Educational Outcomes of Synchronous and Asynchronous High School Students:
A Quantitative Causal-Comparative Study of Online Algebra 1

A doctoral thesis presented by
Sharon Berry

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

College of Professional Studies
Northeastern University
Boston, Massachusetts
August, 2017
Acknowledgements

First and foremost, I would like to express my deepest thanks to my advisor, Dr. Corliss Brown Thompson, for guiding me through the dissertation phase of my coursework. Your helpful feedback and endless support throughout this long journey was greatly appreciated.

I would also like to thank my thesis committee members, Dr. Kelly Conn and Dr. Mark Slider, for their feedback, encouragement, and valuable time during the defense process.

A special thank you to all my Northeastern classmates for the constant encouragement on our message boards. Knowing that others are facing the same struggles and frustrations has been very comforting.

Last, but not least, a huge, heartfelt thank you to my family. I could not have completed this without your love and support. John, thank you for putting up with my laptop being a third wheel on every vacation we've taken in the last five years, including our honeymoon. What some would have been annoyed with, you turned into a joke between us, taking pictures of me working to finish a paper or complete a discussion board post during our trips. Thank you also to my parents for always supporting my educational journey, even when it veered in an unpredictable direction.
Abstract

This study used a quantitative, causal-comparative design. It compared educational outcome data from online Algebra 1 courses to determine if a significant difference existed between synchronous and asynchronous students for end-of-course grades, state assessments scores, and student perceptions of their course. The study found that synchronous students had significantly lower end-of-course grades and standardized test scores than asynchronous students. In addition, it was found that there was no difference between synchronous and asynchronous formats in student perceptions of transactional distance. Nevertheless, the findings provide valuable information regarding outcomes in online Algebra 1 courses. The study includes a discussion of the problem of online mathematics instruction, along with several research-based suggestions for improving online mathematics instruction at the high school level. Several recommendations for future research are discussed.

*Keywords:* online high school mathematics, synchronous and asynchronous, Algebra 1, transactional distance theory
Table of Contents

Chapter 1: Introduction ........................................................................................................... 9
  Statement of the Problem ................................................................................................. 9
  Significance Statement .................................................................................................... 10
  Purpose Statement ........................................................................................................ 13
  Positionality Statement .................................................................................................. 13
    My Background ........................................................................................................... 14
    Socioeconomic Status and Geographic Location ....................................................... 14
    Online Teaching Experience ....................................................................................... 15
    Online Student Experience ......................................................................................... 16
  Challenges Relating to my Positionality and Biases ..................................................... 16
The Study ............................................................................................................................ 16
Research Question ........................................................................................................... 17
  Subquestions ................................................................................................................ 17
Theoretical Framework .................................................................................................... 18
  The Three Variables Defined ....................................................................................... 19
  Guiding Principles ....................................................................................................... 22

Chapter 2: Literature Review .............................................................................................. 24
  History of Distance Education ....................................................................................... 27
  Expansion of Online Learning ....................................................................................... 28
  Benefits of Online Schooling ....................................................................................... 31
    Equity ........................................................................................................................ 31
    Communication ......................................................................................................... 33
    21st Century Skills .................................................................................................... 34
  Challenges .................................................................................................................... 34
  Factors for Success ...................................................................................................... 37
    Student Traits ........................................................................................................... 37
    Dialogue ................................................................................................................... 38
    Course Structure ...................................................................................................... 40
    Learner Autonomy .................................................................................................... 42
  Efficacy ......................................................................................................................... 44
    Synchronous and Asynchronous .............................................................................. 45
    High School Mathematics ......................................................................................... 51
  Conclusion ..................................................................................................................... 54

Chapter 3: Methodology .................................................................................................... 59
  Restatement of the Problem .......................................................................................... 59
  Research Questions and Hypotheses ........................................................................... 60
    Research Question .................................................................................................... 60
    Subquestions .............................................................................................................. 61
    In-Depth Look at Each Subquestion ......................................................................... 61
  Research Design .......................................................................................................... 65
  Population and Sampling ............................................................................................. 66
  Data Collection ............................................................................................................ 69
Appendices........................................................................................................................................157
Appendix A: IRB Approval .............................................................................................................157
Appendix B: Transactional Distance Scale .........................................................................................158
List of Tables

1. Types of K-12 Online Programs ................................................................. 25
2. Pennsylvania Keystone Exam Performance Level Definitions .......................... 71
3. Student Demographics ........................................................................... 87
4. Chi-Square Results .................................................................................. 89
5. Group Statistics for STAR 360 Math Scores and Students' Age ..................... 91
6. T-Test Results for STAR 360 Math Scores and Students' Age ......................... 92
7. Group Statistics for End-of-Course Grades ................................................. 95
8. T-Test Results for End-of-Course Grades .................................................. 96
10. T-Test Results for Keystone Scores ........................................................... 98
11. Tests of Normality ....................................................................................101
12. Test for Multicollinearity ..........................................................................103
13. Test for Homogeneity of Variance ............................................................104
14. MANOVA Result .....................................................................................105
15. Group Means for Constructs ....................................................................106
16. Shapiro-Wilk Test for Normality for Synchronous Students .......................109
17. Spearman's Rho Correlation for Synchronous Student ............................... 110
18. Shapiro-Wilk Test for Normality for Asynchronous Students ....................... 115
19. Spearman's Rho Correlation for Asynchronous Students ............................116
List of Figures

1. The interaction between structure, dialogue, and autonomy ........................................... 21
2. Linearity of each DV with the IV ....................................................................................... 102
3. Scatter plot showing relationship between Keystone Exam scores and final grades for synchronous students ........................................................................................................ 107
4. Synchronous final grades box plot .................................................................................... 108
5. Synchronous Keystone Exam grades box plot ................................................................. 109
6. Scatter plot showing relationship between final grades and Keystone Exam scores for asynchronous students ........................................................................................................ 112
7. Asynchronous final grades box plot ................................................................................ 113
8. Asynchronous Keystone Exam grades box plot ............................................................... 113
9. Scatter plot of final grades and Keystone Exam scores without outliers ...................... 114
Chapter 1: Introduction

Statement of the Problem

The story of our nation's public schools failing to provide a quality education for all students is not new. It is a topic of discussion on television, in newspapers and magazines, and during most political debates. In recent years, this has led to national pressure to improve K-12 education (C. Kim, Park, & Cozart, 2014). For various reasons, many families seek alternatives to their neighborhood public schools. In the past, alternatives have come in the form of vouchers, private schools, and charter schools (Ryan, 2010). A more recent alternative, the option to attend public school completely online, may be a much-needed solution. There has been a dramatic increase in the number of online K-12 courses offered since the start of this century (Barbour & Reeves, 2009; P. Kim, Kim, & Karimi, 2012; Liu & Cavanaugh, 2012).

Online learning is relatively new at the high school level, so there is little research on the efficacy of K-12 online education (Murphy, Rodriguez-Manzanares, & Barbour, 2011; Rauh, 2011). Previous research at this level focused on the advantages and disadvantages of online schooling (Cavanaugh, Barbour, & Clark, 2009) and on comparing instruction in online courses to that in classroom-based courses (Goel, Zhang, & Templeton, 2012; Murphy et al., 2011). As more online courses and programs are offered at the high school level, additional research on online education is needed to provide information that will help stakeholders make informed decisions about online learning. Students and parents have many options when choosing an online program (Koenig, 2011), and need additional information to aid their decision making process. Teachers, administrators, and policy makers want proof that students are receiving a high-quality education in the online environment. As the number of students enrolled in online courses continues to grow (Barbour & Reeves, 2009), and stakeholders are faced with choosing
between asynchronous and synchronous modes of online instruction, additional research is needed to compare educational experiences in synchronous and asynchronous courses.

Because success in mathematics is essential in moving a society forward, the United States government has placed importance on improving mathematics instruction in schools (Liu & Cavanaugh, 2012). Specifically, the quality of algebra courses has been receiving attention due to U.S. students performing lower than their international peers on international mathematics tests, students scoring below the proficiency level on state math tests, and the increased need for qualified workers in science and engineering fields (Cavanaugh, Gillian, Bosnick, Hess, & Scott, 2008). Some research suggests math and science are the hardest content areas to teach online (Cavanaugh et al., 2008), making it more important that students who choose online education have access to high quality math courses. This study added to current research by determining whether the method of online instruction, synchronous versus asynchronous, affects students' educational outcomes in Algebra 1.

Significance Statement

Due to technological advances in recent years, the American economy is tied to global markets. It has become apparent that the success of the United States in this global economy requires students to become technically skilled (Gomez & Albrecht, 2013). Many students graduating from the public school system are not prepared for the rigorous demands of post-secondary educational institutions or the 21st century workforce (Kay, 2010). Routine jobs, historically filled by individuals who did not graduate from high school or attend college, can now be done by technology (Kay, 2010). It has become clear that if the United States wants to continue to be competitive in the global market, all high school students should graduate from high schools that provide a rigorous, quality education.
According to the Alliance for Excellent Education (2010), about 7,000 students drop out of school daily in the United States. Leaving school prior to graduation has negative effects on students, their families, school districts, and neighborhoods, and those effects are felt at the state and federal level. Traditionally, high school dropouts earn less than high school graduates, have increased health costs, are more likely to be incarcerated, and put a strain on the welfare system (National Education Association, 2008). It is easy to understand why increasing the graduation rate has become a national focus: it alleviates the stress put on social and economic programs. As Kay (2010) noted, even those students who do graduate may have lacked access to a rigorous curriculum that would have prepared them for a successful future.

The lack of equitable access to rigorous, high-quality instruction is evident on national tests, such as the Scholastic Aptitude Test (SAT). The 2015 College Board Program Results (College Board, 2015) shows a bleak picture of students’ future. The College Board (2015) found that less than half (41.9%) of all students in the graduating class of 2015 who took the SAT were academically prepared for college-level course work, based on their test scores. According to the 2013 SAT Report on College & Career Readiness (College Board, 2013), 89% of the students who met or exceeded the college and career readiness benchmark in 2013 took upper level math courses (above Algebra 2), and 79% of the students who met the benchmark took Advanced Placement (AP) or honors-level courses. These results support the need for all students to have equitable access to rigorous, high-quality educational opportunities.

One potential solution to the lack of access to rigorous, high-quality courses is to encourage students to participate in online courses (Flowers, 2011). Online education could be the answer to preparing students for global competitiveness (Zucker & Kozma, 2003). Students living in rural areas or attending low-achieving schools that lack quality higher level courses
could have access to improved educational opportunities through online courses (Cavanaugh, 2001). Online courses could increase access to a rigorous curriculum with high-quality, trained teachers; which would contribute to the success of all students (Museus, Palmer, Davis, & Maramba, 2011). Effective online education is also a viable option for students who have become disengaged in school and need a fresh start, free from distractions. Taking courses online may be what some students need to successfully complete graduation requirements.

As shown by the increased demand for online courses (Barbour, 2011; Cavanaugh, Gillan, Kromrey, Hess, & Blomeyer, 2004) and the rising student enrollment in online programs, online education will continue to be an educational choice, at least for the near future. To provide an effective alternative to classroom-based education, K-12 schools must offer online courses and programs that are high in rigor and quality. Before they can offer such courses, school administrators must have reliable research studies that enable them to make educated decisions regarding their programs, specifically relating to the creation and maintenance of synchronous and asynchronous courses.

A study of the effectiveness of synchronous and asynchronous online course formats is important for several reasons, the first of which is simply the growing number of virtual learning opportunities available to high school students. Concerns have been raised about the educational outcomes of online programs, so evaluating the quality and effectiveness of these programs has become a priority for educators (Cowan, 2009). Online education can be utilized to provide access to quality instruction for all students. Individual students and families are affected the most by online education, as it offers much-needed flexibility (P. Kim et al., 2012; Koenig, 2011) for students involved in competitive athletics, modeling, or drama; for students whose parents serve in the military and are required to move frequently; and for those families affected
by safety or overcrowding issues in their neighborhood school (Greenway & Vanourek, 2006).

**Purpose Statement**

The purpose of this causal-comparative research study was to determine if a significant difference exists between the educational outcomes of students enrolled in synchronous online Algebra 1 courses and those enrolled in asynchronous courses. This research added to the current research on online education by exploring differences between synchronous and asynchronous courses. This is important for those stakeholders who have already chosen online courses as their best educational option. This study is important to a practitioner audience because it provides insight into whether asynchronous courses have educational outcomes comparable to the outcomes obtained in a synchronous setting. District and school administrators can use the information gained from this research to plan and develop their own online courses. Creating quality online courses in both synchronous and asynchronous formats will improve students’ learning experiences. Furthermore, the findings will guide much-needed future research into creating and teaching quality online courses. As the number of students interested in taking online courses continues to grow (Barbour & Reeves, 2009), further research will be needed to determine what developers and teachers can do to improve the educational experience in online courses.

**Positionality Statement**

This study originates from the researcher's experiences with online education. In recent years, online education has become increasingly popular at the secondary level (Cavanaugh et al., 2009). Many high schools offer individual courses, or even entire programs, online. It is important for school leaders who embrace online education to determine which online delivery method, synchronous or asynchronous, would be most beneficial for their school. In examining
this problem of practice, my perspective on online learning is drawn from my experiences.
Creswell (2012) stressed the importance of researchers disclosing experiences and biases that may affect the study.

My Background

I have been fortunate in my teaching career to have experience in elementary, secondary, and community college teaching. I taught second and fifth grades at a traditional elementary school in Virginia, and high school math at two different public, cyber charter schools in Pennsylvania. I have also taught at a community college, where I taught both traditional and hybrid courses. In my online teaching experience, I have taught synchronous and asynchronous courses. My experience with traditional and online education has fostered my interest in the effectiveness of online educational programs.

Socioeconomic Status and Geographic Location

My family lived in a rural community in upstate New York while I was growing up. My family was lower middle class. My high school graduating class had 73 students, only about half of whom continued their education at a two or four year college or technical program. My high school did not offer any Advanced Placement courses at the time, and precalculus was the highest math class offered. After high school, I attended a small private college in western Pennsylvania where most students were from upper and upper middle class families and had attended larger suburban schools. Most of my classmates had access to upper level and AP courses in high school that better prepared them for the rigors of college.

My family's socioeconomic status and our geographic location influenced my problem of practice in some very obvious ways. Living in a rural area limited the number of advanced level courses offered at my high school. My current teaching experience, at a cyber charter school,
offers a solution to the lack of rigorous, high-quality courses available to students in rural or low-income schools.

**Online Teaching Experience**

As an online educator at a public K-12 cyber school in Pennsylvania with almost 9,000 students, and as a student in an online doctoral program, this problem of practice is personally meaningful to me. My experience as a high school math teacher at a cyber school in Pennsylvania has illuminated both the benefits and drawbacks of online education. Online education can support individualized instruction for all students as well as provide an alternative for students and families who are not satisfied with their current educational experience. Students from across Pennsylvania are able to enroll at my school. There are no district restrictions for attending, other than being a resident of the state. The school provides all students with a computer, printer, scanner, headset with microphone, and camera, and also reimburses families for internet service. The statewide enrollment and supply of technology equipment eliminates two of the factors Ryan (2010) addressed as hindrances to quality education: access to high-quality education because of geographic location and income level.

Through my online teaching experience, I have taught both synchronous and asynchronous courses. In general, I find that students in synchronous courses are more likely to stay up to date with their assignments, interact more with their peers, and be more engaged in the class and the school community. Many high school students seem to lack the self-motivation and organization skills necessary to be successful in asynchronous courses. The guidance provided and the opportunity for immediate feedback in synchronous courses appear to be beneficial to many high school students. Even at the doctoral level, I have found self-motivation and organization necessary for success in my own online courses.
Online Student Experience

As a student in an online doctoral program, I understand the challenges of online learning, such as the lack of socialization, difficulty building relationships, importance of self-motivation, and the necessity of time management and being able to work independently. Students in online programs lack the face-to-face interactions that many high school students need. This lack of socialization with peers and teachers is often cited as a drawback of online education. Cowan (2009) noted that using online education as the total instructional method may cause students to lose many of the benefits of traditional schools, including face-to-face interaction, exposure to diversity, and social development.

Challenges Relating to my Positionality and Biases

My personal and professional experiences have led me to believe online education can be an effective alternative to classroom education at the high school level in many circumstances. As I researched online learning and gathered data, it was important to remember that although my experience with online education has been favorable, not everyone has the same viewpoint. During the literature review, it was imperative to explore research studies that both supported and challenged the efficacy of online instruction. Research studies that compared synchronous and asynchronous learning outcomes for high school students were a priority, but all studies relating to the two methods of online instruction were considered.

The Study

Even as the number of online courses and programs continues to increase in the United States, research comparing the educational outcomes of synchronous and asynchronous courses is still catching up. The goal of this study was to provide additional research about synchronous and asynchronous courses to parents, teachers, administrators, and district employees who are
interested in creating or modifying existing online courses or programs without allowing biases to interfere with the research, data collection, or analysis.

The primary aim of this study was to explore whether students in asynchronous courses had the same educational outcomes, as measured by state test scores, final course grades, and student surveys, as their peers who received synchronous instruction. This aim led to the following research questions.

**Research Question**

Does the method of online instruction, synchronous versus asynchronous, affect the educational outcomes, measured by (a) end-of-course grades, (b) state standardized test scores, and (c) students' perceptions of educational experience, of Algebra 1 students enrolled at a public, cyber charter school in Pennsylvania?

**Subquestions**

- To what extent do end-of-course grades differ between synchronous and asynchronous students enrolled in Algebra 1 at a public, cyber charter school in Pennsylvania?
- To what extent do scores on the Algebra 1 Keystone Exam differ between synchronous and asynchronous students enrolled in Algebra 1 at a public, cyber charter school in Pennsylvania?
- To what extent do synchronous students' perceptions of their educational experiences differ from the perceptions of asynchronous students enrolled in Algebra 1 at a public, cyber charter school in Pennsylvania?
- Does a correlation exist between Algebra 1 end-of-course grades and Keystone Exam scores for synchronous students enrolled in Algebra 1 at a public, cyber charter school in Pennsylvania?
Does a correlation exist between Algebra 1 end-of-course grades and Keystone Exam scores for asynchronous students enrolled in Algebra 1 at a public, cyber charter school in Pennsylvania?

These research questions framed this investigation into whether or not educational outcomes in Algebra 1 are affected by the mode of online instruction (synchronous or asynchronous). The following theoretical framework was chosen to guide the research because it focuses on three very important factors in online instruction: dialogue, structure, and learner autonomy. These factors are integrated into courses differently depending on the mode of instruction, but all affect the educational outcomes (final course grades, state test scores, student perceptions) of online courses.

**Theoretical Framework**

The theoretical framework chosen to guide this research study was the transactional distance theory. This theory was developed by Michael Moore, beginning in the early 1970s when it was originally coined the theory of independent learning and teaching (Moore, 1973). Moore’s original theory focused on three factors: learner autonomy, teacher-created instructional programs, and communication systems. In 1980, Moore renamed his framework the theory of transactional distance and by 1993, Moore had fully developed and defined the theory.

Moore's (1973) goal was to create a theoretical framework that embraced the growing field of distance education. Transactional distance is not only the geographic distance between the instructor and student in a learning environment, but more importantly it is the distance caused by communication factors that must be overcome for learning to occur (Moore, 1991, 1993). Some transactional distance exists in all learning programs, virtual and classroom-based (Moore, 1980), but because of the geographic distance between the instructor and students in
virtual learning, transactional distance is greater in online courses. Transactional distance in online learning is a function of three variables: dialogue, structure, and learner autonomy (Moore, 1993).

**The Three Variables Defined**

**Dialogue.** Moore (1993) defined dialogue as it relates to transactional distance theory as:

Dialogue is developed by teachers and learners in the course of the interactions that occur when one gives instruction and the others respond...A dialogue is purposeful, constructive and valued by each party. Each party in a dialogue is a respectful and active listener; each is a contributor, and builds on the contributions of the other party or parties...The direction of the dialogue in an educational relationship is towards the improved understanding of the student. (p. 21)

Immediate feedback and face-to-face communication opportunities are a challenge that teachers and students must face in the virtual setting. The amount of dialogue in an online course is determined by many factors, including the teacher’s educational philosophy, the personalities of both the instructor and students, the subject matter being taught, the number of students on a teacher's caseload, and the types of communication used (email, phone, discussion board, class discussion during virtual lessons, and recorded videos) (Moore, 1993). Dialogue between students and the instructor and between students is more likely to occur in synchronous courses. Students are able to ask questions, receive immediate feedback, and interact in real-time discussions during synchronous class sessions. Asynchronous students can communicate with the teacher by email, phone, and discussion boards, but they do not receive immediate feedback or benefit from listening to other students’ questions and comments. Moore (1993) proposed that transactional distance is likely to be lessened through the use of highly interactive mediums, such
as phone calls and class discussions, rather than less interactive mediums, like video recordings or written lessons. The amount and type of dialogue in a class will drive the structure required.

**Structure.** The second variable affecting transactional distance is structure, which Moore (1993) defines as “the rigidity or flexibility of the programme's educational objectives, teaching strategies, and evaluation methods. It describes the extent to which an education programme can accommodate or be responsive to each learner's individual needs” (p. 23). The structure of a course is primarily determined by the communications being used, the instructor’s teaching philosophy, the content being taught, and the personalities of both the instructor and the students (Moore, 1993). Highly structured courses define the materials and skills for the student, and allow no variation. Video recordings and static pre-made online lessons are highly structured, while live discussions and questions requiring open-ended written responses are less structured (Moore, 1993). Transactional distance is lower when there is frequent dialogue and minimal structure in a course (Moore, 1980, 1991). Asynchronous course materials are more likely to be highly structured, because dialogue does not occur frequently. These highly structured course materials provide guidance and direction to the student (Moore, 1993) and create a high level of transactional distance. Synchronous courses have lower transactional distance due to the increased dialogue present. In synchronous courses, students are able to receive directions and guidance through dialogue with a teacher (Moore, 1993). Synchronous course instructors are able to modify instruction based on the needs and interests of students during the live sessions, whereas asynchronous students do not receive that benefit. Similarly, teachers are able to adjust their teaching methods and strategies and include various evaluation methods during synchronous instruction, none of which are possible during asynchronous instruction.

**Autonomy.** The final variable in transactional distance theory is the autonomy of the
learner, which Moore (1993) defines as “the extent to which in the teaching/learning relationship it is the learner rather than the teacher who determines the goals, the learning experiences, and the evaluation decisions of the learning programme” (p. 28). Autonomous learners use the instructor to guide learning when they encounter an obstacle, but are able to independently monitor and direct their own learning (Moore, 1972, 1973, 1980). In contrast, non-autonomous learners need an instructor to direct their learning (Moore, 1973). A course with low dialogue and high structure, as found in asynchronous delivery formats, will require the learner to exercise more autonomy (Moore, 1993). This relationship can be seen in Figure 1. The nature and personality of the learner, specifically the potential to be self-directed, is important in successful online learning (Moore, 1993). Dialogue, structure, and autonomy work together in virtual courses. Students in asynchronous courses have greater autonomy, allowing for more flexibility in pacing, class work schedule, and determining which resources are used to learn content, although they also have greater structure and less dialogue. Students in synchronous courses must attend live class sessions at specified times and follow the pace set by the teacher, so they have less autonomy, but they also have less structure and increased dialogue. A student cannot be successful in a course that demands more autonomy than that student possesses (Moore, 1980), making it essential to match the course to the student’s level of autonomy.

![Autonomy](image)

**Figure 1.** The interaction between structure, dialogue, and autonomy (Andrade, 2015).

Academic success in online courses is determined by a number of factors relating to
dialogue, structure, and autonomy. In many traditional high schools, teachers are responsible for leading the learning and assessment, and students become passive learners (Moore, 1980). In virtual courses, students are required to participate more actively in their learning. To aid students in their learning, online instructors should structure course materials for learners with varied levels of autonomy (Moore, 1980). Instructors must provide opportunities for frequent and quality communication, as well as appropriately structured learning materials (Moore, 1991) to support learning.

**Guiding Principles**

The guiding principles of the transactional distance theory are as follows (Moore, 1993).

- Transactional distance is continuous, not discrete;
- Transactional distance is relative, not absolute;
- Transactional distance is minimized by highly interactive communication mediums;
- Course structure is determined by communications media used, teacher philosophy, personalities of teacher and students, content being taught, and constraints imposed by the educational institution;
- The greater the transactional distance, the more autonomy the learner must exhibit; and
- The greater the structure and the lower the dialogue, the more autonomous the learner.

Moore's transactional distance theory focuses the research questions for this study. According to Moore, online learning will be maximized if the transactional distance is minimized through interaction, structure, and autonomy. Synchronous courses have increased opportunities for dialogue between the teacher and student as well as between students. Similarly, synchronous students also experience less structure in the course as the instructor is able to modify the pace of the content and also target areas in need of review through direct
observation during required class sessions. Increased dialogue and less structure decreases transactional distance. However, with increased dialogue and decreased structure, students will have less autonomy. In contrast, asynchronous students will have less dialogue, more structure, and need to exhibit greater autonomy as they are directing their own learning and monitoring their understanding independently. The subquestions chosen for this study investigate whether transactional distance impacts student achievement and student perceptions.
Online learning has become increasingly popular in the United States. Most colleges and many high schools now offer courses or even entire programs online. Early online courses were presented in asynchronous formats, but advances in technology have afforded schools the opportunity to offer synchronous courses (Hrastinski, 2008a). With the rapid growth of online education programs in high schools, the need has arisen to assess the efficacy of synchronous and asynchronous formats of online education (Roblyer, Freeman, Donaldson, & Maddox, 2007).

Online education has become popular because schools and families recognize the importance of expanding access to high-quality courses and providing educational choice (Barbour & Reeves, 2009; Rauh, 2011). Virtual schools vary greatly in the characteristics that define them (Greenway & Vanourek, 2006). Some virtual schools allow students to be dual enrolled, meaning a student can take a few courses online while remaining enrolled in a regular public school for other courses. Some virtual schools require students to be solely enrolled in their program, taking all their courses online. Some virtual schools service only students in one district, while others provide services to students living in a specific state, and still others offer courses to anyone in the United States (Greenway & Vanourek, 2006).

Virtual schools are classified by many characteristics, including comprehensiveness (supplemental or stand alone), geographic reach (one district or statewide), type (public, private, charter), location (students are located in a school or at home), delivery (synchronous or asynchronous), and control (who runs it) (Greenway & Vanourek, 2006). Watson, Winograd, and Kalmon's (2004) widely used classification of virtual school programs identified five types of online programs available to K-12 students in the United States. Table 1 gives a brief
overview of these five different types of programs.

Table 1

*Types of K-12 Online Programs*

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statewide supplemental programs</td>
<td>Students take individual courses but are enrolled in a physical school or cyber school within the state. These programs are authorized by the state and overseen by state education governing agencies.</td>
</tr>
<tr>
<td>District-level supplemental programs</td>
<td>Are typically operated by autonomous districts and are typically not tracked by state agencies.</td>
</tr>
<tr>
<td>Single-district cyber schools</td>
<td>Provide an alternative to the traditional face-to-face school environment and are offered by individual districts for students within that district.</td>
</tr>
<tr>
<td>Multi-district cyber schools</td>
<td>Are operated within individual school districts but enroll students from other school districts within the state. This represents the largest growth sector in K-12 online learning.</td>
</tr>
<tr>
<td>Cyber charters</td>
<td>Are chartered within a single district but can draw students from across the state. In many cases they are connected in some way to commercial curriculum providers.</td>
</tr>
</tbody>
</table>

*Note.* Descriptions of program types are taken from Watson et al. (2004).

Distance education, distance learning, online education, virtual schools, and cyber schools are used interchangeably in most research (Rice, 2006). Due to the ambiguous nature of these terms, this study has adopted the definition of a virtual school given by Barker, Wendel, and Richmond (1999): *Virtual schools* are “characterized by a structured learning environment under the direct supervision of a teacher, web-based delivery to home or in a setting other than that of the teacher, and contains instruction that may be synchronous or asynchronous” (p. 2).

*Online education* and *virtual education* will be used synonymously to mean an educational setting where the teaching occurs geographically apart from the student who is learning through the use of computers and telecommunications technology (Moore, 1972; United States Department of Education, 2006).

Virtual schools provide several delivery format options. Some offer *synchronous courses*,
in which students are required to log in and attend a live classroom session led by the instructor at a specified time each day (Freeman, 2010). Students in synchronous courses are able to interact with the teacher in real time during the lesson and get immediate feedback to their questions (Hrastinski, 2008a; Martin, Parker, & Deale, 2012). Others offer asynchronous courses, which are more flexible and allow students to log in anytime during the day to complete their lessons and assignments (Hrastinski, 2008a). Asynchronous courses allow students to interact with their teachers, but there is often a delay in feedback due to the teacher and student not being online at the same time (Freeman, 2010).

The idea of distance education is not new, but with recent technological advances, the growth of virtual education has exploded (Rice, 2006). According to Davis (2012), all 50 states offer online learning, through either school districts or private providers. The rapid growth of online education has exposed national concerns about the effectiveness of these programs (Davis, 2012). The effectiveness of online courses and student achievement is still being debated by scholar-practitioners, with most of the past research in online education focusing on college programs (Barth, Hull, & St. Andrie, 2012). The advantages and disadvantages of online education (Cavanaugh et al., 2009) and the academic achievement of online students versus their traditional classroom counterparts (Goel et al., 2012; Murphy et al., 2011) have been studied and reported on in depth.

Even though online education has been occurring since the late 1970s, research on the efficacy of K-12 online education is relatively new (Rauh, 2011). While evidence is limited, there is good reason to suggest that cyber education is effective and, with high-quality educators teaching online courses, students can excel in academics (Lips, 2010). Greenway and Vanourek (2006) stressed that putting the word “virtual” in front of “school” does not make that school
good or bad. The quality of a school is based on the quality of the curriculum, teachers, and leadership (Greenway & Vanourek, 2006). Cavanaugh et al., (2004) suggested that teacher quality is the leading factor in student learning, regardless of whether the student is online or in a traditional classroom. With research on the efficacy of online education at the K-12 level being new (Barth et al., 2012; Liu & Cavanaugh, 2012; Murphy et al., 2011; O'Dwyer, Carey, & Kleiman, 2007; Rice, 2006), there are even fewer studies (Offir, Lev, & Bezalel, 2008; Olson & McCracken, 2015; Roblyer et al., 2007) assessing the difference in learning outcomes for synchronous and asynchronous learners. This lack of research on synchronous and asynchronous formats drove the need for this study.

This review of the literature on online education begins with a history of distance education, followed by reasons for the rapid expansion of online learning in the United States. The advantages and disadvantages of online programs are discussed briefly. Factors affecting student success are explored, with a focus on student traits, dialogue, course structure, and learner autonomy. The review ends with an in-depth look at research relating to the efficacy of online high school mathematics courses and synchronous and asynchronous courses.

**History of Distance Education**

The history of distance education is long; it dates to the 1700s, when job training was provided through mail correspondence (Olszewski-Kubilius & Corwith, 2010). Correspondence education continued into the 1800s, as colleges began offering students the opportunity to take distance courses (Greenway & Vanourek, 2006). Students living off campus exchanged lessons and assignments with their professors using the Postal Service (Olszewski-Kubilius & Corwith, 2010). Distance education expanded in the 1930s, when radio was used to provide learning opportunities to elementary and high school students (Cavanaugh et al., 2004). In the 1950s,
distance education improved slightly because of newer technologies such as television (Olszewski-Kubilius & Corwith, 2010). Classes incorporated radio and television broadcasts to get information to students faster. In the late 1970s, the use of computers, videoconferencing, and the Internet led to email and online sharing of files, which eventually led to today’s online education programs (Cavanaugh et al., 2004).

Online learning has been practiced since 1995, when the first Canadian virtual school was founded (Barbour & Reeves, 2009). Originally, this Canadian virtual school was established to provide students living in rural areas access to courses their schools could not offer. Virtual schools quickly spread to urban areas in Canada and the United States (Barbour & Reeves, 2009). Florida Virtual School (FLVS) and Virtual High School (VHS), the first online schools in the United States, were created in 1997 (Barbour & Mulcahy, 2008; Barbour & Reeves, 2009). FLVS was established through money from state legislation, while VHS was established through a 5-year federal grant (Barbour & Mulcahy, 2008). FLVS and VHS were large, multistate programs that brought online education to the nation’s attention (Greenway & Vanourek, 2006). The creation of Florida Virtual School and Virtual High School spurred the growth of virtual learning.

**Expansion of Online Learning**

Online courses and schools have proliferated in the almost 20 years since FLVS and VHS were created (Barbour & Reeves, 2009). Although online courses were first introduced to provide students with classes their school districts could not supply, to provide remediation courses to students who were behind in graduation credits, for home-schooled students, for students with scheduling conflicts, to high school dropouts wanting to earn their high school degree (Horn, 2010), for pregnant teens, and for incarcerated youth (Ramaswami, 2009), online
education is now viewed as a viable option for all learners. Rural schools still lead online course enrollment, with 46% of rural districts reporting student participation compared to 28% of urban districts and 23% of suburban districts (O’Dwyer et al., 2007). As of 2013, 31 states offered full-time virtual schooling (Chingos, 2013). Christensen and Horn (2008) predicted that about 50 percent of high school courses will be offered online by 2019.

Since 1997, the demand for online education has increased exponentially (Barbour, 2011; Cavanaugh et al., 2004). Virtual education offers learning opportunities at any time and across geographic boundaries (Olszewski-Kubilius & Corwith, 2010). The North American Council for Online Learners and The Partnership for 21st Century Skills (2006) claimed online education improves the effectiveness of education by offering more academic choices with easy access to exceptional courses and teachers.

Spurred by A Nation at Risk (United States National Commission on Excellence in Education, 1983) and the belief that racial, economic, and social inequalities exist in education, a shift to a business model of education began (Mondale & Patton, 2001). The business model encouraged competition between schools to attract students, in much the same way that businesses compete for customers (Mondale & Patton, 2001). The voucher system, charter schools, and online education allowed families more choice than just their neighborhood school.

Online education has been viewed as a possible solution to many of the educational problems facing our country, including low-achieving schools, overcrowding, lack of access to qualified teachers, and the inability to provide high-quality education to students who need more flexibility (Cavanaugh et al., 2009). One of the greatest forces driving the expansion of online learning is the inequality that exists in public schools. Since educational reform began, advocates of school choice have fought to expand the options available to families living in areas with
underperforming schools that lack the financial means to move to a neighborhood with high-quality public schools or pay private school tuition (Chingos, 2013). There are many high-quality alternatives available to families now, in the form of vouchers and charter schools, but parents are often constrained by geography (Chingos, 2013). Virtual schooling has the potential to minimize these geographical constraints.

In the late 1990s almost all high school students attended school with structured class periods in sometimes overcrowded brick-and-mortar buildings (Rice, 2006; Young, Birtolo, & McElman, 2009), but the educational landscape has changed. Virtual learning is less expensive than traditional schooling (Christensen & Horn, 2008) and does not require students to attend their brick-and-mortar school, alleviating the overcrowding issue. Online learning could help solve the financial issues facing many schools by eliminating the need for expensive renovations and expansions (Chaney, 2001; Christensen & Horn, 2008; Rice, 2006). In contrast to overcrowded urban and suburban schools, rural schools face their own challenges leading to the need for online education.

Virtual schools began in Canada in order to fill a need for high-quality courses in rural areas. Often times small rural schools cannot offer higher level math and science courses (Barbour & Reeves, 2009) because they do not have enough highly qualified teachers to provide the variety of courses required (Barbour & Mulcahy, 2008; O'Dwyer et al., 2007) or because it is difficult to attract and retain qualified teachers in rural areas (Barbour & Mulcahy, 2006). The lack of student interest in higher level math and science courses in small schools is another challenge (Christensen & Horn, 2008). From a financial standpoint, it is not realistic to offer and staff courses that very few students will take. Offering online courses to students in rural areas is a viable way to provide those students with the same educational experiences as their urban
counterparts (Barbour & Mulcahy, 2008). Providing equitable access to educational opportunities for all students has been, and continues to be, a national focus.

An increasing number of students and families need more flexibility than is provided in structured brick-and-mortar schools (Rice, 2006). Online education is ideal for students who are not able to attend traditional schools due to hospitalization, suspension, assignment to an alternative program, incarceration, travel due to athletic events or parent occupation (political or military), the need to work, and those not successful in traditional school environments due to behavior issues (Barbour & Reeves, 2009; Rice, 2006). The flexibility provided by asynchronous online courses and virtual schools is attractive to many families who struggle to meet the rigid schedule of traditional schools. Many benefits are provided to students and families in online schools.

**Benefits of Online Schooling**

Online education may provide a solid solution to increasing concerns about the inequity of education provided to students in the United States (Chaney, 2001; Flowers, 2011; Rauh, 2011). School choice, which previously included public, private, charter, and homeschooling, now includes virtual schooling (Barbour & Reeves, 2009; Cavanaugh et al., 2004; Rice, 2006). School choice is important to families for various reasons, some of the most often cited being flexibility for student-athletes or military families (Greenway & Vanourek, 2006; P. Kim et al., 2012), the desire to have a more customized learning plan to meet student needs (Marsh, Carr-Chellman, & Sockman, 2009), the lack of quality curriculum at local schools, and safety or overcrowding issues at neighborhood schools (Greenway & Vanourek, 2006).

**Equity**

According to Brint (2006), social class is one of the major contributors to school inequity.
In many rural and lower income areas, higher level and Advanced Placement (AP) courses are not offered—either because of a lack of student interest or a lack of qualified teaching staff (Olszewski-Kubilius & Corwith, 2010). Taking courses virtually allows students living in districts where there is little student interest or a lack of qualified teachers to participate in higher level or AP courses (Barbour & Mulcahy, 2006; Barbour & Reeves, 2009). Online education eliminates the biggest factor influencing the quality of education, which is geographic location (Chaney, 2001). The inaccessibility of high-quality teaching to students living in a lower income community is eliminated with online education by providing those students with access to resources and teachers not available locally (Cavanaugh et al., 2004), further reducing the inequality of education (Lips, 2010). Online education opportunities have the potential to eliminate geographic and demographic obstacles in educational equality by giving students in all neighborhoods equal access to courses (Cavanaugh et al., 2004; Lips, 2010), including Advanced Placement courses.

Taking AP courses significantly improves achievement on national and international tests and prepares students for the rigorous demands of college education. Schools serving low-income and minority students offer significantly fewer AP courses than schools in affluent communities (Hallett & Venegas, 2011). Since AP courses serve as a rigorous preparation for college (Klopfenstein, 2004), it is important to provide all students with access to AP courses that meet college-level learning standards. Hallett and Venegas (2011) caution that while it is important to increase access to AP courses, it is just as important to maintain the rigorous quality of the courses, so students have equitable access to both quantity and quality. Advanced Placement courses taught online by highly qualified, experienced teachers eliminate all challenges discussed: geographic, socioeconomic, and the academic performance of
neighborhood schools.

**Communication**

Another advantage of online learning is the opportunity to bridge the home-school gap by increasing communication between parents and teachers. Increased communication allows families and teachers to work together to provide the best educational opportunity for each child (Currie-Rubin & Smith, 2014). Because everything is done online, parents are able to view lessons, completed and overdue assignments, teacher feedback, and grades for every assignment the student is given (Rauh, 2011; Zappe, Sonak, Eunter, & Suen, 2002). In other words, the school becomes virtually transparent to the family. This open communication allows parents to be an active part of their child's education (Currie-Rubin & Smith, 2014). Some online programs even allow parents to view lesson plans and content from the lessons, so they know exactly what their child is learning (Perkins & Pfaffman, 2006). In addition to increasing communication between parents and teachers, online education supports increased communication between students and teachers (Cavanaugh et al., 2004).

Online education also provides the opportunity for more one-on-one interactions between students and teachers than traditional school settings (Rauh, 2011; Rice, 2006). Cavanaugh et al. (2004) reported an increase in the amount of student-teacher communication in online courses compared to courses offered in a traditional setting. Increased communication between teachers and students provides valuable information about student learning, allowing targeted instruction or remediation as needed. Customized instruction is more easily done in an online setting (Christensen & Horn, 2008), providing students a more individualized learning plan (Greenway & Vanourek, 2006).
21st Century Skills

Finally, The North American Council for Online Learning and The Partnership for 21st Century Skills (2006) report that virtual schools provide students with collaborative and self-paced learning environments, which support 21st century skills. To better prepare students for the competitive job market and postsecondary education, they need to be taught more than subject specific content (Kay, 2010). Students need problem-solving skills and to be able to exhibit proficiency in technology related areas (Kay, 2010). Online learners gain skills in self-directed learning, time management, and personal responsibility that will benefit them in their future (North American Council for Online Learning & The Partnership for 21st Century Skills, 2006). Cavanaugh et al. (2009) and Barbour and Reeves (2009) pointed out that these benefits are doubted by critics and that little research has been conducted to support the claims. In addition to the advantages presented, online education has many challenges as well.

Challenges

The most commonly noted challenge is the lack of socialization for students enrolled solely in an online school (Cavanaugh et al., 2004; Greenway & Vanourek, 2006; Muilenburg & Berge, 2005; Rice, 2006). Cowan (2009) reported that using online education as the only instructional format causes students to lose many of the benefits of traditional schools, including face-to-face interaction, exposure to diversity, and social development. Parents cite the lack of social development as a drawback of online education (Cavanaugh et al., 2004; Shoaf, 2007). To combat this challenge, many online schools have begun offering opportunities for students to socialize with their peers. Many virtual schools provide students face-to-face access to academic clubs, sports teams, field trips, proms, and graduation (Greenway & Vanourek, 2006).

Cavanaugh et al. (2004) warned that students in an online school can feel isolated without
the social interaction a traditional school offers. Melkun (2012) noted that online education contradicts the proven best practice of collaboration. Teachers in virtual schools should encourage students to communicate with their peers in online forums, through email, and in synchronous lessons, and to work together in small groups when possible. However, Hrastinski (2008a) found that discussion boards in online courses were 90 percent content related, with very little social interaction occurring between students. C. Kim et al. (2014) posited that improving social presence in courses, both among students and between students and the instructor, may improve student motivation and achievement. Increasing social interactions in online courses may increase retention and reduce the high dropout rate associated with online courses (Rice, 2006).

Another challenge for online schools is academic integrity (Chertok, Barnes, & Gilleland, 2014; M. Lee & Figueroa, 2012; Panagakos & Paskey, 2010; Yang & Cornelious, 2005). The authenticity of submitted work is very difficult to assess in online courses (Spaulding, 2009). Plagiarism (Chertok et al., 2014; McGee, 2013; Miller & Young-Jones, 2012), submitting assignments completed by others (Chertok et al., 2014; McGee, 2013), and using cheat sheets or search engines to look up answers during tests (Chertok et al., 2014; McGee, 2013; Miller & Young-Jones, 2012) are the most commonly referenced concerns. In most online schools, tests are taken by the student in an unproctored environment (Kleinman, 2005), which makes it difficult to determine if the work submitted belongs to the student. Miller and Young-Jones (2012) found that students felt it was easier to cheat in virtual classes than in face-to-face classes. While authenticity of work is a challenge, there have been many software programs developed that allow teachers to view the students while they are taking tests in their homes. Programs like Turnitin check for originality and plagiarism, and random test generators create assignments
from large question banks so no two tests are the same (Panagakos & Paskey, 2010). Online charter schools are responsible for teaching the state's academic standards (P. Kim et al., 2012), and for giving state-required assessments (Marsh et al., 2009).

Online education lacks many of the additional support programs available in traditional schools, such as free or reduced lunch for low-income students (Rauh, 2011). Some students depend on the breakfast and lunch provided at school and would not benefit from attending school online. Rauh (2011) concluded that students from lower income schools are less likely to take online courses than students from middle or upper income schools. It was unclear whether families were unaware of the option to take courses online or if they chose not to participate. Students with low reading ability levels or with limited English language proficiency may find the heavily text-based instruction found in many online courses more difficult than the face-to-face oral instruction available in traditional schools (Cavanaugh et al., 2004; Donlevy, 2003; Greenway & Vanourek, 2006). In sum, at-risk populations of low-income and lower achieving students may not find the support they need in an online setting.

Yang and Cornelious (2005) reported that online learners must take more responsibility for their learning than students in traditional schools, which may be difficult at the high school level. Similarly, Chaney (2001) believed online education was not a good option for students who lack self-motivation. In many traditional secondary schools, the teacher is responsible for leading student learning and students tend to be passive in their learning (Moore, 1980). Therefore, traditional schools may provide better educational opportunities than the online format for passive learners. Students with parents who are not active in the online learning process are also less likely to benefit (Cowan, 2009). Online education opens the communication barriers often found in traditional schools, but this also puts more responsibility on families to
remain involved in their child's education (Currie-Rubin & Smith, 2014). Students without strong self-motivation and parental involvement may not benefit from online education.

The last challenge occurs at the school, district, and state level. Pandolfo (2012) reported that the majority of online educators felt undertrained in areas relating to online instruction when they began teaching online. Yang and Cornelious (2005) agreed with the importance of training online faculties on how to use designated software, interact with students over the Internet, and develop online facilitation skills. Untrained online teachers may find it difficult to be effective instructors (Mupinga, 2005). Teaching online requires additional skills beyond those required to teach in a traditional classroom (Mupinga, 2005). Teachers should receive adequate training on skills and strategies relevant to the challenges they will face as online educators (Mupinga, 2005). Although education researchers generally agree on the benefits and challenges of online learning, there is no consensus that online learning provides a high-quality learning experience (Cavanaugh et al., 2009).

Factors for Success

Student Traits

Several student traits have been recognized as being beneficial for success in virtual learning. Successful students in an online environment will usually be those who are independent learners (Barbour & Mulcahy, 2008; Cavanaugh et al., 2009), are highly motivated (Cavanaugh et al., 2004; Cavanaugh et al., 2009; M. Lee & Figueroa, 2012; Rice, 2006), are organized (Rice, 2006), have good time management skills (Cavanaugh et al., 2009; M. Lee & Figueroa, 2012), and have strong technology skills (Cavanaugh et al., 2009, Rice, 2006). P. Kim et al. (2012) also found that online courses require more active student participation, self-discipline, and family support. For students who exhibit these traits, online schooling may be as effective as traditional
face-to-face education (Greenway & Vanourek, 2006). But, can online education meet the needs of students who do not exhibit these traits? Rice (2006) noted that very little research exists that determines whether online education can provide the academic support needed for students with learning disabilities, learning deficiencies, or language barriers. Offir et al. (2008) claimed online education, even in a synchronous format, is not ideal for students with low cognitive abilities. In addition to these student traits, academic success in online courses is determined by dialogue, structure, and autonomy (Moore, 1972, 1973, 1980, 1991, 1993).

**Dialogue**

Low retention rates in online courses have been a challenge facing many high schools and colleges (Simpson, 2004). As noted previously, social interaction is a challenge in the online setting (Cavanaugh et al., 2004; Cowan, 2009), and students report that socialization is the biggest barrier to success (Muilenburg & Berge, 2005). Muilenburg and Berge (2005) expanded on this further, noting that social interaction affects student enjoyment of their online courses, the effectiveness of online learning, and the likelihood of taking another course online. Increasing and improving the social presence in online courses may help increase retention rates, while also improving student motivation and achievement (C. Kim et al., 2014). Hawkins, Graham, Sudweeks, and Barbour (2013) also found that high-quality and frequent interactions lead to higher online course completion rates, especially for at-risk students.

A qualitative case study conducted by Vonderwell (2003) focused on ways to improve the efficacy of communication between student and instructor, student and student, and student and content. Data were collected through interviews, review of emails between the instructor and student, and asynchronous discussion board transcripts. Communication strategies employed in the course were email, weekly feedback posted for the entire class, weekly feedback sent to
individual students on their participation and performance, and discussion boards on the Blackboard platform. Students were also divided into small discussion groups to complete three collaborative discussions each week. Although the online environment allowed students to ask more questions than they could in a traditional classroom setting, results showed that most students were dissatisfied with the asynchronous forms of communication used. In an asynchronous environment, students reported a lack of communication and collaboration between students, a lack of participation in non-graded class discussions, and a delay in receiving feedback from teachers and peers. The difficulty in getting asynchronous discussions started with only a few participants, and the lack of social interactions in asynchronous communications, have been noted in other research as well (Hrastinski, 2008a). Vonderwell (2003) cautioned that increasing the amount of communication does not by itself lead to an increase in student learning.

Building a strong learning community in the online setting is important to student success (Ronsisvalle & Watkins, 2005). Vonderwell (2003) found that increasing only asynchronous communication is not an effective way to build stronger online communities. Martin et al. (2012) explored communication in a synchronous instructional technology course. Twenty-one graduate students were given open-ended online surveys and interviews to measure the interaction between teacher and student, student and student and student and content in the course. The course instructor of was also interviewed and three recorded class sessions were randomly selected and analyzed. Students were allowed to interact synchronously during online virtual class sessions. Students reported their appreciation for immediate feedback during synchronous sessions and the ability to send private messages to both the instructor and to other students in the course. The instructor checked for understanding throughout the lesson, using polling tools
and microphone discussions, making it easier for students to ask questions and self-assess their understanding. Students also took advantage of the chat functions of the virtual classroom and could comment on other students' ideas or ask questions without interrupting the speaker. Using the webcams during class helped students develop more personal relationships. Seeing the other students, hearing their voices, and working collaboratively in breakout rooms helped create a sense of community. The live online class sessions provided students with time to discuss the content with their classmates, allowing more interaction between the student and content than in asynchronous courses. That study was limited by its small sample size and the inclusion of only graduate-level technology students with strong technology skills.

One of the most important forms of communication is between the teacher and student (Offir et al., 2008). Simpson (2004) stated that two types of teacher-student communications are used in online settings: reactive and proactive. Reactive communication is when the instructor responds to a student initiated message (by phone or email). Proactive communication is when the instructor initiates contact with students. Proactive communication is the most effective type because it reaches students who have become disengaged, are at risk of dropping out, or who may not initiate contact with the instructor (Simpson, 2004). Student success in online courses may be improved by increasing communication, both during live class sessions and through written messages. Increased communication may ultimately make students feel more engaged and less isolated, which ultimately will improve retention rates.

**Course Structure**

Attrition rates for online courses can be up to 50 percent (E. Lee, Pate, & Cozart, 2015), compared to around 10 percent in traditional classroom courses (Panagakos & Paskey, 2010). The lack of student connection to the instructor, their classmates, and the content increases
attrition rates. The structure of online courses can alleviate those feelings of disengagement and thereby reduce student attrition rates. Course structure is the collection of course goals and objectives, teaching strategies used by the instructor, evaluation and assessment tools, and the flexibility of the course to meet individual learning needs (Offir et al., 2008). Differentiating instruction, pacing, and assessments is a way to meet the various needs of each student.

Tomlinson and Kalbfleisch (1998) posited that a one-size-fits-all approach to teaching is not effective for student learning. Online courses can differentiate content, pacing, and assessment. Milman (2015) cautioned that differentiation does not mean watering down the content to make it easier. Differentiation is a way to provide various opportunities for students to learn the content, use different instructional strategies, and demonstrate understanding in numerous ways (Rayfield, Croom, Stair, & Murray, 2011). It is more difficult in asynchronous courses, as they are usually fully created prior to the start of the course, making it difficult to adjust the course based on student need (Zajac, 2009). In traditional classroom settings, teachers are able to adjust their instructional strategies, pacing, and assessments based on student interests, behavior, and readiness (Milman, 2015; Rayfield et al., 2011; Zajac, 2009) to meet the needs of diverse student populations. Synchronous courses allow instructors to differentiate in the same way. Teachers can use formative assessments throughout the live online class sessions to gauge proficiency with the content, they can change the pacing of the lessons and course based on student needs, and they can change their instructional practices to adapt their teaching to meet the needs of students in the class. Even the easiest type of differentiation, content differentiation to support students with different learning styles, requires teacher flexibility (Milman, 2015).

Many online courses are very text heavy and may not support students who are not
linguistic learners. Changes to both the course content and the instructional strategies can support all online learners. Online courses provide educators with an opportunity not afforded in traditional classroom settings. The content of online courses can be presented in several ways: through text, video, audio files, and through the use of visual aids when possible (Milman, 2015; Zajac, 2009). Students can choose how they want the content presented so it supports their learning style. During live class sessions, online teachers are able to use multiple instructional strategies to support learner preferences. Students can interact with the content through class discussion, self-reflection, exploration, group work, and presentations in the online classroom (Akdemir & Koszalka, 2008).

**Learner Autonomy**

A final factor affecting success in online courses, and a trait necessary for students to independently complete online coursework, is autonomy (Cavanaugh et al., 2004). With dropout rates reaching 50 percent in online courses, course completion is a concern at all schools offering them (E. Lee et al., 2015). Learner autonomy helps predict course completion and success (Yen & Liu, 2009). Autonomous learners are able to direct their learning and constantly self-monitor their understanding of content (Moore, 1972). They are able to ask for help when they need it, but use the teacher more as a facilitator or guide than as the primary learning tool (Linn, 1996). Online courses should be structured with this in mind.

When creating online courses, instructors should provide activities to promote autonomy and opportunities that encourage students to become more autonomous. There are two types of learning, passive and active (Linn, 1996). Passive learning is what traditionally comes to mind when we think of school: the responsibility to instruct and assess belongs to the teacher. Passive learners listen to teacher-led lessons, often do not create connections between new content and
previously learned ideas, and do not reflect on their learning (Linn, 1996). Active learning requires students to be responsible for guiding and monitoring their own learning. The goal is for students to become active learners, so instructors can guide them to be autonomous (Linn, 1996). Autonomy can be learned and reinforced by working alone or in groups (Eneau & Develotte, 2012). Suggested activities that support autonomy and can be completed by students alone include self-reflection about their strengths and weaknesses (Eneau & Develotte, 2012) and finding and analyzing their mistakes (Linn, 1996). Collaborative course activities that support autonomy include informal discussions and peer mentoring opportunities (Linn, 1996), as well as participation in online discussion boards where students summarize their own learning, but also comment and gain further understanding from their classmates’ posts (Eneau & Develotte, 2012). The greatest success in encouraging autonomy is seen when the instructor provides choice in course activities (E. Lee et al., 2015; Linn, 1996), connects projects and assignments with the students’ personal interests (E. Lee et al., 2015), and relates course activities and assignments to real-world problems (Linn, 1996). The dropout rate in online courses may be reduced by increasing student autonomy (E. Lee et al., 2015).

By their nature, online courses require all students to be more autonomous than they would be in traditional classroom settings because the student and instructor are separated geographically. This leads to fewer teacher-student and student-student interactions (Linn, 1996). The ability to be autonomous ultimately leads students to be more successful in asynchronous courses (Offir et al., 2008). Asynchronous students receive less direct instruction from the teacher and are in a much less structured course environment. Because autonomy is learned and developed over time, younger students often need more guidance and supervision (Cavanaugh et al., 2004) and therefore may be more successful in synchronous settings. Well-
created online courses should provide opportunities for learning autonomy, but have built-in support so the instructor can provide guidance, instruction, and monitoring when needed (Lewis, Whiteside, & Dikkers, 2014). E. Lee et al. (2015) found that autonomous students were more engaged in their online courses and felt more ownership in their work. The more autonomous a student is in online courses, the greater the likelihood of successful course completion (Yen & Liu, 2009). Student autonomy is a great way to engage students, teach self-reflection skills, and reduce the 50 percent dropout rate in online courses, all of which lead to greater efficacy in online courses.

**Efficacy**

The effectiveness of online education is still being debated. Early results, from 1980-1998, suggested that students enrolled in online courses outperformed students in a classroom setting; but this was because attendance in early distance education courses was very selective (Barbour & Mulcahy, 2008). More recent research shows conflicting results when comparing the academic performance of online and classroom-based students at the high school and college level (Hughes, McLeod, Brown, Maeda, & Choi, 2007). While some studies showed better learning outcomes from classroom-based education (Barbour & Mulcahy, 2006; Heissel, 2016; Summers, Waigandt, & Wittaker, 2005), others reported better outcomes from online education (Barbour and Mulcahy, 2008; Hughes et al., 2007; Shea, Fredericksen, Pickett, Pelz, & Swan, 2001), and still others claimed that classroom-based and online courses have similar learning outcomes (Allen & Seaman, 2010; O'Dwyer et al., 2007). Some researchers found the exponential growth of online programs, given the lack of high-quality research relating to the efficacy of those programs, frustrating (Davis, 2012). Molnar et al. (2014) cautioned that most research comparing student performance in online versus classroom-based settings has focused
on individual courses rather than full-time programs, and the research on full-time programs lacks reliable and valid evidence. Rice (2006) also found that studies at the K-12 level were difficult to analyze because of the small sample sizes, confounding variables, lack of a similar comparison group, or differences in the course instructor's experience level and training.

Recently, the credibility of online programs has been tainted by media reports of cyber schools being nothing more than diploma mills (Ramaswami, 2009). One instance of such abuse came to light when state officials investigating University High School in Miami, Florida, found that the school was not accredited, did not offer courses, and only functioned to help student-athletes boost grade point averages so they could become eligible for college athletics (Ramaswami, 2009). For reasons like this, evaluating the quality and effectiveness of online programs is a major concern of educators (Cowan, 2009).

One measure of assessing the effectiveness of online programs is to use the school or district's standardized test scores and Adequate Yearly Progress (AYP) reports. Caution should be taken to not assess a program based solely on one measure, like AYP. Just as student learning, progress, or achievement should not be evaluated using only state standardized tests, ratings of the effectiveness of online programs should not be based only on those same tests. Student success in an online environment should be measured the same way it is measured in a classroom setting: academic performance, retention, academic achievement, and student satisfaction (Ronsisvalle & Watkins, 2005).

**Synchronous and Asynchronous**

Early online courses were delivered asynchronously, but recent advances in technology have provided the tools necessary to offer courses synchronously (Hrastinski, 2008a). Generally, both synchronous and asynchronous courses are delivered through a learning management
system, such as Blackboard, Angel, or Moodle (Jackson, 2012). There are several differences between synchronous and asynchronous course formats. Asynchronous students are not online at the same time as their instructors, but are able to communicate with the instructor through email, phone calls, and often on discussion forums (Hrastinski, 2008a). Asynchronous courses do not afford students the benefit of asking questions during a lesson to better understand and process the content (Offir et al., 2008). Asynchronous students are supported through email, content material, and discussion forums (Jackson, 2012; Murphy et al., 2011). Asynchronous students benefit from being able to log into their course and complete work at a convenient time for them (Hrastinski, 2008b; Olson & McCracken, 2015). It is much more flexible than the more rigid synchronous course structure.

Synchronous courses more closely resemble classroom-based courses because they require students to be in the same virtual classroom as the teacher at a specified time in order to receive instruction (Jackson, 2012). Live interaction between the teacher and students occurs by using web cameras, microphones, and speakers or headsets (Jackson, 2012). Students in synchronous courses benefit from being able to ask the instructor questions during the live sessions and get the answer immediately (Hrastinski, 2008a; Kunin, Julliard, & Rodriguez, 2014). They are also more likely to develop relationships with their peers, which decreases feelings of isolation, and develop learning communities (Hrastinski, 2008a). Hrastinski (2008b) found that synchronous communication between students allowed them to get to know each other better, created strong relationships, and was more interactive than asynchronous communication, all of which led to increased student participation in the online course. Synchronous courses use tools such as videoconferencing; audio conferencing; instant messaging; and online classroom collaboration software such as Elluminate Live, Wimba, or
BlackBoard Connect (Jackson, 2012; Murphy et al., 2011). Olson and McCracken (2015) noted that students who are drawn to the flexible nature of online learning may not be interested in synchronous courses. Very little research has been conducted comparing student achievement in synchronous and asynchronous formats.

Roblyer et al. (2007) conducted a quantitative study of 43 different semester-long classes offered by Alabama Connecting Classrooms, Educators, and Students Statewide (ACCESS) at 101 different schools. ACCESS was created to provide students living in low-income and rural parts of Alabama with courses that were not offered at their neighborhood school. Offerings included elective courses, AP courses, and remediation courses; all offered in synchronous and asynchronous formats. Data collection methods included online surveys, in-person interviews, phone interviews, enrollment information provided by the schools, student achievement, and completion rates. Results showed no difference in student satisfaction between synchronous and asynchronous courses, and no significant differences were found in student achievement between the two formats. Students were, however, more likely to drop or withdraw from an asynchronous course than from a synchronous one. Sixty-eight percent of the students in this study perceived that they had less access to the teacher than they had in previous courses taken in a traditional classroom setting. Some factors that could have affected the results of the Roblyer et al. (2007) study include that the students were from small schools in low-income areas and the various synchronous and asynchronous courses were taught by different teachers, causing a lack of consistency across instructors.

A qualitative study of first year dental students compared face-to-face, synchronous, and asynchronous learning (Kunin et al., 2014). In this study of 169 students, face-to-face students were in the same classroom as the instructor, synchronous students watched the live lecture from
a separate location, and asynchronous students were able to watch the prerecorded lectures. Face-to-face and synchronous students were able to ask questions during the lecture and asynchronous students asked questions by emailing the instructor or posting to an online discussion forum. Surveys were given to students in all three instructional formats to determine their preference. Students who had taken an online course previously were more comfortable with the online format. Students rated face-to-face and asynchronous formats significantly higher than synchronous formats for effectiveness of instruction and clarity of presentation. Students and researchers acknowledged that technology issues during the synchronous sessions led to delays in beginning the lectures, audio issues during the lecture, and students not being able to ask the instructor questions. These technology difficulties may have led to the lower ratings for the synchronous format. Barbour (2008) noted technical problems as being the most common drawback in online courses. Surprisingly, no difference was reported in student-teacher and student-student interaction in the synchronous and asynchronous course formats. Students in the synchronous course format suggested the instructor include distance students in the discussion more often to make it more interactive and engaging. Including only motivated, highly achieving adult students was one drawback of this study, making it difficult to generalize to broader populations. Another drawback was that students in the synchronous format were just viewing the same lecture being given to the face-to-face students. Different instructional practices were not used to create a positive learning environment for the students who were separated geographically from the instructor.

Olson and McCracken (2015) conducted a mixed-methods study to determine if differences existed between student perceptions and final course grades for students in synchronous and asynchronous courses. A 5-week undergraduate course was offered online in a
synchronous and asynchronous format. Students were randomly assigned to a format, but were allowed to switch to the other format if they wanted. Sixteen students were in the synchronous format and 22 were in the asynchronous format. The same instructor taught both formats, and the same assignments and course materials were used in both formats. Synchronous students were required to participate in one Adobe Connect session each week. Two sessions were offered each week and students were able to choose which session best fit their needs. During the synchronous session, the teacher delivered content, discussed the week's assignments, and answered student questions. Researchers collected data using an end-of-course evaluation, the Classroom Community Inventory, open-ended questions to measure overall course perceptions, and final course grades. Only 10 synchronous and 10 asynchronous students completed the course evaluations. Results showed no significant difference in student satisfaction, academic achievement, or the sense of community between the two groups. There were several limitations to this study. Only one course was included in the study, giving the researchers a very small sample size. Because of the small sample, it is difficult to generalize the results to other college courses. The synchronous course was not adapted to meet student needs. No changes were made to course content or assignments based on information gained during the synchronous sessions. The two formats were essentially identical with respect to content and assignments. Finally, the length of the course was a limitation. With only five synchronous sessions, it may have been difficult for students to build a sense of community.

Little research is available on the difference in educational outcomes and student perceptions between synchronous and asynchronous courses. Available literature presents mixed findings on student satisfaction in synchronous and asynchronous courses. Roblyer et al. (2007) and Olson and McCracken (2015) reported no difference in student satisfaction between
synchronous and asynchronous students, while Kunin et al. (2014) found that students rated the asynchronous format higher than synchronous formats. There are several possible explanations for these differences. First, the populations of the studies were very different. Roblyer et al.'s (2007) sample included high school students taking courses they did not have access to through their neighborhood school, Olson and McCracken’s (2015) sample included undergraduate students, and Kunin et al.’s (2014) sample included graduate students. Second, the biggest complaint of the synchronous format in Kunin et al.'s (2014) study was technology issues during the class that caused audio delays and the inability to ask questions during the lecture. Two studies, Olson and McCracken (2015) and Kunin et al. (2014), failed to alter the course based on format. Course content and assignments were identical for both formats. Finally, Kunin et al.’s (2014) study only included data collected on student perceptions of the different course formats, not actual academic achievement data. Future research should focus on academic measures, such as course grades or standardized test scores, as well as student perceptions, to determine if differences exist in the educational outcomes of synchronous and asynchronous course formats.

As virtual education continues to grow and schools decide whether to offer online courses or entire full-time programs, or just refine their already existing programs, administrators, teachers, parents and students need more data so they can make educated decisions when choosing between synchronous and asynchronous courses. Future research should focus on schools that offer both synchronous and asynchronous courses to their students, so participants in the study have similar demographic characteristics and have the same teachers. It would also be beneficial if the courses were specifically designed for online instruction, instead of using a face-to-face course format and presenting it to synchronous and asynchronous students, as was done in Kunin et al. (2014). This type of research will be useful in determining
if a significant difference exists between the educational outcomes of students enrolled in synchronous and asynchronous courses.

**High School Mathematics**

Virtual education in Canada began to provide rural students access to the high-quality courses their peers in larger, wealthier districts were taking (Barbour & Mulcahy, 2006). Barbour and Mulcahy (2006) examined retention rates and achievement on Advanced Placement exams for classroom-based and web-based students. Data showed that classroom-based students had higher retention rates for students in both urban and rural schools than their web-based counterparts. In contrast, the proportion of students taking the AP exam after their course was complete was higher among web-based students in both urban and rural areas than it was among students who received classroom-based instruction. Overall, students receiving instruction in the classroom setting did better on the AP exam (receiving a score of 3, 4 or 5) than students enrolled in the web-based courses (Barbour & Mulcahy, 2006). These results suggest that students enrolled in rigorous AP courses will remain in the course and do better on the exam if they receive classroom-based instruction.

In their quasi-experimental study of an online Algebra 1 course in Louisiana, O’Dwyer et al. (2007) found that students in the online program performed as well on the post-test as students who took the course in a traditional setting. It is important to note, however, that a higher percentage of students in the online group reported they did not have a good learning experience and they did not feel confident in their algebra skills at the conclusion of the course than students who took it in a traditional classroom setting. Students chosen for this study exhibited many of the characteristics presented as being ideal for success in online courses: they were chosen based on their ability to work independently and exhibited strong communication
skills. It is interesting to note that even though the academic performance of the online students matched the classroom-based students, the online students were not as confident in their skills as their classroom peers.

A quantitative study of Algebra 1 courses at three virtual and three traditional schools located in three different states was conducted by Hughes et al. (2007). They found that no differences existed between online and traditional Algebra 1 students on measures of gender, race, age, and parental educational level. However, 81% of students at the traditional schools reported being enrolled in a college prep program, while only 33% of the online students reported being in one. Two validated assessments, the Assessment of Algebraic Understanding (AAU) and the What is Happening in this Class? (WIHIC) classroom perception test, were used to determine whether achievement differences existed between online and traditional classroom students and to gain information about how online and traditional students perceived the learning environment. Online students earned higher total scores on the AAU test, and online students also outperformed classroom-based students on all subscales of the AAU test. Not surprisingly, older students were less likely to be successful on the AAU test. As the age of an algebra student increases, the student is more likely to either be repeating an algebra course after failing it the first time, or to be on a lower math track that started with pre-algebra in high school. One possible flaw with the research method used by Hughes et al. (2007) was that online students took the AAU test at home in an unsecure environment where they could have received help, echoing the academic integrity concerns of M. Lee and Figueroa (2012) and Yang and Cornelious (2005). As reported on the WIHIC, traditional students perceived higher student cohesiveness, course involvement, and cooperation, while online students perceived higher teacher support. Online students receiving more teacher support matches the claims Rauh (2011)
and Rice (2006) made that online students receive more one-on-one support than their classroom counterparts. Hughes et al. (2007) posited that these results bolster the claim that online learning is as effective as traditional classroom learning.

Liu and Cavanaugh (2012) researched factors that influence student performance in online high school algebra courses. Students from traditional public and private schools, as well as home-school students, were eligible to enroll and take classes at the virtual school. Although students participating in the study were from across the state, students with Individualized Education Plans (IEP) or who were eligible for free or reduced lunch were excluded from the study. This exclusion by the researchers makes generalizing the results to other virtual settings very difficult, as the results are skewed by not including students from different socioeconomic backgrounds or those with learning challenges. Final exam scores were collected for 371 students enrolled in Algebra 1 and 176 students enrolled in Algebra 2. Similar to findings by Hughes et al. (2007), students in lower grades did better in Algebra 1 than students in higher grades. Findings also showed that Algebra 1 students who received more teacher comments did better than those with fewer comments. Based on these results, the researchers suggested that increased teacher feedback and student-teacher interaction in Algebra courses may have beneficial effects on online student achievement.

Although research on the efficacy of online learning at the high school level is limited, there are mixed findings on whether students in an online course will achieve the same academic outcomes as students enrolled in a traditional course. Barbour and Mulcahy (2006) found that classroom-based AP students were more successful on AP exams than their web-based counterparts. In contrast, O’Dwyer et al. (2007) reported that web-based students performed similarly to their classroom-based peers on the Algebra 1 posttest, and Hughes et al.’s (2007)
study found that web-based students outperformed classroom-based students on the AAU test. The discrepancy in results could possibly stem from the different tools used to measure achievement. Barbour and Mulcahy (2006) used a standardized test, while O’Dwyer et al. (2007) used a course-specific posttest and Hughes et al. (2007) used a validated assessment. Or, the discrepancy could stem from how the tests were administered. The AP test was administered in a secure environment, the posttest was administered in a classroom setting for all students (even the web based students), and web-based students took the AAU in their homes. A study that includes results from standardized tests, teacher-created tests, and a validated assessment may be beneficial in comparing results between online and classroom-based students.

Unfortunately, some of the research on virtual mathematics instruction excludes important student demographics, specifically lower achieving students and students from families with lower socioeconomic status. Barbour and Mulcahy (2006) only included AP students, who are traditionally higher achieving and highly motivated students. O’Dwyer et al. (2007) only included students whose strong communication skills allowed them to work independently. Liu and Cavanaugh (2012) excluded students with IEPs and who received free or reduced lunch. A need exists to include students from all mathematical ability groups and all socioeconomic groups so practitioners can generalize the findings to their educational setting.

**Conclusion**

The demand for online instruction at all levels continues to grow. The flexibility of online courses and the potential for individualized instruction are both attractive to students. Online education provides a possible solution to equity issues in U.S. schools, to overcrowding, and for students who need more flexibility in their schedules (Cavanaugh, et al., 2009). It also enables students to take courses they would not otherwise have access to. High school students in rural
areas are able to take AP courses and adults in rural areas without nearby colleges are able to enroll in courses and earn college degrees. As the demand for online instruction increases, more and more programs are created. The rapid growth of online courses and programs has led to questions about their effectiveness. Barbour (2010) cautioned that even if online learning does provide increased educational opportunities, it does not guarantee that all online courses and programs will be effective. Some virtual programs are more effective than classroom-based programs, and vice versa (Roblyer et al., 2007). The quality of the course or program, online or classroom-based, depends greatly on the quality of the teacher (Cavanaugh et al., 2004; Greenway & Vanourek, 2006; Lips, 2010) and the quality of the curriculum used (Greenway & Vanourek, 2006).

Many benefits and challenges are associated with online education. The benefits include providing educational equity (Cavanaugh et al., 2004; Lips, 2010), providing access to AP courses (Barbour & Mulcahy, 2006; Barbour & Reeves, 2009), increased communication between family and school (Currie-Rubin & Smith, 2014), increased communication between students and teachers (Cavanaugh et al., 2004; Rauh, 2011; Rice, 2006), and promoting 21st century skills (North American Council for Online Learning & The Partnership for 21st Century Skills, 2006). The most commonly cited challenges include the lack of socialization (Cavanaugh et al., 2004; Greenway & Vanourek, 2006; Muilenburg & Berge, 2005; Rice, 2006); questionable academic integrity of submitted work (Chertok et al., 2014; M. Lee & Figueroa, 2012; Panagakos & Paskey, 2010; Yang & Cornelious, 2005); the lack of additional supports, especially to students from lower socio-economic backgrounds, found in traditional schools (Rauh, 2011); and the need for additional teacher training (Mupinga, 2005; Yang & Cornelious, 2005).
Research suggests that students who are independent learners (Barbour & Mulcahy, 2008; Cavanaugh et al., 2009), are highly motivated (Cavanaugh et al., 2004; Cavanaugh et al., 2009; M. Lee & Figueroa, 2012; Rice, 2006), are organized (Rice, 2006), have good time management skills (Cavanaugh et al., 2009; M. Lee & Figueroa, 2012), and have strong technology skills (Cavanaugh et al., 2009, Rice, 2006) are generally more successful in online courses. Unfortunately, there has been little research done to determine if online education can provide the support necessary for students with learning disabilities or language barriers (Rice, 2006). Student success in online courses is also determined by dialogue, structure, and autonomy (Moore, 1972, 1973, 1980, 1991, 1993). Increasing student-teacher and student-student dialogue, by both synchronous and asynchronous means, may help improve retention rates, student motivation, and achievement (Hawkins et al., 2013; C. Kim et al., 2014). Differentiation of content, process, and product may also improve student achievement (Tomlinson & Kalbfleisch, 1998). Autonomous students are able to self-monitor their understanding and ask for help when they need it. Effective online courses will provide students with activities that promote autonomy, such as group work (Linn, 1996) and selfreflection (Eneau & Develotte, 2012), and relate to the world around them (Linn, 1996).

Studies focusing on online high school mathematics courses have reported mixed findings, which could be explained by the different tools chosen by researchers to measure educational outcomes and the exclusion of important demographic groups. Studies focusing on synchronous and asynchronous instructional formats also reported inconsistent findings, which could be caused by the differing populations studied in the research and by the different measures chosen to demonstrate academic achievement. Many K-12 studies are difficult to generalize due to small sample sizes, the lack of comparison groups, and differences between
instructor’s experience level.

There is a clear need for research focusing on the academic achievement of high school mathematics students at a school that offers instruction in both synchronous and asynchronous formats by the same teachers, using various measures to assess achievement, such as standardized test scores, end-of-course final grades, and a student perception survey. There is also a need for research that includes students from all demographic groups, especially those from lower-income families and those who have learning disabilities or an Individualized Education Plan (IEP).

A study of the effectiveness of synchronous and asynchronous courses, as measured by state test results, final course grades, and student perception of their learning, is important for several reasons. The growing number of virtual learning opportunities available to high school students makes it essential to measure the effectiveness of these programs. Administrators need additional information when planning online courses and programs, teachers need additional information to plan their instruction for effective student learning, and parents need additional information to make informed decisions about the best educational model for their child.

Quantitative data, in the form of final course grades and state test scores from synchronous students and asynchronous students, can be compared to determine the efficacy of the modes of online instruction. Additionally, surveys can be used to determine whether the lack of daily synchronous contact with teachers and peers affects student perceptions of the quality of instruction received, socialization, and general happiness with their educational experience. The purpose of this causal-comparative research study was to determine whether a significant difference exists between the educational outcomes of students enrolled in synchronous and asynchronous Algebra 1 courses, based on (a) final course grades, (b) state standardized test
scores, and (c) student perceptions of the program.
Chapter 3: Methodology

Chapter 2 reviewed available literature on the history of online education, possible explanations for the rapid growth of online education, the benefits and challenges of online education, and educational outcomes of online high school mathematics and of synchronous and asynchronous courses in depth. Chapter 3 restates the research problem, examines the research questions, describes the methodology used to conduct this research, reviews the research design, and discusses the population and sampling used for this study. In addition, this chapter includes the data collection methods used; analysis of the data; threats to validity, reliability and generalizability; and an explanation of how human subjects were protected.

As described in Chapter 1, the purpose of this causal-comparative research study was to determine whether a significant difference exists between the educational outcomes of students enrolled in synchronous and asynchronous online Algebra 1 courses.

Restatement of the Problem

The story of our nation's public schools failing to provide a quality education for all students is not new. It is a topic of discussion on television, in newspapers and magazines, and during most political debates. This has led to national pressure in recent years to improve K-12 education (C. Kim et al., 2014). For various reasons, many families are looking for alternatives to their neighborhood schools. In the past, alternatives have come in the form of vouchers, private schools, and charter schools (Ryan, 2010); more recently, the option to attend public school completely online has been added. Online learning is relatively new at the high school level, so there is little research on the efficacy of K-12 online education (Murphy et al., 2011; Rauh, 2011). Previous research at this level focused on the advantages and disadvantages of online schooling (Cavanaugh et al., 2009) and on comparing instruction in online courses to that
of classroom-based courses (Goel et al., 2012; Murphy et al., 2011). As the number of students enrolled in online courses continues to grow (Barbour & Reeves, 2009) and stakeholders are faced with choosing between asynchronous and synchronous modes of online instruction, further research is needed to compare the educational experiences of students in synchronous and asynchronous courses.

Because success in mathematics is essential in moving a society forward, the United States government has placed importance on improving mathematics instruction in schools (Liu & Cavanaugh, 2012). Specifically, the quality of algebra courses has been receiving attention due to American students performing lower than their international peers on international mathematics tests, students scoring below the proficiency level on state math tests, and the increased need for qualified workers in science and engineering fields (Cavanaugh et al., 2008). Some research suggests math and science are the hardest content areas to teach online (Cavanaugh et al., 2008), making it more important that students who choose online education have access to high-quality math courses. This study added to current research by determining whether the method of online instruction, synchronous versus asynchronous, affects students’ educational outcomes in Algebra 1.

**Research Questions and Hypotheses**

The overarching research question guiding this study is relevant to colleges and high schools nationwide that offer online courses.

**Research Question**

Does the method of online instruction, synchronous versus asynchronous, affect the educational outcomes, measured by (a) end-of-course grades, (b) state standardized test scores, and (c) students' perceptions of their educational experience, of Algebra 1 students enrolled at a
public, cyber charter school in Pennsylvania?

Subquestions

- To what extent do end-of-course grades differ between synchronous and asynchronous students enrolled in Algebra 1 at a public, cyber charter school in Pennsylvania?
- To what extent do scores on the Algebra 1 Keystone Exam differ between synchronous and asynchronous students enrolled in Algebra 1 at a public, cyber charter school in Pennsylvania?
- To what extent do synchronous students' perceptions of their educational experiences differ from the perceptions of asynchronous students enrolled in Algebra 1 at a public, cyber charter school in Pennsylvania?
- Does a correlation exist between Algebra 1 end-of-course grades and Keystone Exam scores for synchronous students enrolled in Algebra 1 at a public, cyber charter school in Pennsylvania?
- Does a correlation exist between Algebra 1 end-of-course grades and Keystone Exam scores for asynchronous students enrolled in Algebra 1 at a public, cyber charter school in Pennsylvania?

In-Depth Look at Each Subquestion

As more and more schools offer online courses and programs at the high school level, it is important to determine whether students in asynchronous courses have the same educational experiences and outcomes as their peers in synchronous courses. That was the overarching research question of this study. The purpose of each subquestion as it relates to the overarching research question is now examined in depth.

Subquestion #1. To what extent do end-of-course grades differ between synchronous and
asynchronous students enrolled in Algebra 1 at a public, cyber charter school in Pennsylvania?

The purpose of the first subquestion was to determine whether differences exist between end-of-course grades for students enrolled in the different delivery formats. While end-of-course grades are only one measure of student learning, comparing grades of synchronous and asynchronous students may show that one group had a statistically significant higher achievement level than the other group. The dependent variable in this question was end-of-course Algebra 1 grades. The independent variable was method of instruction, synchronous or asynchronous.

\( H_0 \): There is no difference between the end-of-course grades of synchronous and asynchronous students.

\( H_1 \): There is a difference between the end-of-course grades of synchronous and asynchronous students.

**Subquestion #2.** To what extent do scores on the Algebra 1 Keystone Exam differ between synchronous and asynchronous students enrolled in Algebra 1 at a public, cyber charter school in Pennsylvania?

The purpose of the second subquestion was to determine whether differences exist between students' scores on the state standardized Algebra 1 Keystone Exam depending on which delivery format they received. Standardized test scores only provide a snapshot of student learning, but because the exam is standardized and all students were assessed on the same test, it provided the opportunity to compare scores between the two groups, synchronous and asynchronous. If no difference exists in educational outcomes between the two groups, there should be no statistical significance between the scores of the synchronous group and the asynchronous group. The dependent variable in this question was Algebra 1 Keystone Exam
scores, and the independent variable was method of instruction, synchronous or asynchronous.

$H_{02}$: There is no difference between the Algebra 1 Keystone Exam scores of synchronous and asynchronous students.

$H_2$: There is a difference between the Algebra 1 Keystone Exam scores of synchronous and asynchronous students.

**Subquestion #3.** To what extent do synchronous students' perceptions of their educational experiences differ from the perceptions of asynchronous students enrolled in Algebra 1 at a public, cyber charter school in Pennsylvania?

The purpose of this subquestion was to determine whether students perceived any differences in their educational experiences. Based on the theory of transactional distance, synchronous students should report more dialogue, less structure, and less autonomy than asynchronous students (Moore, 1972, 1973, 1980, 1993). Of particular interest was how those constructs (dialogue, structure, and autonomy) worked together to determine the students' perceptions of transactional distance. The dependent variable was student perceptions of their educational experiences and the independent variable was the method of instruction, synchronous or asynchronous.

$H_{03}$: There is no difference between synchronous and asynchronous students' perceptions of their educational experiences.

$H_3$: There is a difference between synchronous and asynchronous students' perceptions of their educational experiences.

**Subquestion #4.** Does a correlation exist between Algebra 1 end-of-course course grades and Keystone Exam scores for synchronous students enrolled in Algebra 1 at a public, cyber charter school in Pennsylvania?
One of the biggest challenges, and often one of the most cited disadvantages of online courses, is the inability for instructors to determine whether work submitted by a student was actually completed by that student, or whether outside resources, such as a parent or friend, were utilized to complete the assignment (Chertok et al., 2014; McGee, 2013; Miller & Young-Jones, 2012; Spaulding, 2009). Inflated end-of-course grades and low state test scores would result if students were not truly learning the concepts presented, or if the course was not aligned to the state standards being assessed. Unfortunately, according to the College Board (2016), grade inflation in high school has increased significantly since the late 1990s. The College Board (2016) has seen the average high school grade point average (GPA), as reported by students, increase while SAT scores have declined slightly. Ideally, in this study, a high Algebra 1 course grade would yield a high Keystone Exam score.

H₀₄: No correlation exists between end-of-course grades and Keystone Exam scores for synchronous students.

H₁₄: There is a correlation between end-of-course grades and Keystone Exam scores for synchronous students.

**Subquestion #5.** Does a correlation exist between Algebra 1 end-of-course grades and Keystone Exam scores for asynchronous students enrolled in Algebra 1 at a public, cyber charter school in Pennsylvania?

As with synchronous online learning, students in asynchronous courses could get help from parents and friends on homework. If students learned the concepts presented, you would expect both end-of-course grades and scores on the state Keystone Exam to be high. To prove both programs have the same educational outcomes, correlations between end-of-course grades and state test scores should be similar for both groups, synchronous and asynchronous.
H₀₅: No correlation exists between end-of-course grades and Keystone Exam scores for asynchronous students.

H₅: There is a correlation between end-of-course grades and Keystone Exam scores for asynchronous students.

**Research Design**

A quantitative causal-comparative design was chosen for this study. The causal-comparative, or ex post facto, design was chosen for several reasons. First, no manipulation of the independent variable, synchronous or asynchronous instructional format, occurred. Participants were not randomly assigned to groups. Students were already assigned to synchronous or asynchronous Algebra 1 courses before the research study began. The sample was selected from two pre-existing populations. The use of a causal-comparative design is recommended when two groups differ on a variable, in this case format of instruction, and a researcher wishes to determine the consequences of this difference (Fraenkel, Wallen, & Hyun, 2011). The research hypothesis tested was: No significant difference exists between educational outcomes of students enrolled in synchronous Algebra 1 courses compared to the educational outcomes of students enrolled in asynchronous Algebra 1 courses.

The causal-comparative research design incorporated data collected from both surveys and existing data sets, in the form of end-of-course grades and state assessment scores. The numeric data used came from final course grades and state test scores. In addition, a previously published, closed-ended Likert scale survey was used to gain information about students’ perceptions of the quality of their instruction and their educational experiences in Algebra 1.

One advantage of using existing data sets is the ease of data collection (Butin, 2010). The research site already collects final course grades and state test score information annually and
stores that data electronically, making retrieval simple and fast. A closed-ended Likert scale survey makes coding easy for data input and analysis. Using predetermined questions on a survey eliminates any biases in researcher delivery (Muijs, 2011). All students in both programs received the same exact questions, worded identically, delivered through an online survey.

For this quantitative study, high school students enrolled in Algebra 1 at a public, K-12, cyber charter school in southeastern Pennsylvania were included. Students who participated in the study were enrolled in either a synchronous or asynchronous Algebra 1 course. Student final course grades and scores on the standardized state Algebra 1 Keystone Exam were analyzed using statistical analysis. In addition, a Likert scale questionnaire was given to determine whether statistical differences exist between synchronous and asynchronous students’ perceptions of their educational experiences.

There are several challenges associated with using a causal-comparative design (Fraenkel et al., 2011). The lack of randomization in sample selection makes generalization difficult. In this type of research, there is a lack of control, which leads to biases and threatens the internal validity of the study. Due to the lack of randomization and manipulation of the independent variable, as well as control, causation is difficult to infer. Relationships can be identified using causal-comparative designs, but caution must be taken when interpreting the results and trying to establish causation (Fraenkel et al., 2011).

**Population and Sampling**

For this quantitative causal-comparative study, the target population is all high school students enrolled in online courses in the United States. The accessible population was high school students enrolled at the research site in southeastern Pennsylvania, and the sample was comprised of all high school Algebra 1 students enrolled in synchronous or asynchronous
courses at the research site during the 2015-16 school year. Only students who were enrolled at the school for the full school year were included in the study, meaning no students entering after September 15, 2015, or leaving prior to June 10, 2016, were included. Since the goal of this study was to determine whether a significant difference exists between the educational outcomes of students enrolled in synchronous and asynchronous online Algebra 1 courses, only students who received a full year of instruction in Algebra 1 at the research site were included. There were 499 students enrolled in Algebra 1 for the duration of the 2015-2016 school year who fit this participation criterion. The number of students in this study exceeded the minimum number of 30 participants required for a causal-comparative study (Fraenkel et al., 2011). Of the 499 total participants, 94 took Algebra 1 asynchronously and 405 took the course synchronously. There were 287 female and 212 male students included. Student participants were in Grades 9 through 12 and ranged in age from 14 to 21.

Convenience sampling was used, including only Algebra 1 students at the cyber charter school in the study. As a teacher at the research site, the researcher had easy access to the participants and to data. This created problems of bias since it was not a random sampling of all online students and made generalizing the results to the total population of online students in the United States difficult (Fraenkel et al., 2011; Muijs, 2011). To counter the effects of bias from using convenience sampling, data on family socioeconomic status (determined by free or reduced lunch status), gender, IEP status, age, grade level, and type of community where the family resided (urban, suburban, rural) were collected and analyzed to determine if there were any significant differences between the two groups (Fraenkel et al., 2011).

Access to Algebra 1 students at the research site was granted by the school’s director of academics. Pretest data were collected in early September, 2015. Pretest data, to assess math
content knowledge prior to taking Algebra 1, were used to determine whether external variables were affecting the results. Pretests were administered to students by their Algebra 1 teachers in the regular classroom setting. It was expected that no differences would exist between pretest scores for synchronous versus asynchronous students, minimizing the impact of this moderating variable. Final course grades were posted in June and state assessment scores were available in late August, 2016, although they were not accessed by the researcher until IRB approval (Appendix A) was granted in November, 2016.

After receiving IRB approval, recruitment began for the Likert scale survey. Because most of the subjects were minors, parents were contacted through email for recruitment. An email was sent to all parents of students who were under 18 when enrolled in Algebra 1 at the research site during the 2015-16 school year. An email was also sent to all students enrolled in Algebra 1 who were at least 18 during the 2015-16 school year. All parents and students were invited to attend an informational session during which the researcher explained the research study in depth, explained the survey that students would complete, and answered any questions from parents and students. Three sessions were held, two during the week – one during the day and one in the evening – and the third was held on a weekend. The informational sessions were held online. Since all students were enrolled at the cyber charter school and attended all classes online, parents had the technology necessary to attend the meeting (computer, headset, microphone, camera). After the informational sessions, parents of minors and the students who were 18 or older during the 2015-16 school year were asked to complete a consent form. The informational session was recorded for those parents and students over 18 who could not attend. The recording and consent form were emailed to those parents and students not in attendance for one of the three informational sessions. Once parental consent was obtained, the link to the
online survey was sent to the student. The first page of the student survey included information about the study and clearly stated that participation in the study was voluntary. Student consent was gained by including the following on the first page of the survey: “By typing your name below, you are indicating that you consent to participate in this study. Once you type your name and click the ‘Next’ button, the survey will begin.” The survey included questions relating to students’ perceptions of their educational experiences and the quality of instruction they received in their Algebra 1 course. The main Algebra 1 teachers did not have access to the results.

During the 2015-16 school year, there were five teachers assigned to teach Algebra 1. Each of those five teachers taught synchronous and asynchronous students. This study investigated whether differences existed between the educational outcomes for synchronous and asynchronous course formats. For this reason, data analysis was not performed to determine whether or not the teacher affected student final course grades, state test scores, or survey responses.

The researcher had no direct contact with the participants during the 2015-16 school year. The only direct contact came during the informational sessions in December, 2016, for those students who attended, and through email when the survey link was sent.

**Data Collection**

There were three main instruments used for answering the subquestions.

**Instruments**

**Subquestion #1.** To what extent do end-of-course grades differ between synchronous and asynchronous students enrolled in Algebra 1 at a public, cyber charter school in Pennsylvania?

The data collected for this sub-question were final course grades, continuous data that ranged from 0 to 100. End-of-course numeric grades were obtained from the school database.
Final grades for all 499 participants were gathered and stored in an Excel spreadsheet. Students were identified only by their state student identification number, a unique number assigned to each student in the state of Pennsylvania. Student names were not included on the spreadsheet.

**Subquestion #2.** To what extent do scores on the Algebra 1 Keystone Exam differ between synchronous and asynchronous students enrolled in Algebra 1 at a public, cyber charter school in Pennsylvania?

The data collected for this subquestion were Keystone Exam scores, continuous data ranging from 1200-1800. Keystone Exam scores were received from the Pennsylvania Department of Education in August. After IRB approval was obtained, the director of academics provided access to state test scores for the 2015-16 Algebra 1 students. Scores were collected for 426 of the 499 participants and recorded on the Excel spreadsheet, identifying students only by their state student identification number.

**Keystone Exam.** The Algebra 1 Keystone Exam is a Pennsylvania state achievement test given to students at the end of Algebra 1. The Algebra 1 Keystone Exam is a pre-existing instrument created by the Data Recognition Corporation (DRC). The Keystone Exams replaced the Pennsylvania System of School Assessment (PSSA) tests, which had been administered to 11th grade high school students since 1992 (DRC, 2015).

Beginning in 2008, Pennsylvania, along with the DRC, began developing end-of-course state assessments, known as the Keystone Exams, in Algebra 1, biology, and literature (DRC, 2015). The purpose of these exams was to provide a standards-based, valid, and reliable way for students to demonstrate graduation competency (DRC, 2015). The goal at that time was to extend the Keystone Exams to also include assessments for Algebra 2, geometry, chemistry, civics and government, English composition, U.S. history, and world history, but those tests
were not yet being administered to students as of the 2015-16 school year. Student scores are reported both as a numeric value and as a corresponding performance level of below basic, basic, proficient, or advanced. Students who receive numeric scores of 1500 or above are considered to have demonstrated mastery of the content. Students scoring below 1500 have not demonstrated proficiency of the course content. Table 2 defines each of the performance levels and indicates the corresponding numeric value (DRC, 2015).

Table 2

**Pennsylvania Keystone Exam Performance Level Definitions**

<table>
<thead>
<tr>
<th>Performance Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Advanced</strong> (1546-1800)</td>
<td>The advanced level reflects superior academic performance. Advanced work indicates an in-depth understanding and exemplary display of the skills included in the Keystone Exams Assessment Anchors and Eligible Content.</td>
</tr>
<tr>
<td><strong>Proficient</strong> (1500-1545)</td>
<td>The proficient level reflects satisfactory academic performance. Proficient work indicates a solid understanding and adequate display of the skills included in the Keystone Exams Assessment Anchors and Eligible Content.</td>
</tr>
<tr>
<td><strong>Basic</strong> (1439-1499)</td>
<td>The basic level reflects marginal academic performance. Basic work indicates a partial understanding and limited display of the skills included in the Keystone Exams Assessment Anchors and Eligible Content. This work is approaching satisfactory performance, but has not been reached. There is a need for additional instructional opportunities and/or increased student academic commitment to achieve the proficient level.</td>
</tr>
<tr>
<td><strong>Below Basic</strong> (1200-1438)</td>
<td>The below basic level reflects inadequate academic performance. Below basic work indicates little understanding and minimal display of the skills included in the Keystone Exams Assessment Anchors and Eligible Content. There is a major need for additional instructional opportunities and/or increased student academic commitment to achieve the proficient level.</td>
</tr>
</tbody>
</table>

*Note.* Definitions are taken from DRC (2015).

The Algebra 1 Keystone Exam is comprised of 54 total questions. Of these 54 questions, 12 questions are being field tested for future use, and do not count toward the final student score. There are 36 multiple-choice questions, each worth one point, which account for 60% of the final
score; and six constructed-response questions, each worth four points, which account for 40% of a student's final score.

Exam development followed a cycle consisting of initial test item creation based on Pennsylvania content standards; item review by Pennsylvania educators; review by the Pennsylvania Department of Education; review of test items for bias, fairness and sensitivity; student field testing in 2010; and creation of final operational forms (DRC, 2015).

The reliability of an instrument is the extent to which the scores are free of measurement error (Muijs, 2011) and is important for showing the consistency of a tool (Creswell, 2012). When high-stakes decisions are being made based on an instrument, a coefficient value greater than .8 is desired (Muijs, 2011). The internal consistency was tested using Cronbach's alpha, and found to have a coefficient value of .91 (DRC, 2015). Interrater reliability was also found, due to the need for constructed-response questions on the Algebra 1 Keystone Exam to be hand graded. Interrater agreement was found to be 100% for the Algebra 1 test (DRC, 2015).

Validity may be the most important aspect of an assessment instrument (Muijs, 2011) because it provides evidence that the researcher is measuring what was intended to be measured (Creswell, 2012; Muijs, 2011). Face validity of the Algebra 1 Keystone Exam was established through review by Pennsylvania educators and content specialists at the Pennsylvania Department of Education. Content validity was achieved by using the Pennsylvania Keystone Assessment Anchors and Eligible Content standards for Algebra 1 to develop test items, which then were scrutinized for content and bias, and finally field tested (DRC, 2015). Construct validity, or the internal structure (Creswell, 2012), was also measured using exploratory factor analysis. Discriminant validity evidence was provided using observed and disattenuated correlations between the Algebra 1 exam and the Biology and Literature exams. The correlation
value for Algebra I and biology was .74 (disattenuated .80) and for Algebra I and literature was .64 (disattenuated .70) (DRC, 2015). Students in the seventh and eighth grades taking Algebra I during the 2014-15 school year were required to take the Algebra I Keystone Exam as well as the seventh- or eighth-grade PSSA test. The Keystone Exam and PSSA scores for 8,274 seventh-grade and 38,092 eighth-grade students were compared to establish criterion validity. The Algebra I Keystone Exam had a correlation value of .81 to the seventh-grade math PSSA and a correlation value of .84 to the eighth-grade math PSSA, suggesting that the Keystone Exams measure something similar, but not identical, to the PSSA math tests (DRC, 2015).

**Subquestion #3.** To what extent do synchronous students' perceptions of their educational experiences differ from the perceptions of asynchronous students enrolled in Algebra I at a public, cyber charter school in Pennsylvania?

The data collected for this subquestion were survey responses. A questionnaire was used to collect data relating to students' perceptions of their educational experiences in Algebra I. As this research is grounded by Moore's theory of transactional distance, a survey designed specifically to measure student perceptions based on the three constructs (dialogue, structure, and learner autonomy) of the theory was used. The transactional distance scale was developed by Huang, Chandra, DePaolo, Cribbs, and Simmons (2015) to assess student perceptions of online courses. Permission to use the transactional distance scale was obtained from its authors through email. The transactional distance scale was given to all students who had signed consent forms. Of the 94 total asynchronous students, parental permission for participation was obtained for nine students, seven of whom agreed to participate; only five of them completed the survey. Of the 405 synchronous students, parental permission was obtained for 30 students, 22 of whom agreed to participate and completed the survey. Four additional synchronous students were
already 18 years of age, and they provided their own consent, bringing the total number of synchronous students who completed the survey to 26. The scale utilizes a seven-point Likert scale (strongly disagree, disagree, somewhat disagree, neither agree nor disagree, somewhat agree, agree, and strongly agree) and is appropriate for administration to high school students (Huang et al., 2015).

Transaction distance scale. The survey initially had 108 items on four dimensions--dialogue, structure, learner autonomy, and transactional distance, but was modified after checking for face validity (Huang et al., 2015). The survey items were reviewed by four professors with experience in online education and one graduate student with experience in survey development, in addition to nine undergraduate students taking an online course (Huang et al., 2015). The original survey was revised based on the feedback provided, and reduced to 103 items. This 103-item transactional distance scale was field tested on 227 students taking an online course at a university in the midwestern United States.

To determine validity, exploratory factor analysis (EFA) was conducted on each construct to assess how well the questions loaded on the constructs. Huang et al. (2015) considered a factor loading value above 0.40 as acceptable. Based on this value, five questions in the dialogue dimension, six questions in the structure dimension, three questions in the learner autonomy dimension, and three questions in the transactional distance dimension were removed (Huang et al., 2015).

Based on the field test and the EFA, the final version of the transactional distance scale included 85 questions on the four dimensions (Huang, et al., 2015). Questions from the transactional distance scale can be seen in Appendix B.

The internal consistency of this scale was measured for each dimension using Cronbach's
alpha. The dialogue dimension was divided into two constructs, learner-instructor and learner-learner interactions. Alpha values were found to be .88 for learner-instructor interactions and .95 for learner-learner interactions (Huang et al., 2015). The structure dimension was divided into two constructs, learner-content interaction and learner-interface interaction. Learner-content interaction was divided into two sub-constructs, flexibility, with an alpha value of .94, and formality, with an alpha value of .93. Learner-interface interaction was divided into five sub-constructs: knowledge of media use, with an alpha value of .91; choice of media use, with an alpha value of .72; visualization, with an alpha value of .89; functionality, with an alpha value of .85; and usability, with an alpha value of .77. The learner autonomy dimension was divided into two constructs, independence of learning, with an alpha value of .89, and study habits, with an alpha value of .78. Finally, transactional distance was divided into two constructs, learner-instructor transactional distance, with an alpha value of .96, and learner-learner transactional distance, with an alpha value of .77 (Huang et al., 2015).

The survey measures the three factors in Moore's theory of transactional distance, dialogue, structure, and learner autonomy, as well as students' perceptions of overall transactional distance. Each construct was treated independently. Student responses from the transactional distance scale (Huang et al., 2015) were converted into composite variables, in which the averages of each composite variable were continuous, so the composite variables were treated as continuous data. Student survey responses were collected for 31 of the 499 participants and recorded on the Excel spreadsheet, identifying students only by their state student identification number.

Subquestion #4. Does a correlation exist between Algebra 1 end-of-course grades and Keystone Exam scores for synchronous students enrolled in Algebra 1 at a public, cyber charter
school in Pennsylvania?

The data collected for this subquestion were end-of-course grades and Keystone Exam scores, both continuous data types. End-of-course grades (0 to 100) and state assessment scores (1200 to 1800) collected previously for Subquestions 1 and 2 were used to answer this subquestion.

**Subquestion #5.** Does a correlation exist between Algebra 1 end-of-course grades and Keystone Exam scores for asynchronous students enrolled in Algebra 1 at a public, cyber charter school in Pennsylvania?

The data collected for this subquestion were end-of-course grades and Keystone Exam scores, both continuous data types. End-of-course grades (0 to 100) and state assessment scores (1200 to 1800) collected previously for Subquestions 1 and 2 were used to answer this subquestion.

**Procedure**

Data were collected for students taking Algebra 1 at the research site during the 2015-16 school year. Pretest data were collected in early September, 2015, by the Algebra 1 teachers. All students enrolled in Algebra 1 were scheduled to take the Algebra 1 Keystone Exam in late May, 2016, at proctored, face-to-face sites across the state of Pennsylvania. The completed standardized tests were then sent to the Pennsylvania Department of Education (PDE) for scoring. Final course grades were available in June, 2016. The PDE returned Keystone Exam scores to the school by August, 2016. In November, 2016, students with signed consent forms were contacted to complete the Likert scale survey to gather information regarding students' perceptions of their online Algebra 1 course during the 2015-16 school year. Statistical tests were performed on data collected to answer the research question.
**Instructional Methods**

Instruction in all Algebra 1 courses was similar. The Algebra 1 teachers met weekly to collaborate. During their meetings the teachers planned lessons, shared instructional resources, discussed common issues students were having with the course content, and discussed daily assignments and unit assessments. Teachers in all synchronous courses encouraged active participation during live class sessions and emphasized connecting the Algebra 1 content to real life. Teachers in all asynchronous courses encouraged participation in online discussion boards and also emphasized connecting the Algebra 1 content to real life. Daily homework, announced quizzes and tests, group work, and individual end-of-unit culminating projects were included in both synchronous and asynchronous delivery formats.

**Threats to Validity**

Minimizing the influence of external factors is difficult in an educational setting (Hoy, 2010; Muijs, 2011). Comparing the pretest scores allowed the researcher to determine whether any preexisting differences in content knowledge existed between the synchronous and asynchronous groups (Creswell, 2012). In addition to pretest scores, student demographic information, including gender, age, socioeconomic status (based on free or reduced lunch status), IEP status, community type where the student resided (urban, suburban, rural), and grade level was collected. To reduce the threat that extraneous variables posed to the validity of the study, the synchronous format group was compared to the asynchronous format group to determine whether any statistically significant differences existed (Fraenkel et al., 2011). Few differences were expected to exist between the groups in this study, as all Algebra 1 students who had been at the research site for the entire school year were included. Data analysis was conducted on the moderating variables in order to determine whether differences did exist. Those results can be
found in Chapter 4.

Ideally, all the synchronous and asynchronous sections would have been taught by the same teacher to minimize the effect the teacher had on the outcomes. Unfortunately, this was not possible due to the size of the school and the number of students who took Algebra 1. All five teachers who taught Algebra 1 during the 2015-16 school year had previous synchronous and asynchronous teaching experience and all were considered to be effective teachers by their colleagues and school administration.

Data Analysis

Preparation

SPSS was used to conduct the statistical analysis on the data. Initially, an Excel spreadsheet was created to organize students' demographic information, course format, teacher name, final course grade, Keystone Exam score, and survey responses. Students were identified by their state student identification number only. No student names were contained within the Excel spreadsheet. To prepare the data for analysis, the Excel spreadsheet data were transferred to SPSS. All variables were given a variable name and assigned a variable type (nominal, ordinal, continuous). Only students who were enrolled in Algebra 1 for the entire 2015-16 academic year were included.

Transformation

All non-continuous data were coded. For example, the variable gender was coded as 0 = female and 1 = male, and the variable IEP was coded as 0 = yes, the student has an IEP and 1 = no, the student does not have an IEP. The transactional distance scale developed by Huang et al. (2015) measures student perceptions on four constructs (dialogue, structure, learner autonomy, and transactional distance). Each construct has a set of questions designed to measure student
perceptions on that construct. Responses from each survey questions on the Likert scale survey were coded as 1 = strongly disagree, 2 = disagree, 3 = somewhat disagree, 4 = neither agree nor disagree, 5 = somewhat agree, 6 = agree, and 7 = strongly agree. A composite variable was then created for each of the four constructs.

Research Questions

Does the method of instruction, synchronous versus asynchronous, affect the educational outcomes, measured by (a) end-of-course grades, (b) state standardized test scores, and (c) students' perceptions of their educational experience, of Algebra 1 students enrolled at a public, cyber charter school in Pennsylvania?

**Sub-questions #1 and #2.**

- To what extent do end-of-course grades differ between synchronous and asynchronous students enrolled in Algebra 1 at a public, cyber charter school in Pennsylvania?
- To what extent do scores on the Algebra 1 Keystone Exam differ between synchronous and asynchronous students enrolled in Algebra 1 courses at a public, cyber charter school in Pennsylvania?

These subquestions inquire into the differences in one continuous dependent variable (DV) between two groups. End-of-course numeric grades (a continuous variable) between synchronous and asynchronous students (a nominal variable) were compared in the first subquestion and Keystone Exam scores (a continuous variable) were compared in the second. A t-test was appropriate because there was one continuous DV, and one nominal independent variable (IV) with two groups (Muijs, 2011). A t-test allows a researcher to determine if the relationship between two variables is statistically significant, meaning it has a low probability of occurring in the sample if no relationship exists in the population, as well as how large the effect
size is, or the strength of the relationship between the two variables (Muijs, 2011). Since a comparison of math achievement of synchronous and asynchronous students was desired, the means of those two groups were used. P-values, to determine whether the difference in means was statistically significant, and Cohen's d, to determine whether there was a practical significance, were also used. A p-value should be small for researchers to claim that the difference is statistically significant. A p-value of less than .05 is acceptable for stating that a statistically significant difference exists between the two groups (Muijs, 2011). To determine whether the effect is strong or weak, Cohen's d can be used. A d value of 0-0.20 shows a weak effect, a value of 0.21 to 0.50 shows a modest effect, 0.51-1.00 shows a moderate effect, and a d value greater than 1.00 shows a strong effect (Muijs, 2011). In order to rely on the results of the t-test, three assumptions must be met. First, the dependent variable must be continuous. Second, only two groups can be compared. Finally, samples must be randomly selected. Muijs (2011) acknowledged the difficulty of using randomly selected samples in educational research, but stated that convenience samples can be used with the t-test as long as the samples are large and the two groups do not differ too much in size. It is important to remember that finding a significant difference does not prove causality (Muijs, 2011).

**Subquestion #3.**

- To what extent do synchronous students' perceptions of their educational experiences differ from the perceptions of asynchronous students enrolled in Algebra 1 at a public, cyber charter school in Pennsylvania?

This subquestion had one independent variable, method of instruction, with two groups, synchronous or asynchronous. There was only one dependent variable, student perception, which was continuous. Because the survey used measured student perceptions on four constructs
(dialogue, structure, learner autonomy, and transactional distance), each construct was treated independently. This divided the original single dependent variable into four DVs and a multivariate analysis of variance (MANOVA) was performed. All four of the DVs looked at different aspects of the overall student perception rating. MANOVA tests the null hypothesis that the two group means are equal in the population (Muijs, 2011). The MANOVA test allows researchers to test the effect of an independent variable on two or more dependent variables. The MANOVA test calculates the relationship between the IV with each of the DVs and can also calculate the relationship between the IV and all the DVs together by creating a new DV that is a linear combination of all the variables. (Muijs, 2011). Muijs (2011) cautioned that creating a new combination DV is appropriate only when each of the original DVs measure different aspects of the overall whole and when the original dependent variables are not strongly correlated. Several assumptions must be met in order to use the MANOVA test. First, the dependent variable must be continuous, and the independent variable must have two or more categorical groups. Second, the data cannot contain outliers. If outliers exist, they must be removed from the analysis. Third, the dependent variable must be normally distributed. Finally, the MANOVA test assumes a linear relationship between the independent and dependent variables (Muijs, 2011). The intention was to use Wilks' Lambda as the test statistic, but because of assumption violations, Pillai’s Trace was used instead. Pillai’s Trace and the significance value were used to determine whether the relationship between the IV and each of the DVs was statistically significant (Muijs, 2011). Again, a significance level of less than .05 was required. To calculate an effect size with MANOVA, eta squared was calculated. Eta squared allows a researcher to compare the strength of the effect of all the different DVs. An eta squared value of 0-.1 is a weak effect, .1-.3 is a modest effect, .3-.5 is a moderate effect, and a value greater than .5 is a strong effect (Muijs,
Subquestions #4 and #5.

- Does a correlation exist between Algebra 1 end-of-course grades and Keystone Exam scores for synchronous students enrolled in Algebra 1 at a public, cyber charter school in Pennsylvania?
- Does a correlation exist between Algebra 1 end-of-course grades and Keystone Exam scores for asynchronous students enrolled in Algebra 1 at a public, cyber charter school in Pennsylvania?

To address these questions, Algebra 1 Keystone Exam scores (a continuous variable) and Algebra 1 final course grades (a continuous variable) were compared for both synchronous and asynchronous students. The intention was to use a Pearson's r correlation coefficient as the test statistic because both variables being compared were continuous, but because of assumption violations, Spearman's rho was used instead. Spearman's rank correlation coefficient and the p-value were used to determine if a correlation existed. An $r_s$ coefficient of 1 indicates a perfect positive relationship, a coefficient of -1 indicates a perfect negative relationship and a coefficient of 0 indicates no relationship at all between the two variables. The p-value and the correlation coefficient determine the direction of the relationship, the strength of the relationship and the statistical significance of the relationship. Ideally, a strong positive relationship would exist, meaning a high final course grade predicts a high standardized test score.

Validity, Reliability, and Generalizability

There are several challenges associated with using a causal-comparative design. The lack of randomization in sample selection makes generalization difficult. In this type of research, there is a lack of control of the extraneous variables which leads to biases and threatens the
internal validity of the study. Due to the lack of randomization and manipulation of the independent variable, as well as control, causation is difficult to infer (Creswell, 2012; Muijs, 2011). Relationships can be identified using causal-comparative designs, but caution must be taken when interpreting the results and trying to establish causation.

Using a convenience sample also challenges the generalizability of the study (Fraenkel et al., 2011). Convenience samples cannot be considered representative of the general population, making generalizability of the results difficult (Creswell, 2012). To improve generalizability, information on student and family demographics were collected and included in the analysis.

**Protection of Human Subjects**

Prior to beginning data collection, approval from IRB was obtained. As this study involved minors, a full review was required. No treatment was given in this study, so no subjects were at risk for physical or psychological harm. No deception was utilized in this study.

Prior to survey data collection, an informational email was sent to the parents or guardians of all students who were under the age of 18 when they took Algebra 1 during the 2015-16 school year and also to those students who were 18 or older when they took Algebra 1. Information about the purpose of the study and the right of refusal to participate was explained. Guardians were provided with the researcher's contact information and encouraged to contact the researcher at any time with questions. This information was presented in text form through email, and also during live informational sessions held for parents and those students who were 18 years of age or older during the 2015-16 school year.

All data collected were stored electronically in an Excel spreadsheet that was password protected. Once the Excel spreadsheet data was transferred to SPSS, the desktop where the SPSS document was stored was also locked and password protected. Students were identified by their
state student identification number, so individual student names were not associated with any test results or survey answers. Students and parents were informed that individual responses to the survey were not being shared with any teachers at the research site. Guardians and students were also informed that no students were being identified during the analysis of data or for publication.
Chapter 4: Data Analysis and Results

The purpose of this causal-comparative research study was to determine whether a significant difference exists between the educational outcomes of students enrolled in synchronous and asynchronous online Algebra 1 courses. The overarching research question that guided this study is relevant to high school teachers and administrators nationwide who offer online courses: Does the method of online instruction, synchronous versus asynchronous, affect the educational outcomes, measured by (a) end-of-course grades, (b) state standardized test scores, and (c) students' perceptions of their educational experience, of Algebra 1 students enrolled at a public, cyber charter school in Pennsylvania? The subquestions were as follows:

- To what extent do end-of-course grades differ between synchronous and asynchronous students enrolled in Algebra 1 at a public, cyber charter school in Pennsylvania?
- To what extent do scores on the Algebra 1 Keystone Exam differ between synchronous and asynchronous students enrolled in Algebra 1 at a public, cyber charter school in Pennsylvania?
- To what extent do synchronous students' perceptions of their educational experiences differ from the perceptions of asynchronous students enrolled in Algebra 1 at a public, cyber charter school in Pennsylvania?
- Does a correlation exist between Algebra 1 end-of-course grades and Keystone Exam scores for synchronous students enrolled in Algebra 1 at a public, cyber charter school in Pennsylvania?
- Does a correlation exist between Algebra 1 end-of-course grades and Keystone Exam scores for asynchronous students enrolled in Algebra 1 at a public, cyber charter school in Pennsylvania?
Student Demographics

This study was conducted at a public, cyber charter school in southeast Pennsylvania, where a convenience sample was used. Only Algebra 1 students at the research site were included. Students taking Honors Algebra 1 and Developmental Algebra were not included. There were 837 students enrolled in the full year Algebra 1 course in the fall of the 2015-16 school year, and 643 students enrolled in the course in the spring. Only students who were enrolled in the course for the full year were included in the study, to eliminate other factors that may affect the educational outcomes. There were 499 students who were enrolled in Algebra 1 at the research site for the full school year.

Of the 499 total students, 94 students took Algebra 1 asynchronously and 405 took the course synchronously. There were 287 female students and 212 male students included. Family socioeconomic status, based on free and reduced lunch qualifications, was available for 379 students and showed that 282 students qualified for free or reduced lunch and 97 students did not. Participants were enrolled in Grades 9 through 12 during the 2015-16 school year, with 124 students enrolled in ninth grade, 253 students enrolled in 10th grade, 92 students enrolled in 11th grade, and 30 students enrolled in 12th grade. Data on the type of community (urban, suburban, rural) where each student resided were also collected. The community status of each student's home school district (the district the student would have attended if he or she were not enrolled in a cyber charter school) was obtained from the Pennsylvania Department of Education website, and is based on data collected by the National Center for Education Statistics (NCES). Two hundred twenty-six students lived in an urban area, 186 students lived in a suburban area, and 87 students lived in a rural area. Of the 499 total participants, 120 students had an IEP. Participants ranged from 14 to 21 years old, with the mean age for asynchronous students being 16.26 and the
mean age for synchronous students being 16.53. Additional information about the composition of the synchronous and asynchronous groups can be found in Table 3.

Table 3

**Student Demographics**

<table>
<thead>
<tr>
<th>Course Format</th>
<th>Asynchronous</th>
<th>Synchronous</th>
<th>Total for each group</th>
<th>Total Number of Participants Data is Available</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>IEP</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>Count</td>
<td>27</td>
<td>93</td>
<td>120</td>
</tr>
<tr>
<td>No</td>
<td>Count</td>
<td>67</td>
<td>312</td>
<td>379</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>Count</td>
<td>58</td>
<td>229</td>
<td>287</td>
</tr>
<tr>
<td>Male</td>
<td>Count</td>
<td>36</td>
<td>176</td>
<td>212</td>
</tr>
<tr>
<td><strong>SES (F/R lunch)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>Count</td>
<td>50</td>
<td>232</td>
<td>282</td>
</tr>
<tr>
<td>No</td>
<td>Count</td>
<td>22</td>
<td>75</td>
<td>97</td>
</tr>
<tr>
<td><strong>Grade Level</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9th</td>
<td>Count</td>
<td>30</td>
<td>94</td>
<td>124</td>
</tr>
<tr>
<td>10th</td>
<td>Count</td>
<td>40</td>
<td>213</td>
<td>253</td>
</tr>
<tr>
<td>11th</td>
<td>Count</td>
<td>16</td>
<td>76</td>
<td>92</td>
</tr>
<tr>
<td>12th</td>
<td>Count</td>
<td>8</td>
<td>22</td>
<td>30</td>
</tr>
<tr>
<td><strong>Type of Community</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>Count</td>
<td>31</td>
<td>195</td>
<td>226</td>
</tr>
<tr>
<td>Suburb</td>
<td>Count</td>
<td>48</td>
<td>138</td>
<td>186</td>
</tr>
<tr>
<td>Rural</td>
<td>Count</td>
<td>15</td>
<td>72</td>
<td>87</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>Count</td>
<td>94</td>
<td>405</td>
<td>499</td>
</tr>
</tbody>
</table>

**Bias**

A convenience sample was used because students were not randomly assigned to synchronous or asynchronous modes of instruction, but were already assigned based on their educational needs as determined by their parent or guardian, guidance counselor, and their own preference. A causal-comparative design was chosen because there was no manipulation of the independent variable (mode of instruction), students were pre-existing populations, and because the purpose of the study was to determine the consequences of the difference in mode of
instruction (Fraenkel et al., 2011). Because a convenience sample and a causal-comparative design were used, the lack of randomization makes it difficult to generalize the findings to other school settings (Creswell, 2012). To improve the generalizability of the study and to minimize the effects of bias from not being able to control extraneous variables, student demographic information was compared to determine whether any statistically significant differences existed between the asynchronous and synchronous groups.

**Data Analysis and Results**

Data collected for this study were analyzed, interpreted, and explained in the context of each subquestion. First, tests for pre-existing differences between the synchronous and asynchronous groups were conducted to determine whether any extraneous variables could be affecting the educational outcomes of students. Next, t-tests, a one-way multivariate analysis of variance (MANOVA), and a correlation coefficient were used to determine whether the null hypothesis for each subquestion was accepted or rejected.

**Chi-Square Analysis for Pre-Existing Differences**

Data on participants' gender, grade level, IEP status, type of community, and family economic status (as measured by free and reduced lunch status) were collected and analyzed using SPSS. Since grade level was ordinal (9\textsuperscript{th}/10\textsuperscript{th}/11\textsuperscript{th}/12\textsuperscript{th}), and gender (male/female), IEP status (yes/no), type of community (urban/suburban/rural), and family economic status (yes/no based on eligibility for free or reduced lunch) were all nominal data types, coding was required prior to conducting quantitative analysis using SPSS (Muijs, 2011). The Pearson's chi-square test statistic, p-value, and phi were used to determine whether pre-existing differences between the independent variable, method of instruction, and the aforementioned dependent variables existed. Chi-square was used because the independent variable was nominal and the dependent variables
were ordinal or nominal (Muijs, 2011). Results are shown in Table 4.

Table 4

*Chi-Square Results*

<table>
<thead>
<tr>
<th></th>
<th>Pearson's Chi-Square</th>
<th>Asymptotic Significance (2-sided)</th>
<th>Phi</th>
<th>Approximate Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade Level</td>
<td>5.17</td>
<td>3</td>
<td>.160</td>
<td>.10</td>
</tr>
<tr>
<td>Gender</td>
<td>0.83</td>
<td>1</td>
<td>.362</td>
<td>.04</td>
</tr>
<tr>
<td>IEP Status</td>
<td>1.39</td>
<td>1</td>
<td>.239</td>
<td>.05</td>
</tr>
<tr>
<td>Community Type</td>
<td>9.930</td>
<td>2</td>
<td>.007</td>
<td>.14</td>
</tr>
<tr>
<td>SES (free/reduced lunch)</td>
<td>1.15</td>
<td>1</td>
<td>.284</td>
<td>-.060</td>
</tr>
</tbody>
</table>

Table 3 shows 10th grade was the most common grade level for the synchronous and asynchronous Algebra 1 groups. Of the 94 asynchronous students, 31.9% were ninth graders, 42.6% were 10th graders, 17.0% were 11th graders, and 8.5% were 12th graders. Of the 405 synchronous students, 23.2% were ninth graders, 52.6% were 10th graders, 18.8% were 11th graders, and 5.4% were 12th graders. Table 4 shows that no significant difference was found between method of instruction and grade level (chi-square = 5.17, df = 3, p = .160). A phi value of .10 shows a weak effect size. Table 3 shows both groups have more females than males. The asynchronous group was 61.7% female and the synchronous group was 56.5% female. Table 4 shows that no significant difference was found between method of instruction and gender (chi-square = 0.83, df = 1, p = .362). A phi value of .04 shows a very weak effect size. Table 3 shows that both groups had more students without IEPs than with IEPs. Of the 94 asynchronous students, 71.3% did not have an IEP; of the 405 synchronous students, 77.0% did not. Table 4 shows that no significant difference was found between method of instruction and IEP status (chi-square = 1.39, df = 1, p = .239). A phi value of .05 shows a very weak effect size. Table 3
shows that suburban communities were most common for asynchronous students, while synchronous students were most commonly from an urban community.

Additionally, Table 4 shows that a significant difference was found between method of instruction and community type (chi-square = 9.930, df = 2, p = .007). A phi value of .14 shows a weak to modest effect size. Of the 94 asynchronous students, 33.0% were from an urban area, 51.1% were from a suburban area, and 16.0% were from a rural area. Of the 405 synchronous students, 48.1% were from an urban area, 34.1% were from a suburban area, and 17.8% were from a rural area. Table 3 shows that both groups had more students identified with free or reduced lunch status than not. Of the 72 asynchronous students who had data available, 69.4% of them qualified for free or reduced lunch. Of the 307 synchronous students who had data available, 75.6% qualified for free or reduced lunch. Table 4 shows that no significant difference was found between method of instruction and whether or not students qualified for free or reduced lunch (chi-square = 1.15, df = 1, p = .284). A phi value of -.06 shows a very weak effect size.

**T-Test Results for Pre-Existing Differences**

Data on participants' age and math pretest scores were collected and analyzed using SPSS. All high school students at the research site are given the math and reading Renaissance STAR 360 test each September to help teachers determine areas of strengths and weaknesses. The STAR 360 math assessment takes approximately 20 minutes to complete and is adaptive, meaning it automatically adjusts the difficulty of the questions based on student responses. STAR 360 math scores range from 0 to 1400. STAR 360 pretest data was available for 363 students, 77 in the asynchronous mode and 286 in the synchronous mode. The t-test, p-value, and Cohen's d were used to determine whether pre-existing differences between the independent
variable, method of instruction, and age or pre-test score existed. A t-test was performed because the independent variable was nominal and the dependent variables were both continuous (Muijs, 2011).

To use the t-test, three assumptions must be met. The dependent variable must be continuous, only two groups can be compared, and samples must be randomly selected from the population (Muijs, 2011). The first two conditions were met, but this study utilized a convenience sample, which was not random. Muijs (2011) noted that random sampling is often difficult in educational settings, but the t-test can still be useful as long as the groups are large.

Results are shown in Tables 5 and 6.

Table 5

*Group Statistics for STAR 360 Math Scores and Students’ Age*

<table>
<thead>
<tr>
<th>Course Format</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>STAR 360 Math</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asynchronous</td>
<td>77</td>
<td>789.26</td>
<td>79.48</td>
<td>9.06</td>
</tr>
<tr>
<td>Synchronous</td>
<td>286</td>
<td>760.98</td>
<td>95.41</td>
<td>5.64</td>
</tr>
<tr>
<td>Age in Years</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asynchronous</td>
<td>94</td>
<td>16.26</td>
<td>1.47</td>
<td>0.15</td>
</tr>
<tr>
<td>Synchronous</td>
<td>405</td>
<td>16.53</td>
<td>1.19</td>
<td>0.06</td>
</tr>
</tbody>
</table>
Using the t-test for independent samples, no statistically significant difference \((t = -1.68, df = 123, p = .095)\) in age was found between synchronous \((M = 16.53, SD = 1.19)\) and asynchronous students \((M = 16.26, SD = 1.47)\). Cohen's effect size value \((-0.203)\) suggests a weak practical significance. Among Algebra 1 students who completed the STAR 360 math pretest \((N = 363)\), a t-test for independent samples showed a statistically significant difference \((t = 2.39, df = 361, p = .017)\) in pre-test scores between synchronous \((M = 760.98, SD = 95.41)\) and asynchronous students \((M = 789.26, SD = 79.48)\). Cohen's effect size value \((.32)\) suggests a weak to modest practical significance.

Two significant differences between the synchronous and asynchronous groups were found. The first difference was the type of community in which the participants resided \((urban, suburban, rural)\). Challenges relating to community type, specifically urban and rural areas, are well documented in research \((Barbour & Reeves, 2009; Boutte, 2012; Du Plessis, 2014; Jacob, 2007; Olszewski-Kubilius & Corwith, 2010; Parsley & Barton, 2015; Ryan, 2010)\). Schools in urban areas often face challenges relating to overcrowding, underfunding, crime, the inability to attract and retain highly qualified teachers, low student achievement, and high poverty rates.
(Boutte, 2012; Jacob, 2007; Ryan, 2010). Rural area schools face challenges such as underfunding, the inability to attract and retain highly qualified teachers, limited course offerings, outdated technology, and high numbers of lower income families (Barbour & Reeves, 2009; Du Plessis, 2014; Olszewski-Kubilius & Corwith, 2010; Parsley & Barton, 2015). In a traditional school setting, educational opportunities offered to students may be affected by community type because of teacher quality and resources available (Barbour & Mulcahy, 2006; Barbour & Reeves, 2009; Cavanaugh et al., 2009). Fortunately, the type of community may not have affected the resources available to online students as much as traditional school students: All students at the research site, regardless of their type of community, had access to the same course materials; received the same computers, printers, and headset; had access to the same quality technology support; and were taught by the same teachers. Many of the challenges facing students living in urban and rural areas are related to socioeconomic status.

The socioeconomic challenges of urban and rural communities put learners in those areas at a disadvantage. It is important to note that no difference in socioeconomic status, based on eligibility for free or reduced lunch, was found between the two groups in this study. Both groups had high rates of students who qualified for free or reduced lunch (69.4% for asynchronous and 75.6% for synchronous), a clear indicator of low income levels. Community type alone, without considering the challenges relating to socioeconomic factors, may have a lesser affect on educational outcomes in cyber education than in a traditional school setting. Online settings provide equal access to resources (technology, teachers, course materials), but they do not eliminate all the effects of socioeconomic status and community type on educational outcomes.

The second difference found was the STAR 360 math pretest scores. This difference may
affect the educational outcomes for the synchronous and asynchronous groups. The mean score for asynchronous students was almost 30 points higher than the mean for synchronous students, meaning the asynchronous group was already achieving at a higher level than their synchronous peers before the Algebra 1 courses started.

**Data Instruments**

Educational outcomes in this study were measured by final Algebra 1 grades, Algebra 1 Keystone Exam scores, and student self-perceptions of their Algebra 1 course. Algebra 1 grades, on a scale from 0 to 100, were the actual grades students received from their teacher based on their grades for daily class assignments, homework, quizzes, unit tests, and end-of-unit projects. The Algebra 1 Keystone Exam is a Pennsylvania state standardized achievement test given to students at the end of Algebra 1. The Algebra 1 Keystone Exam is a pre-existing instrument created by the Data Recognition Corporation (DRC, 2015). Student scores are given as a numeric value from 1200 to 1800. As this research is grounded by Moore's theory of transactional distance, a survey designed specifically to measure student perceptions based on dialogue, structure, and learner autonomy was used. The transactional distance scale developed by Huang et al., (2015) was used to assess student perceptions of online courses. Huang et al.'s (2015) survey of transactional distance (Appendix B) contains 85 questions. Students were asked to respond to each item using a 7-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = somewhat disagree, 4 = neither agree nor disagree, 5 = somewhat agree, 6 = agree, and 7 = strongly agree).

**Statistical Analysis**

Analysis of the data using SPSS was performed for each subquestion to answer the research question: Does the method of online instruction, synchronous versus asynchronous,
affect the educational outcomes, measured by (a) end-of-course grades, (b) state standardized test scores, and (c) students' perceptions of their educational experiences, of Algebra 1 students enrolled at a public, cyber charter school in Pennsylvania?

**Analysis of End-of-Course Grades**

**Subquestion #1.** To what extent do end-of-course grades differ between synchronous and asynchronous students enrolled in Algebra 1 courses at a public, cyber charter school in Pennsylvania?

H₀₁: There is no difference between the end-of-course grades of synchronous and asynchronous students.

H₁: There is a difference between the end-of-course grades of synchronous and asynchronous students.

The independent variable for this subquestion was mode of instruction and the dependent variable was end-of-course grades. End-of-course grades were available for all students (N=499). As with the previous use of the t-test, the assumption requiring a random sample was not met, but because the groups were large a t-test was still useful (Muijs, 2011). The group statistics and results from the independent samples t-test are shown in Tables 7 and 8.

Table 7

*Group Statistics for End-of-Course Grades*

<table>
<thead>
<tr>
<th></th>
<th>Course Format</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final Grade %</td>
<td>Asynchronous</td>
<td>94</td>
<td>72.53</td>
<td>24.56</td>
<td>2.53</td>
</tr>
<tr>
<td></td>
<td>Synchronous</td>
<td>405</td>
<td>60.32</td>
<td>26.20</td>
<td>1.30</td>
</tr>
</tbody>
</table>
Hypothesis testing. Among students taking Algebra 1 during the 2015-16 school year (N = 499), synchronous students (M = 60.32, SD = 26.20) had significantly lower end of course grades than asynchronous students (M = 72.53, SD = 24.56). Using the t-test for independent samples, a statistically significant difference between course format and final course grade was found (t = 4.12, df = 497, p < .001). Cohen's effect size value (.32) suggests a weak to modest practical significance. The null hypothesis was rejected. There was a difference between end–of-course grades for synchronous and asynchronous students.

It is important to remember two things when interpreting these results. First, because a causal-comparative design was used, correlation does not imply causation (Creswell, 2012; Fraenkel et al., 2011). Higher end-of-course grades in asynchronous courses may not mean that the asynchronous mode of instruction was more effective. Second, the fact that asynchronous students started Algebra 1 with a higher mean STAR 360 math score (M = 789.26) than synchronous students (M = 760.98) may also have affected their final course grades. In addition, asynchronous students failing Algebra 1 at the end of each marking period (quarter) were flagged by the school administration. Guidance counselors contacted those students and their families to determine if the student would be more successful in a synchronous format. Some students, because of work or family obligations during the school day, remained asynchronous regardless
of their failing status. Other students and families decided to change the student’s status midyear from asynchronous to synchronous to give the student more structure and direct instruction from the live class sessions in the hopes of improving course grades. Students’ course format was recorded at the end of the school year. It is possible that some students reporting low end of course grades started the year in an asynchronous course format and ended the year in a synchronous course format, affecting the mean final course grades for both synchronous and asynchronous formats.

**Analysis of Keystone Exam Scores**

**Subquestion #2.** To what extent do scores on the Algebra 1 Keystone Exam differ between synchronous and asynchronous students enrolled in Algebra 1 at a public, cyber charter school in Pennsylvania?

H<sub>02</sub>: There is no difference between the Algebra 1 Keystone Exam scores of synchronous and asynchronous students.

H<sub>2</sub>: There is a difference between the Algebra 1 Keystone Exam scores of synchronous and asynchronous students.

The independent variable for this subquestion was mode of instruction and the dependent variable was Algebra 1 Keystone Exam scores. Algebra 1 students were scheduled to take the Keystone Exam at the end of their Algebra 1 course in May, 2016. All 499 students were scheduled to take the exam, but only 426 completed the test. There are many reasons a student would not complete the test, including religious exemption, refusing to start or complete the test, or being sick during the testing week. As with the previous use of the t-test, the assumption requiring a random sample was not met, but because the groups were large, a t-test was still useful (Muijs, 2011). The group statistics and results from the independent samples t-test are
shown in Tables 9 and 10.

Table 9

**Group Statistics for Keystone Scores**

<table>
<thead>
<tr>
<th>Group Statistics</th>
<th>Course Format</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keystone Score</td>
<td>Asynchronous</td>
<td>78</td>
<td>1455.87</td>
<td>41.51</td>
<td>4.70</td>
</tr>
<tr>
<td></td>
<td>Synchronous</td>
<td>348</td>
<td>1440.88</td>
<td>35.34</td>
<td>1.90</td>
</tr>
</tbody>
</table>

Table 10

**T-Test Results for Keystone Scores**

<table>
<thead>
<tr>
<th>Levene's Test for Equality of Variances</th>
<th>F</th>
<th>Sig.</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keystone Score</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equal variances assumed</td>
<td>5.87</td>
<td>.016</td>
<td>3.28</td>
<td>424</td>
<td>.001</td>
</tr>
<tr>
<td>Equal variances not assumed</td>
<td>2.96</td>
<td>.004</td>
<td>103.45</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Hypothesis testing.** Among students who took the Algebra 1 Keystone Exam in May 2016 (N = 426), asynchronous students (M = 1455.87, SD = 41.51) scored significantly higher than synchronous students (M = 1440.88, SD = 35.34). Using the t-test for independent samples, a statistically significant difference between course format and standardized test scores was found (t = 2.96, df = 103.45, p = .004). Cohen's effect size value (.39) suggests a modest practical significance. The null hypothesis was rejected. There was a statistically significant difference between Keystone Exam scores for synchronous and asynchronous students.

Again, it is important to remember two things when interpreting these results. First, because a causal-comparative design was used, correlation does not imply causation (Creswell, 2012; Fraenkel et al., 2011). Higher Algebra 1 Keystone Exam scores among asynchronous
students may not mean the asynchronous mode of instruction was more effective. Second, the fact that asynchronous students started Algebra 1 with a higher mean STAR 360 math score (M=789.26) than synchronous students (M=760.98) may also have affected their Algebra 1 Keystone Exam scores. Changing failing students’ format from asynchronous to synchronous mid-year to provide those students with additional support may have affected Keystone Exam scores as well.

**Analysis of Synchronous and Asynchronous Students' Perceptions**

Subquestion #3. To what extent do synchronous students' perceptions of their educational experiences differ from the perceptions of asynchronous students enrolled in Algebra 1 at a public, cyber charter school in Pennsylvania?

H\textsubscript{03}: There is no difference between synchronous and asynchronous students' perceptions of their educational experiences.

H\textsubscript{3}: There is a difference between synchronous and asynchronous students' perceptions of their educational experiences.

The transactional distance scale (Huang et al., 2015) measured student perceptions of their educational experience based on 85 questions. The survey was divided into four main constructs: dialogue, structure, autonomy, and transactional distance. Each construct was treated independently by dividing the original dependent variable into four dependent variables. The complete set of survey questions included in each construct can be found in Appendix B.

**Consent.** Of the 94 total asynchronous students, parental permission for participation was obtained for nine students, seven of whom agreed to participate; only five completed the survey. Of the 405 synchronous students, parental permission was obtained for 30 students, 22 of whom agreed to participate and completed the survey. Four additional synchronous students were
already 18 years of age and they provided their own consent, bringing the total number of synchronous students who completed the survey to 26. This poor response rate could have been a result of many factors. Since the researcher was not an Algebra 1 teacher and completing the survey did not affect students' grades, there may have been little perceived benefit from participating. In addition, to maintain separation between the school and the study, the researcher used a non-school email address for all correspondence with families. This could have resulted in parents disregarding the email, believing it was spam or junk mail. The greatest challenge for participation in the survey was the delay in administration. Participating students took Algebra 1 in 2015-16, but due to constraints relating to IRB approval, were not asked to complete the perceptions survey until December of the following school year. The response rate may have been higher had the survey been given immediately following the completion of the course.

**Variables.** The independent variable for this subquestion was mode of instruction and the dependent variable was student perception. The survey measured the three factors in Moore's theory of transactional distance, dialogue, structure, and learner autonomy, as well as students' perceptions of overall transactional distance. Each construct was treated independently. Composite variables were created in SPSS, with students' ratings on individual questions in each construct averaged into one construct score. Despite much debate over treating Likert scale data as continuous or ordinal, many researchers support considering Likert data as continuous, especially when there are five or more categories, so parametric statistical tests can be performed (Labovitz, 1970; Norman, 2010). The Likert scale data in this study were converted to composite variables, where the averages of each composite variable were continuous; these composite variables were treated as continuous data.

**Testing model assumptions.** The original single dependent variable was divided into
four composite dependent variables, which looked at four different aspects of the overall student perception rating; therefore a multivariate analysis of variance (MANOVA) was used to analyze the data. In order to use a MANOVA test, several assumptions must be met (Muijs, 2011). The dependent variables must be continuous data, and the independent variable must have two or more categorical groups; both of these conditions were met.

In addition, MANOVA is sensitive to outliers, so an assumption of the test is that there are no outliers in the data (Muijs, 2011). To check for outliers, a linear regression was performed and the Mahalanobis distance was evaluated. With four dependent variables, the critical maximum value is 18.47. The Mahalanobis value for this study was found to be 11.42.

The MANOVA test also assumes multivariate normality. Results of the normality test can be found in Table 11.

Table 11

<table>
<thead>
<tr>
<th>Tests of Normality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kolmogorov-Smirnov&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Statistic</td>
</tr>
<tr>
<td>mean autonomy score</td>
</tr>
<tr>
<td>mean transaction score</td>
</tr>
<tr>
<td>mean dialogue score</td>
</tr>
<tr>
<td>mean structure score</td>
</tr>
</tbody>
</table>

<sup>Note</sup>. <sup>*</sup> = lower bound of the true significance; <sup>a</sup> = Lilliefors significance correction.

Using the Shapiro-Wilk value, normality can be assumed for mean transaction score, mean dialogue score, and mean structure score (p > .05). Normality cannot be assumed for mean autonomy score (p < .05).

Linear relationships between each pair of dependent variables for each group in the independent variable is also an assumption of MANOVA (Muijs, 2011). A scatter plot was used
to test this assumption in SPSS. Figure 2 shows the scatter plot results.

**Figure 2.** Linearity of each DV with the IV.

The synchronous data appeared to have an elliptical pattern moving from the top left to the lower right of each box, but some of the asynchronous data boxes appeared to be less linear in nature.

MANOVA assumes no multicollinearity. Table 12 shows that all pairs of variables had enough of a relationship ($r > .2$), but none of the variables were multicollinear ($r < .9$).
Table 12

Test for Multicollinearity

<table>
<thead>
<tr>
<th></th>
<th>mean autonomy score</th>
<th>mean transaction score</th>
<th>mean dialogue score</th>
<th>mean structure score</th>
</tr>
</thead>
<tbody>
<tr>
<td>mean autonomy</td>
<td>Pearson Correlation</td>
<td>1</td>
<td>.57**</td>
<td>.47**</td>
</tr>
<tr>
<td>score</td>
<td>Sig. (2-tailed)</td>
<td>.001</td>
<td>.007</td>
<td>.008</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>31</td>
<td>31</td>
<td>31</td>
</tr>
<tr>
<td>mean transaction</td>
<td>Pearson Correlation</td>
<td>.57**</td>
<td>1</td>
<td>.82**</td>
</tr>
<tr>
<td>score</td>
<td>Sig. (2-tailed)</td>
<td>.001</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>31</td>
<td>31</td>
<td>31</td>
</tr>
<tr>
<td>mean dialogue</td>
<td>Pearson Correlation</td>
<td>.47**</td>
<td>.82**</td>
<td>1</td>
</tr>
<tr>
<td>score</td>
<td>Sig. (2-tailed)</td>
<td>.007</td>
<td>.000</td>
<td>.012</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>31</td>
<td>31</td>
<td>31</td>
</tr>
<tr>
<td>mean structure</td>
<td>Pearson Correlation</td>
<td>.47**</td>
<td>.61**</td>
<td>.45*</td>
</tr>
<tr>
<td>score</td>
<td>Sig. (2-tailed)</td>
<td>.008</td>
<td>.000</td>
<td>.012</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>31</td>
<td>31</td>
<td>31</td>
</tr>
</tbody>
</table>

Note. ** = correlation is significant at the 0.01 level (2-tailed); * = Correlation is significant at the 0.05 level (2-tailed).

Finally, homogeneity of variance must be assumed. Box's M was used to test for equality of covariance, since the sample sizes in the independent variable were not equal. A significance value greater than .001 meets the assumption. As seen in Table 13, a significance value of .919 was found for this data. There was no evidence that the covariance matrices were significantly unequal.
Table 13

*Test for Homogeneity of Variance*

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Box’s M</td>
<td>7.67</td>
</tr>
<tr>
<td>F</td>
<td>.45</td>
</tr>
<tr>
<td>df1</td>
<td>10</td>
</tr>
<tr>
<td>df2</td>
<td>219.78</td>
</tr>
<tr>
<td>Sig.</td>
<td>.919</td>
</tr>
</tbody>
</table>

*Note.* Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups; a = design: intercept + courseformat

**Hypothesis testing.** Two assumptions were not met. Some of the asynchronous data did not appear to be linear, and normality could not be assumed for mean autonomy score. Because these assumptions were not met, Wilks’ Lambda could not be used, so Pillai’s Trace value was used instead. A one-way MANOVA revealed no statistically significant difference in student perceptions of their educational experience between synchronous and asynchronous students (Pillai’s Trace = .13, F(4, 26) = 0.97, p = .441, partial eta squared = .13). The null hypothesis was accepted. There was no difference between student perceptions based on mode of instruction. Complete results from the MANOVA can be seen in Table 14.
Table 14

**MANOVA Results**

<table>
<thead>
<tr>
<th>Effect</th>
<th>Value</th>
<th>Hyp. F</th>
<th>Error df</th>
<th>Error df</th>
<th>Sig.</th>
<th>Partial Eta Squared</th>
<th>Noncent. Parameter</th>
<th>Observed Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>.98</td>
<td>265.65&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4</td>
<td>26</td>
<td>.000</td>
<td>.98</td>
<td>1062.60</td>
<td>1.00</td>
</tr>
<tr>
<td>Wilks' Lambda</td>
<td>.024</td>
<td>265.65&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4</td>
<td>26</td>
<td>.000</td>
<td>.98</td>
<td>1062.60</td>
<td>1.00</td>
</tr>
<tr>
<td>Hotelling's Trace</td>
<td>40.87</td>
<td>265.65&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4</td>
<td>26</td>
<td>.000</td>
<td>.98</td>
<td>1062.60</td>
<td>1.00</td>
</tr>
<tr>
<td>Roy's Largest Root</td>
<td>40.87</td>
<td>265.65&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4</td>
<td>26</td>
<td>.000</td>
<td>.98</td>
<td>1062.60</td>
<td>1.00</td>
</tr>
<tr>
<td>Course</td>
<td>.13</td>
<td>0.97&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4</td>
<td>26</td>
<td>.441</td>
<td>.13</td>
<td>3.88</td>
<td>.26</td>
</tr>
<tr>
<td>Format</td>
<td>.87</td>
<td>0.97&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4</td>
<td>26</td>
<td>.441</td>
<td>.13</td>
<td>3.88</td>
<td>.26</td>
</tr>
<tr>
<td>Course</td>
<td>0.15</td>
<td>0.97&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4</td>
<td>26</td>
<td>.441</td>
<td>.13</td>
<td>3.88</td>
<td>.26</td>
</tr>
<tr>
<td>Format</td>
<td>0.15</td>
<td>0.97&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4</td>
<td>26</td>
<td>.441</td>
<td>.13</td>
<td>3.88</td>
<td>.26</td>
</tr>
</tbody>
</table>

*Note.* a = design: intercept + course format; b = exact statistic; c = computed using alpha = .05.

The analysis of Subquestion 3 was limited by the very small number of participant responses. The asynchronous group had a response rate of about 5.3% (5 out of 94) and the synchronous group had a response rate of about 6.4% (26 out of 405). Conclusions cannot be drawn, or generalized to the general population, because of the small sample size of participants in both groups. A look at the means in Table 15 of each construct for the two groups, synchronous and asynchronous, allows us to see whether responses supported Moore's theory of transactional distance. According to Moore, learner autonomy should be higher among asynchronous students (N = 5, M = 5.18) than synchronous students (N = 26, M = 4.80), which it appeared to be based on the limited data. Structure should be higher in asynchronous courses (N = 5, M = 6.17) than in synchronous courses (N = 26, M = 5.70), which again seemed to be supported. Dialogue should be higher in synchronous courses (N = 26, M = 4.37) than in asynchronous courses (N = 5, M = 4.11), which supported the theory. The mean transactional distance score was extremely similar for the two groups (synchronous: N = 26, M = 4.93; asynchronous: N = 4, M = 4.87), supporting Moore's theory that there may be no difference in
transactional distance between the groups. Synchronous students had increased dialogue and less structure, which decreased transactional distance compared to their asynchronous peers. They also had less autonomy, which increases transactional distance compared to asynchronous students. Together, these effects may have caused the similar mean transactional distance scores between the two groups. Again, these conclusions are limited based on the low response rate.

Table 15

*Group Means for Constructs*

<table>
<thead>
<tr>
<th>Group Statistics</th>
<th>Course Format</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>mean autonomy score</td>
<td>Asynchronous</td>
<td>5</td>
<td>5.18</td>
<td>0.36</td>
<td>0.16</td>
</tr>
<tr>
<td></td>
<td>Synchronous</td>
<td>26</td>
<td>4.80</td>
<td>0.98</td>
<td>0.19</td>
</tr>
<tr>
<td>mean transaction score</td>
<td>Asynchronous</td>
<td>5</td>
<td>4.87</td>
<td>1.05</td>
<td>0.47</td>
</tr>
<tr>
<td></td>
<td>Synchronous</td>
<td>26</td>
<td>4.94</td>
<td>1.02</td>
<td>0.20</td>
</tr>
<tr>
<td>mean dialogue score</td>
<td>Asynchronous</td>
<td>5</td>
<td>4.11</td>
<td>1.11</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td>Synchronous</td>
<td>26</td>
<td>4.37</td>
<td>1.09</td>
<td>0.21</td>
</tr>
<tr>
<td>mean structure score</td>
<td>Asynchronous</td>
<td>5</td>
<td>6.17</td>
<td>0.47</td>
<td>0.21</td>
</tr>
<tr>
<td></td>
<td>Synchronous</td>
<td>26</td>
<td>5.70</td>
<td>0.77</td>
<td>0.15</td>
</tr>
</tbody>
</table>

**Analysis of the Correlation between Synchronous Grades and Keystone Exam Scores**

**Subquestion #4.** Does a correlation exist between Algebra 1 end-of-course grades and Keystone Exam scores for synchronous students enrolled in Algebra1 at a public, cyber charter school in Pennsylvania?

H$_{04}$: No correlation exists between end-of-course grades and Keystone Exam scores for synchronous students.

H$_{A4}$: There is a correlation between end-of-course grades and Keystone Exam scores for
synchronous students.

Assumption testing. The independent and dependent variables being compared were both continuous, so the Pearson's r correlation coefficient and p-value were used to analyze this subquestion. The Pearson's correlation coefficient measures the strength and direction of association that exists between two variables (Creswell, 2012; Muijs, 2011). Four assumptions must be met in order to use Pearson's correlation (Muijs, 2011).

First, both variables must be continuous. Final course grades and Keystone Exam scores were both continuous data types, so the first assumption was met. Second, there must be a linear relationship between the two variables. As shown in Figure 3, a linear relationship did not exist.

![Figure 3. Scatter plot showing relationship between Keystone Exam scores and final grades for synchronous students](image-url)
The third assumption is that no outliers exist in the data. If outliers exist, they must be removed prior to analysis. Figure 4 shows the box plot for synchronous students' final course grades and Figure 5 shows the box plot for synchronous students' Keystone Exam scores. While there were no outliers in end-of-course grades, outliers did exist in the Keystone Exam data. The outliers appear at the upper end of the Keystone Exam scores. As seen in the scatter plot, removing the outliers from the upper end of the Keystone Exam scores would not make the relationship between the two variables more linear, so the outliers were not removed.

*Figure 4. Synchronous final grades box plot*
Finally, the data must be normally distributed. A Shapiro-Wilk test was conducted to check for normality. Results are shown in Table 16.

Table 16

**Shapiro-Wilk Test for Normality for Synchronous Students**

<table>
<thead>
<tr>
<th></th>
<th>Kolmogorov-Smirnov&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Shapiro-Wilk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Statistic df Sig.</td>
<td>Statistic df Sig.</td>
</tr>
<tr>
<td>Synch Final Grades</td>
<td>.10 348 .000</td>
<td>.95 348 .000</td>
</tr>
<tr>
<td>Synch Keystone Score</td>
<td>.10 348 .000</td>
<td>.97 348 .000</td>
</tr>
</tbody>
</table>

*Note.* a = Lilliefors significance correction

Neither the final course grades (SW = .95, df = 348, p < .001) nor the Keystone Exam score data (SW = 0.97, df = 348, p < .001) were distributed normally. Three assumptions for using Pearson's r were not met. A linear relationship between the two variables was not found, there were outliers in the Keystone Exam data, and the data was not distributed normally. Instead of
using Pearson’s r correlation, Spearman’s rho must be used. Spearman’s rho is less sensitive to outliers and lack of linearity (Muijs, 2011).

**Hypothesis testing.** Based on the results from the Spearman’s rho correlation in SPSS, shown in Table 17, there was a modest positive correlation between final course grades and Keystone Exam scores ($N = 348$, $r_s = .28$, $p < .001$) for synchronous students. The null hypothesis was rejected, as there was a modest positive correlation between the variables. Even though there was a modest positive correlation, a higher Spearman's rho value would be ideal. A higher correlation coefficient would show that final course grades could be used to predict Keystone Exam scores. The low correlation coefficient could have been caused by a number of factors. The course may not have been completely aligned to the state Algebra 1 standards assessed on the Keystone Exam. This would show higher course final grades, but lower overall Keystone Exam scores. Students may have been able to demonstrate proficiency on content presented in contained units, but were unable to demonstrate proficiency when all course content was assessed at one time. Students may have taken advantage of open notes or open books during quizzes and tests in the online environment, but were unable to do so during the Keystone Exam.

Table 17

**Spearman's Rho Correlation for Synchronous Students**

<table>
<thead>
<tr>
<th></th>
<th>Synch Final Grades</th>
<th>Synch Keystone Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synch Final Grades</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correlation Coefficient</td>
<td>1.00</td>
<td>$.28^{**}$</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td></td>
<td>$.000</td>
</tr>
<tr>
<td>N</td>
<td>405</td>
<td>348</td>
</tr>
<tr>
<td>Spearman's rho</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Synch Keystone Score</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correlation Coefficient</td>
<td>0.28^{**}</td>
<td>1.000</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>0.000</td>
<td>.</td>
</tr>
<tr>
<td>N</td>
<td>348</td>
<td>348</td>
</tr>
</tbody>
</table>

*Note.** = correlation is significant at the 0.01 level (2-tailed).*
Analysis of the Correlation between Asynchronous Grades and Keystone Exam Scores

Subquestion #5. Does a correlation exist between Algebra 1 end-of-course grades and Keystone Exam scores for asynchronous students enrolled in Algebra 1 at a public, cyber charter school in Pennsylvania?

H₀: No correlation exists between end-of-course grades and Keystone Exam scores for asynchronous students.

H₁: There is a correlation between end-of-course grades and Keystone Exam scores for asynchronous students.

Assumption testing. As in Subquestion 4, the independent and dependent variables being compared were both continuous, so the Pearson’s r correlation coefficient and p-value were used to analyze this subquestion. The Pearson’s correlation coefficient measures the strength and direction of association that exists between two variables (Creswell, 2012; Muijs, 2011). Four assumptions must be met in order to use Pearson’s correlation (Muijs, 2011).

First, both variables must be continuous. Final course grades and Keystone Exam scores were both continuous data types, so the first assumption was met. Second, there must be a linear relationship between the two variables. As shown in Figure 6, a linear relationship did not exist.
Figure 6. Scatter plot showing relationship between final grades and Keystone scores for asynchronous students.

The third assumption is that no outliers exist in the data. If outliers exist, they must be removed prior to analysis. Figure 7 shows the box plot for asynchronous students' final course grades and Figure 8 shows the box plot for asynchronous students' Keystone Exam scores. While there were no outliers in the Keystone Exam scores, outliers did exist in the final course grades.
Figure 7. Asynchronous final grades box plot

Figure 8. Asynchronous Keystone Exam grades box plot
The final grades box plot shows that outliers were on the low end of the grades. The scatter plot in Figure 9 shows that removing the outliers, the lower final course grades, may make the relationship more linear. Outliers, identified by the students' state ID numbers, were removed from the data set. After the outliers were removed, another scatter plot was created to see if it was linear. The results are shown in Figure 8.

![Graph showing relationship between Asynch Final Grades and Keystone Exam scores without outliers](image)

*Figure 9. Scatter plot of final grades and Keystone Exam scores without outliers*

The scatter plot now shows a more linear relationship.

Finally, to use the Pearson's r, the data must be normally distributed. A Shapiro-Wilk test was used to test for normality. The results are shown in Table 18. The Keystone Exam scores were distributed normally (SW = .98, df = 78, p = .152), but the end-of-course grades were not normally distributed (SW = .92, df = 88, p < .001).
Table 18

*Shapiro-Wilk Test for Normality for Asynchronous Students*

<table>
<thead>
<tr>
<th></th>
<th>Kolmogorov-Smirnov&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Shapiro-Wilk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Statistic df Sig.</td>
<td>Statistic df Sig.</td>
</tr>
<tr>
<td>Asynch Final Grades,</td>
<td>.11 88 .012</td>
<td>.92 88 .000</td>
</tr>
<tr>
<td>Outliers Removed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asynch Keystone Score</td>
<td>.10 78 .077</td>
<td>.98 78 .152</td>
</tr>
</tbody>
</table>

*Note.* a = Lilliefors significance correction

The non-normality of the final course grade data did not meet the assumption necessary to use the Pearson's r correlation, so Spearman's rho must be used.

**Hypothesis testing.** Based on the results from the Spearman's rho correlation in SPSS, shown in Table 19, there was a moderate positive correlation between final course grades and keystone exam scores (N = 78, r_s = .57, p < .001) for asynchronous students. The null hypothesis was rejected, as there was a moderate positive correlation between the variables. Even though there was a moderate positive correlation, ideally a higher Spearman's rho value would be obtained, showing that high final course grades would predict high Keystone Exam scores, and similarly, that low course grades would predict low Keystone Exam scores. The lower than expected correlation coefficient could have been caused by a number of factors. The course may not have been completely aligned to the state Algebra 1 standards assessed on the Keystone Exam. This would show higher course final grades, but lower overall Keystone Exam scores. Students may have been able to demonstrate proficiency on content presented in contained units, but were unable to demonstrate proficiency when all course content was assessed at one time. Students may have taken advantage of open notes or open books during quizzes and tests in the online environment, but were unable to do so during the Keystone Exam.
<table>
<thead>
<tr>
<th>Spearman's rho</th>
<th>Asynch Keystone Score</th>
<th>Asynch Final Grades</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Correlation Coefficient</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>78</td>
</tr>
<tr>
<td>Asynch Final Grades</td>
<td>Correlation Coefficient</td>
<td>.57**</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>78</td>
</tr>
</tbody>
</table>

Note. ** = Correlation is significant at the 0.01 level (2-tailed).

Summary

The data analysis presented in this chapter utilized statistical measures to test the hypothesis of each of the five subquestions presented in this study. There were two pre-existing significant differences between the synchronous and asynchronous groups, type of community and STAR 360 math pretest scores. As instruction occurred online for all students, and all students had access to the same instructional resources, teachers, and technology equipment, the type of community in which a student resides may have had a lesser affect on the educational outcomes in this cyber setting than in a traditional school setting. An online setting does not eliminate all the educational challenges related to community type, so it must be noted that community type may have affected the learning outcomes in this study. The differences in STAR 360 math pretest scores may have affected the educational outcomes of the two groups as well. The asynchronous group had a significantly higher mean pretest score than the synchronous group.
The t-test conducted for Subquestion 1 revealed that there was a significant difference between the Algebra 1 end-of-course grades of students in the synchronous format and students in the asynchronous format. Therefore, the null hypothesis for Subquestion 1 was rejected. STAR 360 pretest scores and the research site's policy of changing failing students' course format from asynchronous to synchronous to improve achievement by increasing structure and support may have affected the difference in educational outcomes between the two groups. Similarly, the t-test conducted for Subquestion 2 also revealed a significant difference between the Algebra 1 Keystone Exam scores of students in the synchronous format and their counterparts in the asynchronous format. The null hypothesis for Subquestion 2 was rejected. As in Subquestion 1, STAR 360 pretest scores and changing the format for some failing students may have affected the outcome of this subquestion. In analyzing subquestions 1 and 2, some unexpected findings were uncovered. The course pass rate for all participants was 64% while the Keystone Exam pass rate was only 7%. This is discussed further in Chapter 5. The MANOVA test conducted for Subquestion 3 indicated that there was not a significant difference between student perceptions of their educational experience based on course format. The null hypothesis was accepted, but it is important to note that this analysis was very limited based on the number of survey responses received overall, especially from asynchronous students. The Spearman's rho correlation conducted for Subquestion 4 revealed a modest positive correlation between final course grades and Keystone Exam scores for synchronous students. The null hypothesis was rejected. Similarly, the Spearman's rho correlation conducted for Subquestion 5 indicated a moderate positive correlation between final course grades and Keystone Exam scores for asynchronous students. The null hypothesis was rejected for Subquestion 5. A discussion of findings from the study, along with limitations of the study and implications for future research,
are discussed in the next chapter.
Chapter 5: Discussion and Implications for Practice

The purpose of this research study was to compare asynchronous and synchronous students’ end-of-course grades, Algebra 1 Keystone exam scores, and student perceptions of their educational experience to determine whether course format affected educational outcomes. It used existing data for students enrolled in each method of instruction to determine whether there was a significant difference between the two groups on those measures.

Transactional distance theory (Moore, 1972, 1973, 1980, 1991, 1993) guided the research question: Does the method of online instruction, synchronous versus asynchronous, affect the educational outcomes, measured by (a) end-of-course grades, (b) state standardized test scores, and (c) students' perceptions of their educational experience, of Algebra 1 students enrolled at a public, cyber charter school in Pennsylvania? This final chapter discusses the quantitative findings of the research study in relation to the theoretical framework and existing literature, as well as how the findings can add to the current research on online education. It also discusses the two overall findings of lower final course grades and Keystone exam scores for synchronous students, and equivalent student perceptions of their educational experience, as well as the key reasons for these findings. Finally, it explores implications of the findings for educational practice, future research, and policy.

**Findings from Comparisons of the Two Groups**

Student demographic and academic data were gathered and analyzed prior to the study to determine whether there were pre-existing differences between the two groups. Analysis of that data showed that the two populations of students were not significantly different in the areas of grade level, gender, students' IEP status, free or reduced lunch status, or age, but they were significantly different in the type of community and math pretest scores. These differences may
have affected the results of this study. In addition, the two groups were significantly different in size. The synchronous group contained 405 students and the asynchronous group had only 94 students.

**Findings from Subquestions 1 and 2**

Subquestion 1 examined whether there was a statistically significant difference between end-of-course Algebra 1 grades for synchronous and asynchronous students. The null hypothesis for this subquestion was that no difference existed between the end-of-course grades of synchronous and asynchronous students. Subquestion 2 examined whether there was a statistically significant difference between Algebra 1 Keystone Exam scores for asynchronous and synchronous students. The null hypothesis for this subquestion was that no difference existed between the Algebra 1 Keystone Exam scores for synchronous and asynchronous students.

Based on previous literature relating to online instruction (Olson & McCracken, 2015; Roblyer et al., 2007), specifically synchronous and asynchronous delivery formats, it was expected that the results would show no significant difference in final course grades or Keystone Exam scores for the two groups.

The research cited in the literature review revealed that there was no difference in achievement level for students in synchronous versus asynchronous course formats. Roblyer et al.’s (2007) study of 43 semester-long courses at 101 different high schools in Alabama showed no difference between the achievement levels for synchronous and asynchronous students. Students enrolled in the courses came from low-income rural schools with limited access to broad course offerings. The courses in the study ranged from remediation courses to AP courses, involving participants of all ability levels. Olson and McCracken (2015) reported similar findings in their study of final course grades in a 5-week undergraduate online course. They
found no significant difference in final course grades between the synchronous and asynchronous groups. The findings from these two studies on educational outcomes for synchronous and asynchronous students suggested that there should be no differences in the two groups’ final course grades and Keystone exam scores.

In accordance with previous research (Olson & McCracken, 2015; Roblyer et al., 2007), it was hypothesized that there would not be a significant difference between final course grades for the two populations of students. However, a t-test indicated that there was a statistically significant difference between course format and final course grade (t = 4.12, df = 497, p < .001). Synchronous students had significantly lower end-of-course grades than their asynchronous counterparts.

In accordance with previous research (Olson & McCracken, 2015; Roblyer et al., 2007), it was hypothesized that there would not be a significant difference between the standardized test scores for the two populations of students. However, a t-test indicated that there was a statistically significant difference between course format and Keystone Exam score (t = 2.96, df = 103.45, p = .004). Synchronous students had significantly lower standardized test scores than their asynchronous counterparts.

Two moderating variables may have affected the results of the first two subquestions, the type of community and STAR 360 math pretest scores. Because instruction occurred online for all students, and all students had access to the same instructional resources, teachers, and technology equipment, the type of community in which a student resided may not have affected final course grades or Keystone Exam scores as much as it would have in a traditional school setting. As mentioned previously, online education does not eliminate all the educational challenges associated with community type. The differences in STAR 360 math pretest scores
may have affected the educational outcomes of the two groups. The asynchronous group had a significantly higher mean pretest score than the synchronous group, which may have affected both their final course grades and Keystone Exam scores.

The research site's policy of continuously monitoring students' grades and attendance and making changes to mode of instruction could also have affected the results. Throughout the year, students are moved from asynchronous status to synchronous if they are not performing well academically. Similarly, students doing very well can change from synchronous to asynchronous status. This practice is good from an educational standpoint because it allows successful students more flexibility and provides lower performing students with more structure. From a research standpoint, however, this is problematic because it causes the asynchronous group to include more students who have been successful and the synchronous group to include more students who have been struggling academically.

Although these results were not expected, in retrospect it is understandable that asynchronous students at the research site outperformed their synchronous peers in both final course grades and standardized test scores. The pre-existing differences in pretest scores, coupled with the research site's practice of requiring struggling students switch to the synchronous format in order to provide more structure and support, gave the asynchronous group an academic advantage over the synchronous group.

**Findings from Subquestion 3**

Subquestion 3 examined whether a statistically significant difference existed between synchronous and asynchronous students' perceptions of their educational experience in Algebra 1. The null hypothesis for this research question was that no difference existed between synchronous and asynchronous students' perceptions. According to previous literature on
synchronous and asynchronous delivery formats (Kunin et al., 2014; Olson & McCracken, 2015; Roblyer et al., 2007), it was expected that the results would show no significant difference in student satisfaction ratings for the two groups.

The research cited in the literature review revealed mixed reviews about synchronous and asynchronous students' views of their educational experiences. Roblyer et al.’s (2007) study of 43 semester-long courses at 101 different high schools in Alabama reported finding no difference between the satisfaction levels of synchronous and asynchronous students. Similarly, Olson and McCracken (2015) found no difference between reported student satisfaction in the synchronous and asynchronous groups. In contrast, Kunin et al. (2014) showed that asynchronous students rated the effectiveness and clarity of their course significantly higher than synchronous students, but there was no difference in student-teacher and student-student interaction ratings between the two groups. The findings from these three studies on student perceptions of synchronous and asynchronous courses suggested that there would not be any differences in perception between the two groups.

Following the majority (Olson & McCracken, 2015; Roblyer et al., 2007) of these studies, it was hypothesized that there would not be a significant difference between students' perceptions of their educational experiences for the two populations of students. A one-way MANOVA supported the hypothesis and revealed no statistically significant differences in student perceptions based on the mode of instruction they received (Pillai’s Trace = 0.13, F(4, 26) = 0.97, p = .441, partial eta squared = .13). It is important to remember that these results are limited, as response rates were only about 5% for the asynchronous group and 6% for the synchronous group.

The transactional distance scale was created by Huang et al. (2015) specifically for use in
online courses. The focus of the survey is dialogue, structure, and autonomy to measure transactional distance. Surprisingly, there were no significant differences reported on dialogue for the two groups. Synchronous students met with their teachers and classmates every day, giving synchronous students increased opportunities to interact socially, yet there was no difference reported between the two groups. This may be because the teachers in the asynchronous courses communicated frequently through emails or phone calls, or responded often to discussion board posts. Again, the results for subquestion 3 and the conclusions drawn are limited because of the low survey response rate. These results cannot be generalized to other populations.

**Findings from Subquestions 4 and 5**

Subquestions 4 and 5 examined whether a correlation existed between end-of-course grades and standardized test scores for each group. Based on previous literature on online instruction, it was expected that the results would show a positive, but possibly weak, correlation between end-of-course grades and standardized test scores.

The research cited in the literature review did not include specific studies focused on the correlation between end-of-course grades and standardized test scores for online students. The research presented did, however, show that students taking online Algebra 1 courses performed at least as well as students taking the same course in a classroom setting (Hughes et al., 2007; O'Dwyer et al., 2007) on posttests. In contrast, Barbour and Mulcahy (2006) reported that students taking classroom-based AP courses did better on the AP exam than students taking web-based AP courses. O'Dwyer et al.'s (2007) study investigated the outcomes of an online Algebra 1 course designed for students in schools that did not have enough qualified mathematics teachers. Those students received instruction online from a certified math teacher at another
school, but were in a computer lab with a classroom teacher who monitored students during tests. Results showed that students in the online group performed as well as students in the classroom-based group on the course posttest. The Hughes et al. (2007) study found that online Algebra 1 students outperformed classroom-based students on the Assessment of Algebraic Understanding (AAU) test given at the end of the course. It must be noted that these results may be flawed because online students were taking the test at home, in an unproctored environment. In a study on retention rates, participation on AP exams, and achievement on AP exams, Barbour and Mulcahy (2006) found that students in classroom-based AP courses did better on the AP exam than students enrolled in AP courses online.

In addition to the research on performance for classroom-based and online students, additional research exists on the correlation between Algebra 1 end-of-course grades and state test scores. The Texas Education Agency (1999) released a report comparing course pass rates and standardized state assessment pass rates for a simple random sample of 16,401 middle and high school students who took Algebra 1 during the 1998-1999 school year. The participant pass rate for the course was 79%, while the pass rate for the state Algebra 1 test was only 45%. Analysis of the data produced a Spearman's rho correlation coefficient of 0.64, indicating there was a moderate correlation between student end-of-course grades and state test scores.

Based on the research presented in the literature review suggesting that online Algebra 1 students do as well as classroom-based students on end-of-course exams, as well as the Texas Algebra 1 report, it was hypothesized that there would be a positive correlation between end-of-course grades and Keystone Exam scores for synchronous and asynchronous students. A Spearman's rho correlation showed a modest positive correlation between final course grades and Keystone Exam scores for synchronous students (N = 348, r_s = .28, p < .001), and a moderate
positive correlation for asynchronous students \((N = 78, r_s = .57, p < .001)\). While both groups showed positive correlations, the asynchronous group had a stronger correlation. Ideally, for both groups, a higher correlation coefficient would be desirable. A higher Spearman's rho value would show students' final course grades could be used to predict their Keystone Exam scores.

The lower-than-expected correlation coefficients could have been caused by a number of factors. The courses may not have been completely aligned to the state Algebra 1 standards assessed on the Keystone Exam. This would show higher course final grades, but lower overall Keystone Exam scores. Also, students may have been able to demonstrate proficiency on content presented in contained units, but were unable to demonstrate proficiency when all course content was assessed at one time. Additionally, as mentioned in Chapter 3, the College Board (2016) reported that grade inflation in high schools has increased significantly since the late 1990s. Ziomek and Svec (1997) studied the ACT scores and student-reported GPAs of 2,100,074 students between the years of 1989 and 1994. Results similar to those reported by the College Board (2016) were found. During the 5 year period, students reported statistically significant higher GPAs despite no change in the ACT scores earned. Grade inflation may have caused an increase in the end-of-course grades, with some passing students not being truly proficient in the course content. Finally, students may have taken advantage of open notes or open books during quizzes and tests in the online environment, but were unable to do that on the Keystone Exam.

**Findings in Relation to Theoretical Framework**

This research study was guided by Moore's (1993) transactional distance theory, which was created in response to the growing field of distance education. The theory states that transactional distance in online learning is a function of dialogue, structure, and learner autonomy (Moore, 1993).
Dialogue

One of the greatest challenges in online education is the lack of socialization (Cavanaugh et al., 2004; Greenway & Vanourek, 2006; Muilenburg & Berge, 2005; Rice, 2006). This lack of socialization can lead to students feeling isolated (Cavanaugh et al., 2004). Increased student and teacher dialogue, as well as student-to-student dialogue, may improve achievement (Hawkins et al., 2013; C. Kim et al., 2014) as well as alleviate the lack of socialization and lessen feelings of isolation (C. Kim et al., 2014). Offir et al. (2008) found that synchronous courses offered the opportunity for increased socialization, while asynchronous courses lacked necessary dialogue between the teacher and students; this prevented students from asking questions that would lead to a deeper understanding of the content. Similarly, Hrastinski (2008a) found that synchronous students were more likely to develop relationships with their peers, leading to stronger relationships (Hrastinski, 2008b). Synchronous courses allow students the opportunity to see other students, hear their voices, and work collaboratively in breakout rooms, which may help create a sense of community (Martin et al., 2012). Based on information obtained through the review of previous literature, it was expected that synchronous students would perform better academically and would report higher levels of dialogue than asynchronous students.

Unfortunately, only one of those expectations was met. Asynchronous students significantly outperformed synchronous students in both end-of-course grades and Keystone Exam scores. This finding may have been affected by higher pretest scores in the asynchronous group, showing they had a greater understanding of mathematical content prior to the start of the Algebra 1 course, as well as the school’s policy of moving failing asynchronous students to the synchronous track so they could receive additional support. Synchronous students (N = 26, M = 4.37) did have a slightly higher mean dialogue score than asynchronous students (N = 5, M =
Survey questions asked students to measure both the quantity and quality of communication with the teacher and with other students in the class. These results have limited usefulness due to the small response rate from both groups.

**Structure**

Together with dialogue, the structure of online courses may also help improve student achievement. Course structure is comprised of the course goals and objectives, teaching strategies, assessment tools, and the flexibility of the course in meeting individual learning needs (Offir et al., 2008). Synchronous courses are more conducive to differentiation (Tomlinson & Kalbfleisch, 1998) because they allow the teacher to adjust instructional strategies, pacing, and assessments based on students' interest and need (Milman, 2015; Rayfield et al., 2011; Zajac, 2009). Synchronous students have the opportunity to interact with the content through class discussion, exploration, group work, and presentations (Akdemir & Koszalka, 2008), something their asynchronous peers lack. According to Moore (1980, 1991, 1993), highly structured courses define the materials and skills for the student, and allow no variation. Video recordings and static premade online lessons are highly structured, while live discussions and questions requiring open-ended written responses are less structured (Moore, 1993) because they allow for variation based on students' interests and needs. From the literature review, it was expected that synchronous students would perform better academically and report lower levels of structure than asynchronous students.

As reported previously, asynchronous students significantly outperformed synchronous students in both end-of-course grades and Keystone Exam scores, which may have been affected by the extraneous variables already discussed. Synchronous students (N = 26, M = 5.70) did have a lower mean structure score than asynchronous students (N = 5, M = 6.17). Survey
questions asked students to rate the flexibility, formality, and technology use in the course to measure structure. Once again, these results have limited usefulness due to the small response rate from both groups.

**Autonomy**

Autonomy, the third factor of transactional distance, may also improve student achievement. Autonomous learners are able to constantly self-monitor their understanding of content (Moore, 1972), asking for clarification from the teacher when needed (Linn, 1996), while nonautonomous learners need the teacher to direct their learning (Moore, 1973). A course with low dialogue and high structure, like asynchronous courses, requires the learner to exhibit more autonomy (Moore, 1993). Moore (1980) posited that a student will be unsuccessful in a course that demands more autonomy than that student possesses, an idea that supports the research site's policy on moving unsuccessful asynchronous students to a synchronous class where they have greater dialogue with teachers and students and lower structure because the teacher has control over pacing, assessments, and class activities. Autonomy is believed by many researchers to be necessary for success in online courses (Cavanaugh et al., 2004; Offir et al., 2008; Yen & Liu, 2009). The review of previous literature relating to autonomy led to the expectation that asynchronous students would perform better academically and would report higher levels of autonomy than synchronous students.

Supporting the prediction that autonomous students will have greater success in online courses, results showed that asynchronous students significantly outperformed synchronous students in both end-of-course grades and Keystone Exam scores. As predicted, synchronous students ($N = 26, M = 4.80$) did have a lower mean autonomy score than asynchronous students ($N = 5, M = 5.18$) on survey questions asking students to rate their own independence of learning
and study habits. Extreme caution must be taken when extending the autonomy score results to other populations, due to the low response rate.

**Overall Transactional Distance**

Transactional distance, defined as not only the geographic distance between the instructor and the student, but also the distance caused by specific factors in online education (Moore, 1991, 1993), is affected by dialogue, structure, and learner autonomy (Moore, 1993). According to Moore, students will be more successful in online courses if the transactional distance is low. Transactional distance is lower when there is frequent dialogue and minimal structure in a course (Moore, 1980, 1991), as seen in synchronous courses. Asynchronous course materials are more likely to be highly structured, providing more guidance and direction to students, because dialogue does not occur frequently; this creates a high level of transactional distance (Moore, 1993). Students in synchronous courses should feel less transactional distance than asynchronous students due to increased opportunities for dialogue and less structure because the teacher is able to modify the pace and target areas of need. However, synchronous students should exhibit less autonomy than asynchronous students, which would cause their feelings of transactional distance to increase. The research suggested that there may be no difference in transactional distance for the two groups.

As stated in the previous paragraphs, asynchronous students had a higher mean autonomy score, higher mean structure score, and lower dialogue scores than synchronous students, all in support of Moore's theory. These findings support what was expected based on previous research and the transactional distance theory. Synchronous students had lower transactional distance because of more dialogue and less structure, but their overall transactional distance increased due to lower autonomy. Asynchronous students had increased transactional distance because of low
dialogue and high structure, but the greater autonomy lowered their overall transactional distance. Extreme caution must be taken when extending the autonomy score results to other populations, due to the low response rate. The mean transaction score was extremely similar for the two groups (synchronous: \( N = 26, M = 4.93 \); asynchronous: \( N = 4, M = 4.87 \)). The results presented and discussed in this section led to several recommendations, both for the research site and for other institutions offering online courses or entire online programs.

**Recommendations and Implications**

**For the Research Site**

Several implications from this research may be beneficial to the research site. First, it is important to note that asynchronous students at this site will probably continue to outperform synchronous students academically. The purpose of the school's asynchronous track is to provide students who have demonstrated that they are capable of independent learning and educational autonomy with more flexibility and control over their learning. One important benefit of online education is allowing students more flexibility (Greenway & Vanourek, 2006; P. Kim et al., 2012, Rice, 2006), choice (Barbour & Reeves, 2009; Cavanaugh et al., 2004; Rice, 2006), and independence in their learning (Marsh et al., 2009). Unlike most cyber schools, the research site does have a synchronous track for those students who need additional support, are not ready to be autonomous learners, or who prefer more socialization with teachers and peers. Offering both synchronous and asynchronous options is an attractive option for an educational institution. It is recommended that the research site continues to monitor student progress and make changes to individual student learning plans if they lack the autonomy, self-discipline, or independent learning skills necessary to be successful in an asynchronous course. It is also recommended that the research site continues being transparent with parents in regards to the requirements of the
asynchronous course and the policy in place to support their child should the student fail to meet those academic requirements.

In addition, after observing the fall, spring, and final course grades for 499 Algebra 1 students, it was understandable why some researchers believe that cyber school may not be the best educational choice for some students (Cavanaugh et al., 2004; Chaney, 2001; Cowan, 2009; Donlevy, 2003; Greenway & Vanourek, 2006; Yang and Cornelious, 2005). There were 34 students (7% of the research population) who had 0% at the end of at least one semester. Those students were completely disengaged from their courses. Moving forward, it may be beneficial for the research site to create an improvement plan for these disengaged students that involves participation during class activities and completion of assignments in addition to attending live class sessions. If this improvement plan does not work, all stakeholders (parents, child, teachers, and administration) may find it helpful to have a discussion about the student's academic strengths and weaknesses, future plans, and reasons for the lack of involvement in course work to determine what kind of educational placement would be most supportive for that student.

Third, the Algebra 1 team may want to redesign its curriculum to fully align lessons and assessments with the Pennsylvania Algebra 1 Keystone Assessment Anchors. The low correlation coefficients obtained for final course grades and Keystone Exam scores for both modes of instruction imply that the current course is not fully aligned. Furthermore, increasing the rigor of the assignments, especially the constructed-response questions in each unit, may help prepare students for the Keystone Exams. Because 40% of a student's standardized test score comes from the constructed-response questions, focusing on open-ended questions in every assignment may also help improve student test scores.

Finally, the overall course pass rate for the 499 Algebra 1 students was 64% (319 out of
499 students), and the overall Keystone Exam proficiency rate (proficient or advanced) was 7% (35 out of 499). These pass rates show that it may be beneficial, for both the students and for the research site, to provide a math remediation or support class for students entering high school who failed the eighth-grade state standardized test. This additional mathematics instruction would strengthen the skills of lower achieving students and review background concepts needed for success in Algebra 1. The discrepancy between the pass rate for the course and the pass rate on the Keystone Exam, as well as the low correlation between end-of-course scores and standardized test scores, shows that many of the students at the research site were passing the course, but for various reasons were not prepared for the Keystone Exam. Implementing these recommendations may help improve the overall success rate for students, both in the course and on the Algebra 1 Keystone Exam.

**For All High Schools Offering Online Courses or Full Programs**

Recommendations for high schools currently offering, or interested in offering, online courses emerged from the current literature on online education as well as the implications from this study of the educational outcomes of synchronous and asynchronous students. These recommendations focus on four target areas: creating an effective online course, aligning courses to current state standards, deciding what kind of course or program to offer, and building and growing students’ autonomy.

**Creating effective courses.** When developing new courses, it is important to keep the common benefits and weaknesses of online education in mind (Currie-Rubin & Smith, 2014; C. Kim et al., 2014; Martin et al., 2012; Rauh, 2011; Vonderwell, 2003; Zappe et al., 2002). Courses should promote communication between all stakeholders. Parents should be able to view their student's grades, feedback, and assignments still needing to be completed (Rauh, 2011;
Zappe et al., 2002). This transparency will open communication between the school and family and welcome parents to be active in their child's learning (Currie-Rubin & Smith, 2014).

Courses should also take advantage of the opportunity for increasing interactions between students to counter feelings of isolation in the online setting. Increasing the social presence in online courses, by using email, discussion boards, class discussions, and small group work (Vonderwell, 2003); allowing students to use their microphone to share ideas and ask questions; and reaching out to students by phone (Martin et al., 2012), may improve student achievement (C. Kim et al., 2014).

The course structure is also an important aspect of creating online courses. Clearly posting the goals of the course and including a syllabus with expectations, covered content, and types of assignments being utilized in the course will help students visualize what the course will entail (Offir et al., 2008). Teachers should be prepared to differentiate the course in the same way they would in a classroom setting. Constantly monitoring student progress and understanding through formative and summative assessments, and getting to know the students, will help the teacher alter pacing, adjust the instructional strategies used, and determine areas of weakness that require reteaching (Milman, 2015; Rayfield et al., 2011; Zajac, 2009).

Another way to differentiate instruction is to provide the content of the online lesson in several ways, for example, text, video, audio, and visual aids (Milman, 2015; Zajac, 2009), to support various learning styles and allow students choice in how they learn the content. Increasing the communication (parent-school, student-student, and teacher-student) in a course and lowering the structure by allowing teachers to modify pacing, assessments, and delivery will help lower the transactional distance students feel (Moore, 1980, 1991), as supported by the results of this research study.
**Course alignment.** The discrepancy between the course pass rates (64%) and standardized test proficiency rates (7%) for all students included in this study shows the importance of aligning the course curriculum, both its content and assessments, to the state standards. In general, a student who passes a course should be able to score proficient on a standardized test assessing that content. There will be cases where students have text anxiety, or receive additional help or modified assignments from their resource teacher, as stated in the student's Individualized Education Plan, but generally speaking, it would be expected that the final course grade would predict how well a student will do on the state standardized test. A fully aligned curriculum would help strengthen the correlation between the two scores. There was a positive correlation found for both synchronous ($r_s = 0.28$) and asynchronous ($r_s = 0.57$) groups, but it was weaker than anticipated. A stronger course alignment may have strengthened the correlation. Increasing the rigor of the course may also increase the correlation between end-of-course grades and standardized test scores. In the research study, 40% of the standardized test score was comprised of constructed-response questions where students had to show their work or explain what their answer meant in the context of the problem. Aligning the course to match the rigor of the state test and providing students with frequent opportunities to practice answering constructed-response questions would also improve the correlation. Online education has the potential to eliminate some of the obstacles to educational equality by providing all students, regardless of the socioeconomic and racial composition of their neighborhood, equal access to courses (Cavanaugh et al., 2004; Lips, 2010) and high-quality instruction (Cavanaugh et al., 2004).

**Synchronous or asynchronous?** A third recommendation resulting from this study relates to understanding the type of student expected to take online courses. If only independent,
highly motivated students with good time management and technology skills will be allowed to take courses, asynchronous courses will be effective for those learners. Many virtual schools do not offer a synchronous track, but one should be considered if online courses will be taken by students who do not fit the aforementioned profile, including lower achieving students (Rice, 2006), students who speak English as their second language (Cavanaugh et al., 2004; Donlevy, 2003; Greenway & Vanourek, 2006), or unengaged students. Regardless of the format(s) chosen, steps should be taken to reduce the transactional distance felt by students. In this study, the mean transactional distance was similar for the synchronous and asynchronous groups, 4.93 and 4.87 respectively, where 1 is strong disagreement by students with feeling a sense of belonging and community with the teacher and peers and 7 is strong agreement with those feelings. This transactional distance score of close to 5 corresponds to a rating of "somewhat agree" on the survey. Creating a stronger sense of community and engaging students through the strategies discussed relating to communication and differentiation would help improve the transactional distance rating for synchronous and asynchronous students.

**Fostering autonomy.** The final recommendation stemming from this study relates to autonomy. Students in the asynchronous group had a mean autonomy score of 5.18 (a little higher than "somewhat agree") for questions relating to being an independent learner, taking responsibility for learning, and time management. Research presented in the literature review suggested that autonomous students would be successful in an online environment. The asynchronous students were successful in the course, with a mean final course grade of 72.53%. They were not as successful on the Keystone Exams, as the mean standardized test score for asynchronous students was 1455.87. Predicted reasons for the lower standardized test score have already been discussed, but it is important to note that the synchronous group, with a lower
autonomy mean score, had a mean Keystone Exam score of 1440.88, which was significantly lower. Creating lessons and assignments that help students build their autonomy skills could help improve educational outcomes for students. Activities such as self-reflection (Eneau & Develotte, 2012), finding and analyzing their own and others’ mistakes, class discussions, peer mentoring (Linn, 1996), and summarizing their learning (Eneau & Develotte, 2012) help students learn to monitor their understanding of content and self-reflect about what they learn to become more autonomous.

Limitations

Several limitations relating to the research design of the study make generalizing the results to all schools that offer online courses difficult. A causal-comparative design lacks randomization and manipulation of the independent variables. This threatens the internal validity of the study and makes causation difficult to infer. In this study, it cannot be inferred that taking the course asynchronously caused students to have higher end-of-course grades and standardized test scores because students were not randomly assigned to a course format. The research site's policy of changing a failing student's course format from asynchronous to synchronous for added support allowed students to move from one group to another during the study.

In addition, a convenience sample was used for the study. Convenience samples are often used in educational research (Muijs, 2011), but they add sample bias that must be addressed. To counter the bias introduced from using a convenience sample, data on several extraneous variables was collected to determine whether there were any pre-existing differences between the two groups. It is difficult to say that the students in the convenience sample were representative of the overall population (Creswell, 2012). The causal-comparative design and the type of sample used affects the external validity of the study and makes generalizing the results of this
study to the general population of students taking online courses in the United States difficult.

Group size inequity is another limitation that may have affected the results. The study included a large sample of 499 students, but the group sizes varied dramatically, with 94 students in the asynchronous group and 405 students in the synchronous group. Using a t-test with convenience samples is appropriate if the samples are large, which they were, and the two groups do not differ too much in size (Muijs, 2011). The groups for this study did differ considerably in size, making causality based on t-test results even more difficult to infer.

A final limitation of the study relates to the implementation timeline. Participants completed the course during the 2015-16 school year, but were not asked to complete the transactional distance scale (Huang et al., 2015) until 6 months after the course ended (December, 2016). IRB approval constraints dictated when parental consent could be sought, causing the delay in survey completion. The limited response rate (5.3% for asynchronous and 6.4% for synchronous) on the survey could have resulted from this delay. Similarly, it is possible that student responses were different 6 months after completing the course than they would have been immediately following. Sills and Song (2002) cautioned that email and web-based surveys tend to have low response rates. Low response rates from web-based surveys coupled with the delay in administering the survey caused limitations in the use of the conclusions drawn from the survey data.

**Suggestions for Future Research**

While the current study adds significantly to the literature comparing the educational outcomes of synchronous and asynchronous students, there are several limitations to the study that could be explored through additional research. The problem of practice could be more thoroughly examined by addressing these limitations that became apparent during the data
analysis. The data analysis showed that asynchronous students outperformed their synchronous classmates on both end-of-course grades and standardized test scores. The data analysis on students' perceptions was limited in its generalizability to other populations due to the extremely low response rate. However, this research still generated valuable information that suggests several opportunities for future research.

First, one of the greatest limitations of this study was related to the research site's policy of changing failing asynchronous students' mode of instruction to synchronous. Based on the findings of this research, there is little evidence to support that policy. Subquestions 1 and 2 showed asynchronous students had significantly higher end-of-course grades and Keystone Exam scores. It should be noted that students' course format was only recorded at the end of the school year, and no data was collected for students who were switched from an asynchronous to synchronous format to see if they were more successful in a synchronous course. This research study did not determine if a change in course format was beneficial to students. Because of this unique policy, additional research at this site would be valuable in determining whether the additional teacher support and structure provided in synchronous courses is helpful to struggling students. Collecting and analyzing data for all students, not just those in Algebra 1, who are moved from an asynchronous to synchronous format because of failing grades would provide a more complete picture.

The discrepancy between the course pass rate (64%) and standardized test pass rate (7%) for both groups, along with the research presented on grade inflation (College Board, 2016; Ziomek & Svec, 1997), brings to light the need for additional research on the correlation between end-of-course grades and standardized test scores for Algebra 1 courses. Research on both classroom-based courses and online courses would be beneficial. The lack of research
specific to high school Algebra 1 courses taught in synchronous and asynchronous formats makes this topic of considerable interest to online high school mathematics teachers.

The discrepancy between the course pass rate (64%) and standardized test pass rate (7%) for study participants also suggests a need for additional research on high school course alignment to state standards. As the focus on state test scores continues, the need for schools to create curricula aligned to state standards, especially for subject-specific state tests at the high school level, increases. Research should focus on determining whether learning objectives, assessments, and instructional strategies are all aligned to the desired outcomes of the state standards.

Extending this research study beyond Algebra 1 to include other mathematics courses and other content areas would add to the research available on synchronous and asynchronous courses. Extending the study to other content areas would aid in the generalizability of the research to all high schools that offer online courses or programs. Furthermore, extending the study to schools in other states would help the research be applicable to all student demographics.

There were several mediating variables that may have affected the findings. Variables such as assignment completion, synchronous class attendance, and whether or not the student received help on coursework from a tutor or parent all affect a student's end-of-course grade and understanding of the content, which ultimately affects standardized test scores. Students new to virtual learning may find it challenging (M. Lee & Figueroa, 2012), so another mediating variable that could be further explored is whether a student has previous experience in cyber schools. In addition to these mediating variables, there are three moderating variables that may have affected the findings. The language spoken at home, parents' highest education level, and
the type of community (urban, rural, suburban) in which the family resides may also influence student learning. There was a statistically significant difference between synchronous and asynchronous groups on community type in this study. Exploring this variable and how it affects educational outcomes in an online setting may be beneficial. A research study that attempts to determine whether these mediating and moderating variables affect educational outcomes would add to the research available on synchronous and asynchronous formats of online education.

Lastly, because of the poor response rate of the transactional distance scale (Huang et al., 2015), it would be beneficial for additional studies to compare synchronous and asynchronous students' perceptions of their online course using the same instrument. Conclusions cannot be drawn about the differences in perceptions between the two groups from this study because of the low number of respondents. It would be beneficial for researchers to ask students to complete the survey at the end of the course or immediately following the course. This may aid in getting a higher response rate on the survey.

Conclusion

The purpose of this causal-comparative research study was to determine whether a significant difference exists between the educational outcomes of students enrolled in synchronous and asynchronous online Algebra 1 courses. Results showed that a significant difference did in fact exist. Asynchronous students had significantly higher end-of-course grades and significantly higher Algebra 1 Keystone Exam scores. Due to the research site's policy of moving failing students to synchronous formats for additional support and the pre-existing difference in pretest STAR 360 scores, caution must be taken when generalizing these results to other educational settings. No significant difference was found between synchronous and asynchronous students' perceptions of their Algebra 1 course. Unfortunately, the usefulness of
this finding is limited because of the extremely low response rate on the survey. Findings did support Moore's (1993) theory of transactional distance. According to Moore's theory, courses with high dialogue and less structure, like a synchronous format, should have lower transactional distance than courses with low dialogue and high structure. Synchronous courses also require less autonomy, which increases the overall transactional distance felt. The converse is true for asynchronous courses – less dialogue, more structure, and more autonomy – which may have led to the similar mean transactional distance scores between the two groups.

One of the most significant contributions of this study is that it adds to the very limited literature on differences in educational outcomes for synchronous and asynchronous online high school courses. Future research addressing this study's limitations will greatly improve the literature available to families, students, teachers, and administrators. Online education continues to grow and stakeholders need additional information about the educational outcomes of these courses and programs to better understand the differences between the available programs and then make informed decisions regarding online educational choices.

When this study began, the researcher predicted that synchronous students would outperform asynchronous students on final course grades and Keystone Exam scores. These predictions were made because synchronous students received high-quality instruction during live class sessions, were provided with ample opportunities to ask questions, and were able to obtain immediate feedback during class. There were several factors not considered when making this initial prediction. The research site's policy of changing a failing student's status from asynchronous to synchronous, while supporting student achievement by providing necessary intervention, caused unexpected noise in the data. Additionally, the significant difference in the STAR 360 math pretest scores between the two groups was surprising. This difference may have
affected the results in an unforeseen manner.

The results of this study provided the research site with information useful in future planning. It was revealed that while many students were passing the course, only a small percentage were passing the standardized state test. As a result, the school's administrators and teachers can use the findings to improve the alignment of the Algebra 1 courses to state standards, increase the rigor of the course by including more constructed-response questions in lessons and assignments, and create an improvement plan for disengaged students.
References


Ramaswami, R. (2009). Even! But no longer odd: Once regarded as an unconventional alternative for atypical students, virtual schools have achieved mainstream acceptance, and are now seen as providing an education equal to--if not better than--what their traditional counterpart offers. *T.H.E. Journal: Technology Horizons in Education, 36*(5), 38-42.


Appendix A: IRB Approval

Northeastern

NOTIFICATION OF IRB ACTION

Date: November 16, 2016
IRB #: CPS16-09-03

Principal Investigator(s): Cortiss Brown Thompson
Sharon Berry

Department: Doctor of Education Program
College of Professional Studies

Address: 20 Belvidere
Northeastern University

Title of Project: Educational Outcomes in Synchronous and
Asynchronous Online Algebra 1 Courses

Participating Sites: Site permission forthcoming

DHHS Review Category: Expedited #6, #7

Informed Consents: One (1) signed parent/guardian consent and child assent form

This project is approved under 45 CFR 46.404 which applies to children as research subjects and involves research not
involving greater than minimal risk. Adequate provisions are made for soliciting the assent of the children and the
permission of their parents or guardians, as set forth in 45 CFR 46.408.

Monitoring Interval: 12 months

APPROVAL EXPIRATION DATE: NOVEMBER 15, 2017

Investigator's Responsibilities:

1. The informed consent form bearing the IRB approval stamp must be used when
recruiting participants into the study.
2. The investigator must notify IRB immediately of unexpected adverse reactions, or new
information that may alter our perception of the benefit-risk ratio.
3. Study procedures and files are subject to audit any time.
4. Any modifications of the protocol or the informed consent as the study progresses
must be reviewed and approved by this committee prior to being instituted.
5. Continuing Review Approval for the proposal should be requested at least one month
prior to the expiration date above.
6. This approval applies to the protection of human subjects only. It does not apply to any
other university approvals that may be necessary.

C. Randall Colvin, Ph.D., Chair
Northeastern University Institutional Review Board

Nan C. Regina, Director
Human Subject Research Protection

Northeastern University FWA #4630
Appendix B: Transactional Distance Scale by Huang et al. (2015)

<table>
<thead>
<tr>
<th>Transactional Distance Scale Constructs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dialogue:</strong></td>
</tr>
<tr>
<td>Learner-Instructor Interaction</td>
</tr>
<tr>
<td>1 I communicate with my instructor on course-related issues at least once a week.</td>
</tr>
<tr>
<td>2 I communicate with my instructor through multiple communication channels (e.g. emails, phone, discussion board and online chat).</td>
</tr>
<tr>
<td>3 I have opportunities to communicate with my instructor real time in this online class.</td>
</tr>
<tr>
<td>4 Communication between me and the instructor in this online class is a dynamic two-way communication.</td>
</tr>
<tr>
<td>5 I actively engage in dialogues with my instructor to construct and share knowledge.</td>
</tr>
<tr>
<td>6 My communication with the instructor in this online class is intensive.</td>
</tr>
<tr>
<td>7 My communication with the instructor in this course is constructive/helpful in achieving learning objectives.</td>
</tr>
<tr>
<td>8 My communication with the instructor in this online class is something I look forward to.</td>
</tr>
<tr>
<td>9 I value my communication with the instructor on course-related issues.</td>
</tr>
<tr>
<td>10 The instructor values my input in our communication.</td>
</tr>
</tbody>
</table>

<p>| Learner-Learner Interaction          |
| 11 I communicate with my fellow students on course-related issues at least once a week. |
| 12 I communicate with my fellow students through multiple communication channels (e.g. email, phone, discussion board and online chat). |
| 13 I have opportunities to communicate with my fellow students in real time in this online class. |
| 14 Communication between me and other students in this online class is a dynamic two-way communication. |
| 15 I actively engage in dialogues with other students to construct and share knowledge. |
| 16 My communication with other students in this online class is intensive. |
| 17 My communication with other students in this course is constructive/helpful in achieving learning objectives. |
| 18 My communication with other students in this online class is something I look forward to. |</p>
<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>I value my communication with other students on course-related issues.</td>
</tr>
<tr>
<td>20</td>
<td>I believe that other students value my input in our communication.</td>
</tr>
</tbody>
</table>

**Structure:**

**Learner-Content: Flexibility**

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>I receive individualized feedback on my assignments, projects or other required course tasks.</td>
</tr>
<tr>
<td>22</td>
<td>The course is structured in a way that provides me ample opportunities to ask questions and receive useful feedback.</td>
</tr>
<tr>
<td>23</td>
<td>The course is structured in a way that enables me to work at my own pace to meet the course goals and objectives.</td>
</tr>
<tr>
<td>24</td>
<td>The course is structured in a way that encourages me to negotiate with the instructor on the learning objectives, activities, evaluation and technology use for this online course.</td>
</tr>
<tr>
<td>25</td>
<td>The course is tailored to my learning needs that enable me to apply my learning to real-world experiences.</td>
</tr>
<tr>
<td>26</td>
<td>The course is structured in a way that my difficulties during the learning process (e.g. unexpected problems) are accommodated.</td>
</tr>
<tr>
<td>27</td>
<td>The course is structured in a way that enables me to incorporate my previous experience into the course.</td>
</tr>
<tr>
<td>28</td>
<td>I am challenged to achieve to the best of my abilities through instructor focus on individualized instruction and additional resources for advanced learning.</td>
</tr>
<tr>
<td>29</td>
<td>The course is structured in a way that the instructor uses our feedback to modify course material to better meet our learning needs.</td>
</tr>
<tr>
<td>30</td>
<td>The course is structured in a way that encourages me to make my learning needs clear.</td>
</tr>
<tr>
<td>31</td>
<td>The course content is presented using multiple formats, such as text, audio, and video.</td>
</tr>
<tr>
<td>32</td>
<td>A variety of instructor strategies (e.g. discussion, reflection, demonstration, group work, and case study) are used in this course to meet our learning needs.</td>
</tr>
<tr>
<td>33</td>
<td>The course is structured in a way that multiple methods (e.g. assignments, discussion participation, projects and exams) are used to assess my class performance.</td>
</tr>
<tr>
<td>34</td>
<td>The course provides both one-way and two-way communication channels for me to connect to my instructor and fellow students.</td>
</tr>
<tr>
<td>35</td>
<td>I have been given ample opportunities to practice before the final assessment of my performance.</td>
</tr>
</tbody>
</table>

**Learner-Content: Formality**

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>36</td>
<td>A detailed syllabus with clearly defined course objectives and schedule of content is provided at the beginning of the year for this online course.</td>
</tr>
<tr>
<td>37</td>
<td>Clear guidelines/rubrics on assignments, projects or other course-related tasks are provided for this online course.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>38</td>
<td>Clear guidelines regarding the desired quantity/quality of communications in this online course are provided.</td>
</tr>
<tr>
<td>39</td>
<td>Specific due dates for assignments and other course-related tasks are set for this online course.</td>
</tr>
<tr>
<td>40</td>
<td>A detailed course schedule/calendar is provided for this online course.</td>
</tr>
<tr>
<td>41</td>
<td>A detailed course policy (e.g. late submission, missed tests and online discussion behaviors) is provided for this online course.</td>
</tr>
<tr>
<td>42</td>
<td>Course expectations are clearly laid out at the beginning of the semester.</td>
</tr>
<tr>
<td>43</td>
<td>Course content is organized in manageable segments (e.g. units).</td>
</tr>
</tbody>
</table>

**Learner-Interface: Knowledge of Media Use**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>44</td>
<td>I am comfortable working with the course delivery system (e.g. Blackboard) and other technologies required for this course.</td>
</tr>
<tr>
<td>45</td>
<td>I understand how to effectively use the technologies required for this online class.</td>
</tr>
<tr>
<td>46</td>
<td>I have the necessary knowledge and skills to use the technologies required for this online class.</td>
</tr>
</tbody>
</table>

**Learner-Interface: Choice of Media Use**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>47</td>
<td>I have the freedom to choose the technologies I feel comfortable using to communicate with my instructor and fellow students.</td>
</tr>
<tr>
<td>48</td>
<td>A variety of delivery media (e.g. audio, video, live classes) are used in this course.</td>
</tr>
<tr>
<td>49</td>
<td>I have been given ample opportunities to practice the technologies before I am required to use them for course activities.</td>
</tr>
</tbody>
</table>

**Learner-Interface: Visualization**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>The course content is spatially and visually well organized.</td>
</tr>
<tr>
<td>51</td>
<td>The course site is attractive and visually appealing.</td>
</tr>
</tbody>
</table>

**Learner-Interface: Functionality**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>52</td>
<td>The instructor provides resources or tutorials/links to tutorials on technologies used in this online class.</td>
</tr>
<tr>
<td>53</td>
<td>The instructor provides technical support information in case we encounter technical problems for this online class.</td>
</tr>
</tbody>
</table>

**Learner-Interface: Usability**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>54</td>
<td>It is easy to navigate the course site to look for the information that I need.</td>
</tr>
<tr>
<td>55</td>
<td>I often get lost looking for the information in the course site.</td>
</tr>
</tbody>
</table>
### Autonomy:

**Independence of Learning**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>56</td>
<td>I enjoy new learning experiences.</td>
</tr>
<tr>
<td>57</td>
<td>Even when tasks are difficult, I try to stick with them.</td>
</tr>
<tr>
<td>58</td>
<td>I enjoy finding information about new topics on my own.</td>
</tr>
<tr>
<td>59</td>
<td>I am open to new ways of doing familiar things.</td>
</tr>
<tr>
<td>60</td>
<td>I take responsibility for my learning experiences.</td>
</tr>
<tr>
<td>61</td>
<td>I enjoy being given a challenge.</td>
</tr>
</tbody>
</table>

**Study Habits**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>62</td>
<td>I frequently find excuses for not getting down to work.</td>
</tr>
<tr>
<td>63</td>
<td>I plan my time for study effectively.</td>
</tr>
<tr>
<td>64</td>
<td>I am good at meeting deadlines.</td>
</tr>
<tr>
<td>65</td>
<td>My time management is good.</td>
</tr>
</tbody>
</table>

### Transactional Distance:

**Learner-Instructor Transactional Distance**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>66</td>
<td>I feel a strong sense of belonging to this online course.</td>
</tr>
<tr>
<td>67</td>
<td>I feel this online class is a cohesive learning community.</td>
</tr>
<tr>
<td>68</td>
<td>I feel a strong sense of belonging to a cohesive learning community in this online course.</td>
</tr>
<tr>
<td>69</td>
<td>I feel closely connected to my instructor in this online course.</td>
</tr>
<tr>
<td>70</td>
<td>I feel a strong sense of 'being with' my instructor during my learning process.</td>
</tr>
<tr>
<td>71</td>
<td>I feel the presence of my instructor in this online course, despite the physical distance between us.</td>
</tr>
<tr>
<td>72</td>
<td>I feel a strong rapport with my instructor in this online course.</td>
</tr>
<tr>
<td>73</td>
<td>I feel a sense of isolation from my instructor in this online course.</td>
</tr>
<tr>
<td></td>
<td>Description</td>
</tr>
<tr>
<td>---</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>74</td>
<td>I feel I have a shared understanding of the course goals with my instructor.</td>
</tr>
<tr>
<td>75</td>
<td>I feel I have a shared understanding of the course content with my instructor.</td>
</tr>
<tr>
<td>76</td>
<td>I feel I have a shared understanding of the course activities with my instructor.</td>
</tr>
<tr>
<td>77</td>
<td>I feel I have a shared understanding of the assessment methods of my learning with my instructor.</td>
</tr>
<tr>
<td>78</td>
<td>I feel my learning expectations have been met in this online course.</td>
</tr>
<tr>
<td>79</td>
<td>I feel I have learned a great deal in this online course.</td>
</tr>
</tbody>
</table>

**Learner-Learner Transactional Distance**

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>I feel closely connected to my fellow students in this online course.</td>
</tr>
<tr>
<td>81</td>
<td>I feel a strong sense of 'being with' my fellow students in this online course, despite the physical distance between us.</td>
</tr>
<tr>
<td>82</td>
<td>I feel the presence of my fellow students in this online course, despite the physical distance between us.</td>
</tr>
<tr>
<td>83</td>
<td>I feel a strong rapport with my fellow students in this online course.</td>
</tr>
<tr>
<td>84</td>
<td>I feel a sense of isolation from my fellow students in this online course.</td>
</tr>
<tr>
<td>85</td>
<td>I feel students in this online class have a shared understanding of each other's learning experiences.</td>
</tr>
</tbody>
</table>