even more interesting is the fact that the online group actually started out at a lower score on the pretest than the face-to-face students (1.77 to 2.54). The different facets of the unit must be examined to determine a reason for the differences. Topics within this unit included metric conversions, standard conversions, reading a ruler marked in inches, and actual physical measurement (either with a real ruler or on the computer). In this researcher's opinion, the use of a physical ruler on actual objects would seem to be more conducive to measurement, but that was not the case the data presented. All of the other topics within measurement seemed like they could be learned well with either instructional method. Perhaps the online students were more motivated or better able to focus on this familiar topic.

Perimeter was another topic where the gain scores differed greatly in favor of online learning, being statistically significantly different from scores of the face-to-face group at a 0.01 level ($p = 0.007$) with a large effect size (Cohen, 1988) of Cohen's $d =$ 0.84. The Internet contains many different websites and interactive applets that help show the reasoning behind both the Pythagorean Theorem and the circumference of a circle that are difficult to replicate in a traditional classroom. Both of these topics have been traditionally difficult for sixth grade students in this district as well, and the online tools can help contribute to the actual mathematical understanding of these topics. When the underlying workings of a mathematics concept are fully understood by the students, a lasting retention of the topic can be expected. The same comments can be stated for the perimeter unit in regards to the overall posttest scores, which the online learning condition did score higher than the face-to-face group, with results being statistically significant ($p = 0.007$). Because there are many online activities that could aid an instructor with topics dealing with perimeter, teachers utilizing face-to-face instruction should include some of these online tools into their teaching, using a computer lab or classroom projection screen.

The TOST was ultimately needed for this study to show that online and face-to-face learning could be considered equivalent in the level of educational impact. One positive aspect of these results is that a teacher can feel comfortable with implementing a mixture of both methods, with ultimate success depending upon the quality of the teacher's organization and instruction as stated by Sunal et al. (2003). The equivalence of these conditions also helps because there are clear advantages of both types of learning, and the teacher or district can choose which method (or a combination of the two) works best for the given situation. The teacher should always have a positive, caring relationship with the students, and therefore will make the effort to know what will and will not work for each student. Instruction could also be so specific that some students in the same classroom may benefit from online instructions, while others may benefit from face-to-face. Both conditions can coexist at the same time if the teacher is able to take the time to plan and group students accordingly.

Research Question 2

How does students' perceived understanding compare between face-to-face and online mathematics classes for middle school sixth graders?

The results of all the t-test pairings of student responses to mathematical understanding surveys of the conditions showed no significant differences regarding timing during the school year, as well as face-to-face versus online learning. Students ranged in understanding scores from (on average) 8.6 up to 9.0. The reason why all of the survey averages totaled around 9.0, meaning students perceived a high level of mathematical understanding, could be the teacher's strong planning for both conditions. The online environment was scaffolded, so material was easily understandable, and students had the necessary, highly interactive resources to succeed. The teacher also planned lecture-based instruction with manipulatives and peer collaboration to make face-to-face mathematical learning easy to grasp as well.

The high marks earned by students on the posttests indicate that both methods have the potential to be effective as long as each is properly planned and supported by teacher interaction. Any instructional method, no matter how innovative, will falter if time and effort are not put into instruction, resources, and support. Each condition has positive and negative aspects that need to be emphasized or minimized. For instance, the teacher is such a vital part to a face-to-face classroom. If the teacher sits at his or her desk the entire period and does not communicate with the students and offer assistance, face-to-face instruction will fail. Alternately, if an online classroom has a poorly organized interface, a lack of quality resources, and a faulty communication portal, online learning will also be unsuccessful in educating students with deep mathematical understanding. Both methods can be effective in providing students with mathematical competency when operated correctly.

Research Question 3

How does students' enjoyment of learning compare between face-to-face and online mathematics classes for middle school sixth graders?

Over a full academic year, the data show that students did enjoy online learning as a method of instruction better than the face-to-face alternative, similar to the results in a study by Lim et al. (2008). This student enjoyment result was shown through various surveys that students took during each of the mathematical units where they were asked which of the conditions they enjoyed most on a scale of 1 to 10. Results indicated an almost full point difference between online learning (8.9) and its face-to-face counterpart (8.0). This number was significant at a 0.01 level ($p = 0.001$) with a medium to large effect size. That is not to say that students did not enjoy face-to-face learning, or that face-to-face instruction cannot be enjoyable, but there was a measureable difference between the two in the current study. This could be for many reasons, with one being the novelty of this type of instruction. These particular students had not experienced much technology use at all in a classroom setting. This change from the norm could have sparked new interest and motivation to learn.

Even though online learning was the preferred instructional method for enjoyment, the rating for enjoyment decreased from the first trimester (9.2) compared to the third trimester (8.7). This difference in the average was significant at a 0.01 level (p = 0.003) with a small to medium effect size. The thinking for this drop might be that students had an initial liking for online learning due to its novelty, but this liking changed over time after becoming more accustomed to the delivery mode. The interest level dropped back to a normal likability level (8.7) for just online during third trimester compared to 8.4 for both conditions combined during the third trimester. To help alleviate this problem, the instructor might space out the use of technology to maintain student interest. An emphasis on blended learning and variety may help to keep both of the conditions enjoyable for students.

Overall, student enjoyment was high for both conditions throughout the year (8.5 for first trimester and 8.4 for third trimester for both conditions combined). This overall high level of enjoyment may be based on the teacher-student relationships that are so important to middle school students and their learning (Anderson et al., 2004; Buchanan & Bowen, 2008). Even though online instruction is done through a computer, relationships between teachers and students can and need to be cultivated throughout the process. The technology alone does not create the overall enjoyable atmosphere, but rather the teacher making connections with students and making the learning environment enjoyable. This is also true for the face-to-face condition as well.

Effective peer communication could have also made enjoyment scores high for both conditions throughout the year. Johnson et al. (2010) stress peer interaction as making a student's experience in school more enjoyable, and the ability to communicate with peers during both conditions might have played a part in the high survey scores for enjoyment of learning.

Research Question 4

Do students with more technology experience (as measured by home computer use) differ in their achievements in an online learning environment?

At the start of the school year, all of the students were given a survey asking them to state how many hours they spend outside of school on an average weekday on the computer. The computer times ranged from no access outside of the school day, to six hours per night. Despite this varying array of technology use, the results showed little effect on the differences in online scores. This result was surprising because the students' lack of technology integration in previous grades brought the expectation that disparity between students' technology experiences would have an effect on scores. One explanation may be that the students had time before the first online unit started to become familiar with the computers. The study did not begin until September, whereas school started in the middle of August. Students had at least one experience with technology during their mathematics class on most days, giving them almost two weeks to gain confidence.

Another factor may be the general sense that Generation Z students adapt better to technology, because they are entrenched in technology during their daily lives (Dillon, 2007). Students may not have had a significant amount of computer use at home, but may have had access to adaptable technologies such as iPods, cell phones, or video games.

This familiarity may have helped them quickly gain the necessary skills to succeed in an online learning environment.

Even though these statistics regarding home technology use did not result in significant differences in gain scores, students in both the under one hour per night of computer usage and over one hour per night of computer usage did show an improvement on gain scores as the year progressed. The lower computer group averaged a 4.47 points gain during the first trimester during online instruction, and a 4.60 for the year as a whole. The higher computer group averaged a 4.67 points gain during the first trimester, and a 4.96 for the entire year. These increases in gain scores could signify that students had enough technological ability to get started, but as their experience increased, they were able to utilize the advantages of online learning at an increasing level.

Research Question 5

What factors do students report for preference of online or face-to-face learning of mathematics?

Most responses of the students stating the key characteristics they valued in both conditions of learning were recognizable in the professional literature. One of the biggest known advantages of online learning is the ability to work at a pace suitable to learning. This instructional positive was outlined in studies by Serhan (2010), as well as Oliver et al. (2010). From a middle school perspective, students may have put this comment on the survey for a few reasons. Most middle school environments generally contain students of various performance levels. Using the same instructional methods for all students is not an optimal approach because some students excel with minimal coaching, prefer to explore on their own, and have already mastered concepts. Alternatively, many students need extra instructional time because they do not transfer the information to mathematical understanding as quickly. This does not mean that they will not fully understand the concepts eventually, but they must take more processing time, which self-pacing allows.

Sagheb-Tehrani (2008) discussed how a variety of instructional materials can creates an advantage for the online learning environment. This idea was shown by students' answers in the current study. Student comment categories in Table 10 and Table 12 such as "computers help me learn," "visual learner," "videos helpful," "educational games," and "look up info on Google" all garnered multiple responses explaining why students understood and enjoyed mathematics better through the online learning environment. The resources of a face-to-face class may only include the teacher, the text, and any specific manipulative or tool chosen by the teacher. This limited set of resources may or may not be helpful to students. With a computer in a student's possession, the student can be given a list of recommended resources, but can also find his or her own resources. In the current study, many times, students chatted with the teacher saying that they found a new, helpful website or applet. The teacher always forwarded this along to the remaining students to share the idea. Students enjoyed this procedure because it made them more responsible and less helpless if the given resources were not effective in learning.

One interesting disadvantage to online learning is the self-discipline a student must have to stay focused and on track (Song & Hill, 2007; Valtonen et al., 2009). Throughout this study, the teacher actually saw the opposite of this concern. He saw students working hard, communicating, and relishing the opportunity for independence. In most cases, giving a gradual release of responsibility created a motivated group of students eager for a challenge. Many of these students had not been allowed any freedom to attempt, fail, and attempt again. Previous environments were scripted, causing the students to become reliant on teachers. Students loved the new responsibility, and also commented on how it aided learning as well. On the open-response survey, categories from Table 10 and Table 12 such as "increased freedom/responsibility," and "teach myself" were listed by students in the online condition, and no feedback was given in regards to the increased responsibility being a detriment to learning or enjoyment.

The factor that seemed to split the most students on whether they preferred online learning of face-to-face instruction was communication. The importance of communication was found in this study and other previous studies (Barcelona, 2009; Duemer et al., 2002). In the current study, students seemed to evidence one of two points of view. If they enjoyed the online communication system through the chat, and thought it met their learning needs, they favored online learning. If the students preferred to be able to ask questions face-to-face with teachers, and liked the peer-to-peer interaction, face-to-face instruction was their choice.

The success of communication in an online environment can be determined by the quality and set-up of the communication system (Gadanidis et al., 2002). The researcher in the current study had many options for communication, and decided to select an online chat where all participants could see what was being typed at all times. This may have been one of the reasons why enjoyment in online learning decreased somewhat for students. The tedium of typing and reading responses may have discouraged students during the second half of this research study. Seven students changed their allegiance to face-to-face instruction during the final survey on preferred methods, and an increase in interest in talking with people face-to-face (peer or teacher) could also be garnered from the students' written survey responses. Exploration of other online communication options is needed. This may involve video conferencing, blogging, or other means of communication students enjoy more than a chat. The encouragement of side conversations that do not pass through a public forum may also be needed. Some students may have felt that they did not want to type as much because all other students would see and make judgments on what they were thinking, taking away some of the communication advantages that online learning may have for students who are introverts.

Implications

The goal of this study was to determine if online learning was an effective method of instruction for middle school students. The answer to that question is yes. Through the tests of equivalence (TOST), scores for both conditions were deemed to be equivalent. Middle school students can in fact learn through the use of technology.

Aside from the positive student learning aspect an online environment can provide, many ideas were obtained from this research investigation that can help school districts in deciding what will work best for them. First, the study indicated that instructional novelty may be important to middle school students. This idea is supported by the exodus of students who preferred online learning initially, but then decided that they had grown tired of some of the alternative methods, and reverted back to preferring face to face instruction. Complete adherence to digital options may not be best for motivation and interest. Mixing technology with more traditional methods to form a blended classroom may be the optimal combination, but future research will have to determine if this is the case. Using both instructional methods may improve motivation and keep students eager to learn each day because of the variety in learning.

Another idea gleaned from this study is that students are drawn to different aspects of each learning condition. If a teacher could effectively harness all of these advantages, a more effective classroom might be formed. One of these traits is the self-pacing that online learning can support. Self-pacing may be difficult for teachers to implement because of all the advanced planning necessary. Teachers do not always have enough time for the bare minimum of what is required of the profession, so setting curriculum up months in advance may be difficult, but could have rewarding results in student learning. In the writer's experience, middle school students' performance in mathematics often shows a gap between groups of students who excel or struggle. Each of these groups can be kept motivated and progressing through self-pacing because students who need to be accelerated or challenged do not have to wait for others to catch up. Struggling students do not have to feel rushed, but can take time to truly understand the content and ask appropriate questions without feeling pressured to hurry. Differentiation of pacing may work better in an online environment because the sequence of instruction and manipulatives can be set up in advance, but could conceivably function in a more individualized face-to-face setting as well as a blended environment.

Variety of materials was another aspect on which students often commented as being a reason to enjoy one method over another. Both conditions can offer a variety of instructional materials. Whether these instructional supports are physical manipulatives or a whiteboard in a face-to-face environment, or online games and videos in an online situation, choosing a variety of classroom materials could maintain student interest. Often, familiarity influences a teacher's instructional choice. Teachers stepping out of an instructional comfort zone can motivate students by implementing a wide range of materials.

Through a social lens, the instructor observed that students enjoy talking with each other and communicating their mathematical understandings. After a teacher has successfully structured the classroom environment for academic success, communication between peers should be a standard occurrence. Communication was shown to be one of the most important aspects in both conditions for students' learning and enjoyment. Teachers need to relinquish being the sole classroom communicator and share that opportunity with students. Research findings (e.g., Barcelona, 2009; Duemer et al., 2002) in the professional literature repeatedly state that students desire communication, and if that can be integrated with learning, then a more student-centered approach may result. If the teacher is utilizing online communication, he or she must experiment with different versions of communication to find something that is efficient and effective.

Ultimately, technology is a wonderful and welcome addition to the classroom, and has many advantages. The technology by itself does not make online learning a quality mode of instruction (Wang & O'Dwyer, 2011); besides appropriate planning and implementation of instructional technology, success depends upon the teacher's interaction with students. If the researcher were to ask students to work online, and those students had no sense of connection with the teacher, students may not feel inclined to focus on the given tasks. The same situation applies to a face-to-face classroom. If a teacher remains at his or her desk while students are working on tasks, the students may not be attentive as well. In either condition, if students sense a disinterested teacher, they will not value the experience and learning is less likely to take place. This sense of relationship is important in both formats, and the idea that technology is an elixir for education is a false illusion.

Future Research

While this research yielded interesting and informational results, one must always think of ways to improve current practice. The results of this study showed that both online learning and face-to-face instruction can produce similar results, but the participant pool was limited to two classrooms of middle class rural students. Future studies involving an increased number of schools and greater diversity of students could better indicate the feasibility of online instruction with middle school students in other settings.

Another variable to investigate in future studies would be the classroom setting. While instruction was entirely online through laptop computers, the setting of the current study was still a physical classroom at a middle school. Would middle school students be able to handle this same online environment if they were not in the room with the instructor? Changing the environment may provide a setting closer to the traditional online college class. This may also accentuate some of the advantages of online learning that were discussed previously in the review of the literature, such as budgeting time, as well as the sense of community.

A blended classroom is also worth investigating. While the two conditions used in this study were a stark contrast to each other, a blended classroom may be the more successful option for middle school students. Setting up a similar study with a third blended condition may uncover if a mixture of both methods is in fact better.

A final piece of the study to further investigate is the role of the instructor. Middle school students differ from high school or college students emotionally. In many cases, the instructor is a role model. For middle school students, success may be attained because of the relationship with the teacher rather than the instructional method itself. An online study could be devised with two online conditions that varied the social-emotional bond of students to instructor. In both online conditions, appropriate instruction and feedback would be given. However, in one condition, the teacher would expend additional effort to facilitate a social emotional bond with each individual student. This experiment may indicate the importance of an instructor's connection to his or her middle school students for student learning and enjoyment.

The findings of this dissertation concerning the academic and attitudinal online performance of middle school students will be published in the *Journal of Computers in Mathematics and Science Teaching* (Edwards et al., In Press; Edwards & Rule, In Press).

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APPENDIX A

PRETECHNOLOGY EXPERIENCE SURVEY

1. Do you have a computer at home that you can use? Yes No
2. If so, approximately how much time per day do you use this computer? Approximately ____ hours.
3. Circle the things you do most often on the computer:

Word processing	Email	Instant message/chat	Internet searches
Watching videos	Internet games	Reading News	Blogs
Reading books	Shopping	Other ________	Other ________

APPENDIX B

POST-UNIT ATTITUDE SURVEY

After students have experienced each of the instructional units listed in Table 1, they will be asked to rate the unit by circling a number on three very brief rating scales:

On a scale of 1 to 10, circle the number that indicates how well you now feel you understand the mathematics of this topic?

Don't understand it at all	1	2	3	4	5	6	7	8	9	10	Understand it very well

On a scale of 1 to 10, circle the number that indicates how much you enjoyed the format (face-to-face or online) in which information was presented.

Didn't enjoy it at all.	1	2	3	4	5	6	7	8	9	10	Enjoyed it very much

On a scale of 1 to 10, circle the number that indicates how much you liked the math topic just completed.

Didn't like it at all.	1	2	3	4	5	6	7	8	9	10	Liked it very much

APPENDIX C

POSTTEST INSTRUCTIONAL PREFERENCE SURVEY

Now that you have learned two of the four different math topics face-to-face and two online (decimals, statistics, probability, and algebra functions) which method of information delivery/teaching do you think helped you learn math the best (circle one) and give three reasons why.

Face-to-face or Online

1.
2.
3.

Now that you have learned two of the four different math topics face-to-face and two online (decimals, statistics, probability, and algebra functions) which method of information delivery/teaching do you think was the most enjoyable (circle one) and give three reasons why.

Face-to-face or Online

1.
2.
3.

APPENDIX D

UNIT TESTS

Decimals Test

1S) Identify which number in 34.56789 is in the tenths place.

2S) Write the number "two hundred sixty-seven thousandths" as a decimal.

3S) Write the number "5.06" in word form.

4S) Round 3.32 to the nearest whole.

5M) Round 7.391 to the nearest hundredth.

6M) Put the following numbers in order from LEAST TO GREATEST
2.1 2.09 1.999 2.35 3 2.4

7M) Jarvis made a four-digit number with 0, 3, 6, and 7. The number was smaller than 5 but bigger than 1. What could the number be? How do you know?

8A) How many total thousandths are in the number 3.35? Describe how you know by referring to the blocks we used in class.

9A) 4.96 rounded to the nearest tenth is 5. Why?

10A) Jim's time in the 50m freestyle was 25.59 seconds. List a time that is would be slower but still round to 25.59.

Statistics Test

1S) Use the information on page 28 to create a frequency chart displaying the statistics dealing with presidential vetoes.

2S) Using the statistics on page 32 addressing physical activities and calories burned, what interval would you use to display the data on a bar graph?

3M) Create a stem and leaf plot of the statistics on page 37 referring to presidential ages.

4S) Give a median and mode total for the numbers of counties per state using the picture on page 44.

5S) List the mean and range for question 6 on page 48

6A) Which of the measurements does an outlier usually affect the most (mean, median, mode, range). List a set of numbers to help prove your point.

7M) Which method of measurement would best describe the statistics in the chart on page 49 discussing the heights of tennis players (mean, median, mode, range) and why?

8A) Create your own set of data where the mean, median, mode, and range are all 5.

9M) What is the missing number in the table on page 45 dealing with Wimbledon titles? The median of the statistics is 13 while the mode is both 10 and 13.

10A) List a set of numbers where the mean is 10, the median is less than 10, and the mode is greater than 10.

Probability Test

1S) How many outcomes are possible when rolling a standard die once?

2S) If you have 10 cards labeled 1 through 10, then P (multiples of 4) equals what?

3A) Which would have a more likely probability with two dice… rolling a 2 and a 3, or rolling a 2 and a 2? How do you know?

4M) Use the data above question 5 on page 632 to indicate which team you would want to be on if you really wanted to win (Blue, Pink, or White). How do you know?

5S) Draw a target where your chances of hitting a shaded area are ¾.

6A) Draw a tree a tree diagram to show how many outfit combinations are possible if you have 3 choices of pants, 4 shirt choices, and 2 shoe choices.

7A) Give the probability of rolling an even number and then flipping a head on a coin?

8M) Describe a simple game with coins, card, or dice that would be unfair.

9S) What is the theoretical probability of rolling an odd number on a die?

10M) Two students are playing a game with 10 cards. The cards are numbered from 1 to 10. To play the game, the first player draws a card. If the card is below 5, the first player wins. If any other card is drawn, the other person wins. Is this fair and how do you know?

Algebra Test

1S) What is the next number in the following pattern?
480, 492, 486, 498, 492, 504,?

2M) What is the next number in the following pattern?
3, 7, 15, 31, 63,?

3M) What does the X stand for in $4X = 20$?

4M) What does the X stand for in $X/3= 9$?

5S) Is the following equation true?

$$2 + 3X = 17; X=12$$

6S) What does each of the following words mean?
Product-
Sum-
Difference-
Quotient-

7A) Write an expression that shows many apples you would have if you gained three times as many apples as what you started with, and then ate one. Use A for the number of apples you started with, and Z for how many apples you have at the end.

8S) Write an expression describing X decreased by 7.

9A) Make up a story dealing with the expression $d/2 = m$.

10A) Write an expression to show that person A is 8 inches shorter than person B.

Measurement Test

1M) Measure the width of your desk in inches. Be as exact as possible.

2S) What does each of these metric base units measure?

Meter-
Gram-
Liter-

3S) 5.2 m is the same as how many cm?

4S) The height requirement is 5 feet to be able to ride the roller coaster. If Jenny is 50 inches tall, can she ride and how do you know?

5A) Each crate holds 2 pounds. How many crates will be needed to hold 300 books at 4 ounces apiece?

6M) The first time you measure the pencil, it is ¾ of an inch. The second time it measures at 12/16 of an inch. Is it possible that the pencil could be both of these measurements and how do you know?

7S) Measure your math book to the nearest millimeter.

8A) WITHOUT measuring, look at the door and tell me how many inches tall it is. Tell me how you are coming up with this number.

9M) Take a ruler and look between 1 inch and 2 inches. Draw a diagram to show what measurement each line could stand for. List as many as possible.

10A) WITHOUT measuring, how many centimeters is the room from white board to white board? Tell me how you are coming up with this number.

Symmetry Test

1S) Draw a congruent shape to the trapezoid page 445 letter a in the blue book.

2S) List 5 capital letters that show symmetry. Draw dotted lines to show all their lines of symmetry.

3S) Draw a shape of your choosing. Draw a line somewhere near the shape, but not through it. Draw your shape reflected over that line.

4A) Draw a capital H. How many degrees and in which direction does the H need to be rotated to look how it did to start.

5A) A 90-degree turn clockwise is the same as what degree of turn counter clockwise?

6M) Draw a shape of your choice. Draw what this shape will look like after a clockwise turn of 270 degrees.

7S) Draw a shape with only 1 line of symmetry.

8M) Draw an example of a shape that tessellates and prove that it does with a picture.

9M) On page 461 numbers 6, 7, and 8, tell whether you are looking at a reflection, translation, or rotation.

10A) Draw a shape of your choice. Show the shape again after it has gone through the following in this order...
a. 270 degree rotation clockwise
b. reflection with the symmetry line being underneath the original shape
c. translation down and to the left

Geometry Concepts Test

1S) Define the word vertex.

2S) Draw a 140-degree angle and classify it.

3S) 2:15 on a clock would be what kind of angle?

4M) Draw two examples of an isosceles triangle.

5M) Draw a lone segment and a ray that are intersecting, but not perpendicular.

6A) Use the read question 28 and look at the graph on page 411 to determine why the pairs of lines does not add up to 50.

7A) Comment on the following phrase… "two obtuse angles are supplementary."

8A) If a triangle has angles of 130 degrees and 10 degrees, what is its other angle and classify the triangle using two describing words?

9M) Give the supplementary angle for a 45-degree angle.

10S) Explain and draw the difference between parallel and perpendicular.

Polygons Test

1S) What is the name for a 5-sided polygon?

2S) Give an example to help explain the difference between a regular and an irregular polygon.

3S) List a type of road sign and the polygon it relates to.

4S) List the properties of a square.

5M) Draw an irregular nonagon.

6A) Draw a trapezoid and list ALL the properties needed to be a trapezoid.

7A) True or false and why… All squares are rectangles but not all rectangles are squares.

8A) Why can't the kite on page 439 be a trapezoid, a parallelogram, a rhombus, a rectangle, or a square?

9M) If all the sides of an octagon are the same, can it still be a rhombus?

10M) Classify shape number 9 on page 438 in as many ways as possible.

Perimeter Test

1S) What is the perimeter of a square with sides of 10mm?

2S) If one side of a rectangle is twice as big as another side, and the largest side is 20, what is the perimeter of the rectangle?

3S) What is the perimeter of the triangle in number 7 on page 213?

4S) What is the perimeter of a regular hexagon when one of the sides is 8?

5M) To get to school, you walk 6 blocks east and 8 blocks north. Draw this diagram and then calculate how far your trip would be if you took a straight path northeast from your house to the school.

6M) Fill in the blanks for the following circle. You can use 3 for pi.
Radius = _____
Diameter = 10
Circumference = _____

7A) If a goat is tied to a stake and the rope is 30 feet long, how far is it around the circle it could walk around?

8M) On page 213, look at number 9. Find the two missing sides and then the overall perimeter.

9A) Find the PERIMETER (NOT AREA) of the irregular shape at the bottom of page 263. Show how you came to this conclusion.

10A) Find the PERIMETER (NOT AREA) of the irregular shape (number 15) of page 264. Show how you came to this conclusion.

Standard Area Test

1S) What is the area of a square with sides of 10mm?

2S) If the area of a rectangle is 120 square cm and one of its sides is 6cm, what is the other side length?

3S) Using the colored map on page 232, what is the AREA of the outline of the mall?

4S) Give the area of the triangle in question 2 on page 240.

5A) What shape would you want to build a fence if you wanted to maximize its area? Give your reason why.

6M) Fill in the blanks for the following circle. You can use 3 for pi.
Radius = _____
Diameter = 10
Area = _____

7A) If a goat is tied to a stake and the rope is 30 feet long, how big is the space it could use to eat grass?

8A) The circular sandbox is 8 feet across. If the two brother each have a half of the sand box, how big is their half?

9A) A regular decagon is 11 meters across. What shape could you use to help estimate its area and how do you know?

10M) A triangles base is a quarter of what its height is. The height of the triangle is 12. What is the area?

APPENDIX E

INSTRUCTIONAL RESOURCES

Topic	General Task	Online condition hardware, software, or website	Face-to-face condition manipulatives, non-text printed activities
All /Most Topics	Use manipulatives to show concepts	National Library of Virtual Manipulatives (NLVM) (Utah State University, 1999-2010)	Plastic manipulatives
	Watch demonstration of math concepts in video made by instructor	Video posted at instructor's website made with iMovie software (Apple Incorporated, 1999-2011).	Lecture by instructor
	Writing Tool	Promethean ActivInspire (Promethean Limited, 2011),	Paper and Pencil
	Concept Practice	AAA Math (Banfill, 2011)	Math Book
	Concept Practice	Quia (IXL Learning, 2011)	Math Book
	Concept Practice	Funbrain (Pearson Education, 2000-2011)	Math Book
	Concept Practice	Harcourt School (Harcourt, Inc., n.d.)	Math Book
	Concept Practice	Study Stack (Weidner, 2001-2011)	Math Book
	Concept Practice	Crickweb (Crickweb, 2002-2011)	Math Book
	Concept Delivery	YouTube Channel (bucs2812, 2008-2011)	
Decimals	Represent decimal place value	Base 10 blocks from NLVM	Plastic base 10 blocks
	Concept Practice	Baseball Math (Popovici, 2007-2010)	Math Book
Statistics	Concept Delivery	Creating a Frequency Table (TheMathClips, 2009)	Teacher Lecture
Probability	Coin Flip Probability	Ken White's Coin Flipping Page (White, n.d.)	Pennies
	Dice Roll Probability	Simulated Experimental Dice Roll Data (Lemieux, 2002)	Dice
	Spinner Probability	Spinner from NLVM	Paper Spinners
Algebra	Function Practice	Function Machine from NLVM	In and Out Activity

(Table Continues)

Topic	General Task	Online condition hardware, software, or website	Face-to-face condition manipulatives, non-text printed activities
Measurement	Ruler Simulation	The Ruler Game (Spears, 2002-2003)	Plastic Rulers
	Concept Delivery	How to Read a Tape Measure (James01crown, 2009)	Teacher Demonstration
	Concept Delivery	Math Lessons: How to Read a Ruler Marked in 16ths (eHow, 2009)	Teacher Demonstration
Symmetry	Shape Symmetry	Symmetry Game (Hampshire Education, n.d.)	Plastic Shapes
	Reflections	Symmetry Activity (Haelmedia, n.d.)	Graph Paper
	Transformations from one to another	Transformation Golf (Actis, 2001-2003)	Graph Paper
	Transformations from one to another	RoboPacker (Houghton Mifflin, n.d.)	Graph Paper
	Concept Delivery	Video for Lesson 29: Introduction to Symmetry (Mathwithlarry, 2008a)	Teacher Lecture
	Concept Delivery	Video for Lesson 98: Similar vs. Congruent (Mathwithlarry, 2008b)	Teacher Lecture
Geometry	Measure Angles	What's My Angle (Robinson, 2000)	Plastic Protractor
	Estimating Angles	Alien Angles (Math Playground, 2010)	Looking at pictures of angles
	Demonstration	Angles (Episodic, 2008)	Teacher Demonstration
	Concept Delivery	Math Made Easy: Complimentary and Supplementary Angles (Jediteacher2007, 2009)	Teacher Demonstration
Polygons	Drawing Triangles	Triangle Classification Game (Bortolossi, n.d.)	Graph Paper
	Creating Shapes	Geoboard from NLVM	Plastic Geoboards
	Creating Shapes on a Graph	Coordinate Geoboard from NLVM	Graph Paper
	Concept Delivery	Math Made Easy: Polygons (Jediteacher2007, 2009)	Teacher Demonstration

(Table Continues)

Topic	General Task	Online condition hardware, software, or website	Face-to-face condition manipulatives, non-text printed activities
Perimeter	Finding Perimeter	Perimeter Explorer (Shodor, 1994-2011)	Graph Paper
	Finding Compound Perimeter	Perimeter (British Broadcasting Company, 2011a)	Hand Drawn Pictures
	Finding Compound Perimeter	Perimeter Compound Shapes (British Broadcasting Company, 2011b)	Hand Drawn Pictures
	Finding Compound Perimeter	Everything You Want to Know About Perimeter and Area (Birmingham Grid for Learning 1999-2011)	Hand Drawn Pictures
Area	Finding Compound Perimeter	Everything You Want to Know About Perimeter and Area (Birmingham Grid for Learning 1999-2011)	Hand Drawn Pictures