Game-Based Learning and Children with ADHD

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Dedication

I dedicate this dissertation to my family-- My husband, Dan, who has held down the home front during my many trips to Philadelphia and has shown his A+ proofreading skills; my son, William, who is the inspiration for this work; my mother, Margaret “Twinkie” Sullivan, whose wisdom encouraged me to try; and my late father, Neil Sullivan, for teaching me that education is the most important “tool in life’s toolbox” for fulfillment, success and continuous curiosity.

I would be remiss to not include Fr. Mark Cregan, C.S.C., Emeritus President of Stonehill College, in this dedication. His challenge to pursue a doctorate degree set me on the path to this work. He serves as a professional mentor and friend. I’m extremely lucky to have worked with him.
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Abstract

Game-Based Learning and Children with ADHD
Margaret Sullivan-Carr, M.B.A.
Mary Jean Tecce DeCarlo, Ph.D.

Children with ADHD (Attention-Deficit Hyperactivity Disorder) Attention Deficit Hyperactivity Disorder (ADHD) may exhibit behavioral and executive function issues that affect classroom learning. Documented behaviors include inattention, disruptive behavior, and poor social relationships (Gureasko-Moore, DuPaul, & White, 2006). Support for children with ADHD has primarily focused on behavioral modifications and organizational skill enhancement. Computer-assisted or game-based learning has shown promise with this population in small-scale studies (Mautone, 2005; Ota, 2002). This case study research sought to investigate the use of game-based learning and children with ADHD. The subjects were high-school aged children with the primary diagnosis of ADHD who received a game-based intervention. This study shows game-based learning has a positive effect on students with ADHDs’ engagement and interest in Math. The analysis of the data from the qualitative portion of this study lends itself to a grounded theory approach indicating game-based learning is an important consideration in curriculum development for students with ADHD.
CHAPTER 1: INTRODUCTION TO THE RESEARCH

Introduction to the Problem

According to the American Psychological Association, Attention-Deficit Hyperactivity Disorder (ADHD) is a disability diagnosed in approximately 11% (6.4 million) of United States children (CDC, 2015). This number is a 2.9-fold increase from 1990 (Sondik, Madans, & Gentleman, 2011). Reasoning for these increases in diagnoses is debated amongst experts. Some experts cite misdiagnosis of symptoms as a reason for the sharp increase (Nissen, 2006). Others cite increased parent and teacher education on the signs and symptoms of ADHD leading to greater and appropriate diagnosis (Biederman, 2006; CDC, 2015; Merrell & Tymms, 2001).

ADHD is a complex, chronic neurodevelopmental disorder with behavioral and cognitive consequences that has attracted more attention during the past decade (Rapport, et al., 2009). Most of these children remain in mainstream classroom settings, but require educational accommodations to address the associated issues of ADHD.

Children with ADHD may exhibit behavioral issues that can impair learning in the classroom. Documented behaviors include inattention, disruptive behavior and poor social relationships (Gureasko-Moore, DuPaul, & White, 2006). Executive function is inhibited in children with ADHD, leading to issues in the classroom that include problems with memory, reasoning, and general cognitive ability (Daley & Birchwood, 2010). Without supportive interventions, students with ADHD fall behind acceptable levels in subject areas, most notably math and reading as they require a higher level of executive functioning (Zentall, Tom-Wright, & Lee, 2013).
**Statement of the Problem**

Academic modifications are necessary with the ADHD student population to allow for individual success and classroom order for the entire class. Classroom interventions for students with ADHD have focused on teacher-based contingency management strategies more than enhancement of academically-focused assistance (Antshel, et al., 2011). Common classroom modifications include removal of privileges, homework management programs, and material rewards (DuPaul & Eckert, 1998; Fabiano & Pelham, 2003; Pfiffner et al., 2006). There is not a specific strategy that provides consistent and long-term success (Fabiano & Pelham, 2003; Pfiffner et al., 2006; DuPaul, Weyandt, & Janusis, 2011).

Several modifications appear to have promise, but few have been empirically tested. Harrison et al. (2013) note:

Unfortunately, similar to the results of the Tindal and Fuchs (2000) review of the evidence for the effectiveness of accommodations for all disabilities, we found that experts in the field recommend many accommodations; yet few have scientific evidence on the effectiveness. (p.582)

These include peer tutoring, strategies instruction, and computer-assisted instruction (Barkley, 2008; DuPaul & Eckert, 1998). Game-based learning has drawn particular interest by some researchers as it provides a tool to enhance focus for students with ADHD (Muñoz et al., 2015). Game-based learning uses computer games developed and designed for use in an educational setting. The games break material into smaller segments, which is a strategy often used for students with ADHD. The underlying assumption is enhanced focus will lead to better academic outcomes. It has shown promise in small-scale studies (DuPaul & Eckert, 1998; Ota & DuPaul, 2002). These studies further explore the use of game-based learning with the ADHD population to measure levels of focus and disruptive behavior.
Game-based learning for children with ADHD shows promise, but requires additional research to further test the hypothesis that it offers increased academic outcomes (Muñoz et al., 2015; Reid et al., 2002). Previous research has been limited to small-scale studies with no more than 6 participants (Mautone et al., 2005; Ota & DuPaul, 2002). There are still questions on the efficacy and the role of this type of instruction. Furthermore, there is little research that measures the combination of game-based learning with traditional classroom teaching and children with ADHD (Fabio & Antonietti, 2014).

The relationship between ADHD and academic impairment has been well documented (DuPaul & Stoner, 2003; Pfiffner, 1996; Zentall & Meyer, 1987). Academic issues include frequent use of remedial services, lower grades, three times the rate of attrition and school dropout, and lower standardized test achievement (Zentall, Tom-Wright, & Lee, 2013). Test scores for reading and math for children diagnosed with ADHD without remedial support also show significant deficits (Bennedetto-Nash & Tannock, 1999).

School-aged children with ADHD are often placed in classrooms that employ teaching methodologies not prescribed for children with ADHD (Ota & DuPaul, 2002). Studies have shown smaller class sizes with fewer distractions support success for students with ADHD (Loe & Feldman, 2006; Mautone et al., 2005; Raggi & Chronis, 2006). United States public schools rarely have the opportunity to offer small-class settings due to overcrowding and strained budgets (Armstrong, 1999; Biddle & Berliner, 2014). This results in a lower success rate for this population as well as issues for classroom management (Barkley, 2008; Jitendra & DuPaul, 2007).
Purpose and Significance of the Problem

The purpose of this study was to determine whether game-based learning provides an effective accommodation for students with ADHD, thus leading to better academic outcomes. The study reviews the academic indicators and measurements, i.e., test scores of students with ADHD, who receive traditional classroom instruction coupled with a game-based intervention.

Qualitative measures included pre and post intervention teacher interviews about game-based instruction in combination with traditional classroom instruction, a focus group interview with students, and a journal written by the teacher throughout the intervention. The focus group was comprised of students with ADHD who received the game-based intervention. These students were asked questions to gain an understanding of their experience with, and opinion of, game-based learning. The third dimension of the qualitative component of this study was an analysis of the teacher’s journal notes transcribed during the study duration.

Game-based learning has shown promise for students with ADHD as it engages attention and provides an alternative or complementary teaching technique for academic material. Research results have shown the positive effects of videogame play on attention (Lawrence, 2002; Muñoz et al., 2015). Several studies have indicated promise in using video-game based learning in children with ADHD (Mautone et al., 2005; Ota & DuPaul, 2002), but the studies are small-scale and measure factors such as focus, attention, and engagement. They do not measure academic outcomes.

Ota and DuPaul (2002) examined the effects of using game-based learning software to improve math performance and attentiveness in a population of fourth to sixth graders diagnosed with ADHD. The study was small scale (3 subjects), but supports other research (Mautone et al.,
The study did not measure academic outcomes of study participants. Other research indicates game-based learning and students with ADHD enhances attention and engagement in academic material leading to increased executive function and understanding of material (Veenstra, 2012).

Game-based learning is a relatively new teaching model in K–12 classrooms. Research indicates promise for the use of this modality as it promotes experiential, active, and creative learning (Admiraal et al., 2011; Martinussen et al., 2006). These attributes are of particular interest to a student with ADHD. It provides teachers with new options to engage students with technology that is familiar and interesting. Children with ADHD have difficulty focusing in the classroom. Teachers have differing approaches with this population of students. Preliminary research has shown that game-based learning may be advantageous for students with ADHD as it fosters an active and vibrant environment for teaching and learning (Mautone et al., 2005). Game-based learning holds great promise for students with ADHD, yet more research is needed to understand if, how, and why it works.

The results of this study will provide information to teachers for use with students with ADHD. If the hypothesis is supported, it provides evidence to support the use of another “tool” to the “toolbox” of instruction for students with ADHD. It also provides game developers with information on an untapped market segment.

**Research Questions**

There were two research questions for this study. The research was intended to measure (a) the efficacy of the use of game-based learning for children with ADHD in terms of improving
academic outcomes, and (b) to report on the perceptions of the teacher and students who participated in this study. The research questions were:

1. What is the relationship between game-based learning and academic outcomes in Algebra One for students with ADHD?

2. How do teachers and students perceive the influence of game-based instruction on the academic performance of Algebra One students with ADHD?

This research was predicated on the hypothesis that game-based learning coupled with traditional classroom instruction increases academic outcomes for children with ADHD. This hypothesis was based on research that indicates game-based learning increases attention, decreases disruptive behavior in the classroom, and leads to more meaningful academic engagement (Admiraal et al., 2011; Fabio & Antonietti, 2014; Martinussen et al., 2006).

**Researcher Stance and Experiential Base**

The hypothesis for this study stemmed from the author’s personal experience and observations of her fifteen-year old child who has ADHD. Her son was formally diagnosed with ADHD in the third grade. The diagnosis came after several years of severe behavioral issues in school. The issues involved inability to stay seated, inattention to teacher instruction, constant interruption of peers and teachers, and lack of organizational skills. The diagnosis was documented by an independent clinical psychologist specializing in neuropsychology after the school did an initial evaluation that indicated a suspicion of ADHD. The child was also found to have an exceptionally high IQ.

Once the ADHD was documented, the treatment plan included medication, behavior modification, and a Section 504 plan (Section 504 of the Rehabilitation Act of 1973, as amended, 29 U.S.C. § 794) which mandated seating near model peers and assistance with organization of course
materials and homework. Under Federal Law, the Section 504 plan is reviewed on an annual basis (IDEA, 2004).

The author’s son continually struggled with organization, motivation, and attention in school. The author has provided supplemental assistance to her son at home including the hiring of an ADHD coach, and the provision of organizational tools including organization with course materials, and homework calendars. These tools and additional support have resulted in minimal change in organizational outcomes and grades.

The researcher has observed her son’s keen interest and success in subjects that involve a combination of lecture and experiential learning. In contrast, subjects that are delivered primarily through lecture format are very difficult for him to understand as his attention quickly dissolves in the classroom. For example, science is a subject that provides engagement through lab exercises and experimentation. Her son excels in this subject.

The author introduced her son to supplemental learning modalities for subjects that were delivered primarily through lecture at school; i.e., mathematics. The supplemental materials were game-based that provide another way for the student to learn subject matter that may not be comprehended when delivered via lecture-based teaching.

These materials were introduced after the author initially observed her son’s long-standing attention to non-academic video games. This prompted her to surmise academic-based video games may offer a solution to overcome his claims of “boredom” in the classroom and difficulty with comprehension. For example, while in middle school, the video game of Minecraft engaged him for multiple hours. The lecture-style lesson delivery was less action-based, used a linear instruction method, and was less captivating.
Researcher’s Potential Bias

As noted earlier, the researcher had a vested interest in the research as she has a child with ADHD. Given this connection, she took caution to not influence the study through her actions, data analysis, or interactions with study participants.

To ensure validity of data analysis, an unbiased secondary person was asked to validate all data presented in the findings section of this paper.

Conceptual Framework

The research sought to study and test several concepts discussed in the Literature Review (Chapter Two) of this paper. Research streams included ADHD in the classroom, ADHD and educational outcomes, use of video games in education, and game-based learning for children with ADHD. The researcher also sought to understand a teacher’s and students’ perceptions of the influence of game-based learning on academic outcomes.

The first stream of research, ADHD in the Classroom, reviews literature on the issues confronted by students with ADHD and their teachers in the classroom. It reveals the disruptive tendencies, inattention, and fidgety behavior of students with ADHD. The second stream discusses the impact of these behaviors and overall lower academic outcomes (measured by graduation rate, the achievement of passing grades, and test scores) found in children with ADHD compared to normally developed children. The third research stream reviews literature on the relatively new introduction of game-based learning in the classroom. A discussion on the benefits of the instructional tool is presented and its impact on academic outcomes is explored. The final area reviews literature on the use of game-based learning with students with ADHD.
measuring areas of focus and engagement. Figure 1 outlines the conceptual framework for this study.

Small-scale studies that have tested the hypothesis of this study have been conducted and indicate promising results for use of game-based learning and children with ADHD (Annetta, 2009; Ota & DuPaul, 2002). This study replicates elements of these studies with the addition of a qualitative component (see Chapter 3) to understand the teacher’s and students’ perceptions of the additional instructional delivery.

*Figure 1. Conceptual Framework of Study*
Several terms are key to the understanding of this study:

504 Plan -- Section 504 is part of the Rehabilitation Act of 1973, a civil rights statute aimed at ending disability-based discrimination in schools (Zirkel, 2009). A 504 Plan is developed by teachers, parents/guardians, and students to provide accommodations and services to eligible students to support learning and outcomes in a mainstream classroom.

Academic Outcomes – The measurement of lesson comprehension in an academic setting (Harford College, 2013, July 10).

ADHD - a chronic condition that affects millions of children and often persists into adulthood. ADHD includes a combination of problems, such as difficulty sustaining attention, hyperactivity, and impulsive behavior (Mayo Clinic, 2013).

Case Study – “An in-depth exploration of a bounded system (e.g., activity, event, process or individuals) based on extensive data collection” (Creswell, 2012, p. 465).

Game-Based Learning – Game-based learning broadly refers to the use of video games to support teaching and learning (Ott et al., 2013; Perrotta et al., 2013). Also commonly referred to as serious games, Kim and Bae provide further explanation, “Serious games can be defined in various aspects that have elements of fun games. In serious games, functionality and entertainment are not mutually exclusive concepts. Serious games are differentiated from entertainment games in aspect that they don’t only pursuit fun in process and from edu-contents in aspect that they don’t focus only on learning effects as results. Specific purposes and fun elements of games combine and have great synergy effects” (2014, p. 209).
Math Anxiety—“A feeling of tension and anxiety that interferes with the manipulation of numbers and the solving of mathematical problems in ordinary life and academic situations” (Hopko et al., 2003, p. 648).

Multiple Intelligences- A theory developed by Howard Gardner which states humans possess intelligence in various capacities. “Using biological and cultural research, he developed a list of the following intelligences: (1) logical-mathematical intelligence; (2) linguistic intelligence; (3) spatial intelligence; (4) musical intelligence; (5) bodily-kinesthetic intelligence; (6) interpersonal intelligence; and (7) intrapersonal intelligence. Gardner asserts that the intelligences seldom operate independently; they are used concurrently and complement each other” (as cited in Brualdi, 1998, p. 26).

Traditional Classroom Instruction – Based in a school location that primarily uses face-to-face communication as a means for instruction (Bernard et al., 2004).

Assumptions and Limitations

This section provides a summary of the underlying assumptions woven into this study. It also provides the acknowledged study limitations.

Assumptions

The researcher came to this study with several assumptions on ADHD and its impact on academic performance. These assumptions extended to the classroom. It is believed the results of this study will be of great interest to educators who have students with ADHD in the classroom.
The following list summarizes the assumptions for this study:

1. Children with ADHD learn differently.
2. Teachers are open to game-based learning in classrooms.
3. Students have computers available to them for game play in the school setting.
4. Teachers are interested in new teaching techniques for the ADHD population of students.
5. Study participants will have the same interest in game-based learning as the researcher’s son.

Limitations

This study had several limitations due to the number of participants, site selection, length of study, and assumed computer literacy of teachers and students. Due to the setting within a private school focused on students with learning differences, study results may be considered school-specific rather than applicable to classrooms in all schools. The following list summarizes the study limitations:

Study size. This study was limited to the number of students with ADHD enrolled in the two Algebra 1 course sections of School X (the school is assigned the pseudonym of School X for this paper to insure confidentiality of the site and population). The school estimated that 30% of the student population had ADHD as a primary diagnosis. Given the average class size is 15, 30% of this population equals 4-5 students per class. If 100% participation was received, this equated to 8 – 10 study participants who have ADHD.

Despite the teacher’s exemplary efforts, only three students’ parents chose to sign the permission form allowing their child to participate in this study. This situation changed the original study design from a mixed method that would have reviewed data from pre- and post-test assessments (quantitative portion) and the qualitative data elements included in the final study. The researcher concluded that quantitative data from three study participants would not provide information that was meaningful to the study results and discussion. Therefore, the
original study design was changed to a case study methodology to provide an in-depth analysis of the students’ and teacher’s perceptions and attitudes on the use of game-based learning as a complementary teaching strategy in Algebra One.

School Curriculum. School X teaches all classes on the basis of Gardner’s Multiple Intelligences Theory. Given this, teachers utilize a variety of methods including art, linguistic, and spatial representations to instruct students. Assessments of learning content are relatively subjective compared to a mainstream school environment. Given the difference in teaching methodology between the research site and most public schools, results may not be considered applicable by public and mainstream school administrators.

Length of study. The duration of the study is three months. The duration is determined by the researcher’s time limitation due to Ed.D. program requirements. It was also dictated by the access granted to the researcher. School X agreed to host the research for one semester. Ideally, this study would have had a longer duration to provide a longitudinal review of the game-based intervention.

Study Delimitations

This study has several delimitations as a result of the researcher’s decision on research design and site choice.

Computer Game Choice. The computer game Algebra Champ was used in this study. It is a single player game. Although a multi-player game would have offered additional research opportunities, school IT issues prevented its use. The game “provides introductory level algebra skills practice with timed rounds, high scores, and a cage fight theme” (West, AppFindzUS,
The game was chosen based on a literature review and colleague recommendations. The colleague provided an overview of Algebra Champ, “If she really wants a drill-style game that is clearly classroom math, but just adds some game elements (like time limits and levels), she could always do something like this: https://itunes.apple.com/us/app/algebra-champ/id398873050?mt=8” (personal communication, C. Williams, April 24, 2015).

The game was synergistic with lesson plans. The researcher did not find any information to determine which educational computer games are considered “best in the market”, therefore, the choice of Algebra Champ may or may not have been the best choice.

**Site Selection.** The study site was in a school with students with a high degree of computer literacy; results may not duplicate to school settings of students with less computer access and/or aptitude. In addition, the intervention will be difficult to replicate in schools with no or limited access to computers for students and resources to purchase an appropriate game.

**Summary**

Students with ADHD learn differently. Educators have long struggled to find a teaching resource that fits with the factors of inattention and executive function deficits associated with students with ADHD (DuPaul et al., 2006). Traditional classroom strategies show success with behavioral management, but do not provide enhancement for students’ learning (Martinussen et al., 2006).

Research shows students with ADHD respond positively to action based video games as irrelevant information is filtered out and attention is drawn to factors influencing success (Bavelier et al., 2012). Small scale studies of game-based learning and children with ADHD show promising results for use in education (Mautone, 2005; Ota, 2002). These studies review
attention and behavioral measures, but do not assess academic outcomes or teachers’ response to the newly introduced teaching modality. This study furthers the research of Ota and Mautone while focusing on academic outcomes of students’ and a teacher’s observations and reactions to the use of game-based learning complemented by traditional classroom instruction.
CHAPTER 2: THE LITERATURE REVIEW

The purpose of this literature review was to investigate the use of game-based learning and children with Attention-Deficit Hyperactivity Disorder (ADHD). In order to understand the use of game-based learning and the learning deficits of children with ADHD, research was compiled to better comprehend the components within the research questions.

The interest of this research was the use of video game-based learning and children with Attention-Deficit Hyperactivity Disorder. The examination studied the use of games to deliver course content to complement traditional classroom learning in United States schools. Measurements were taken to ascertain if increased academic outcomes are achieved with video game-based learning integrated with traditional classroom teaching for children with ADHD.

ADHD is complex, chronic neuro-developmental disorder with behavioral and cognitive consequences (Rapport et al., 2009) that has attracted more attention during the past decade. Diagnosed cases have increased to 6.4 million United States children between the ages of 3 and 17 in 2014 (CDC, 2015). This number is a 2.9-fold increase from 1990 (Sondik, Madans, & Gentleman, 2011). Males are more likely to be affected with ADHD than females (Purdie et al., 2002). It is estimated that one out of five United States school aged children have ADHD (Fabiano et al., 2003).

Students with ADHD also struggle within normal social frameworks of friendships as their behaviors may hinder the formation of positive relationships with other children (Duhaney, 2003). Researchers have also observed less intimacy and reciprocity in children with ADHD (Normand et al., 2011).
The following sections provide an overview of ADHD and its implication on academic performance. The sections further break the research question down into smaller subjects; i.e., game-based learning, effects of ADHD on academic performance. The first section provides information on children with ADHD in the classroom. The next section offers information on academic outcomes of children with ADHD. Literature suggests the negative effects that ADHD can have on academic outcomes (Zentall, Tom-Wright, & Lee, 2013). The next section discusses the use of game-based learning in the mainstream classroom citing the proponents and opponents of use. The following section describes the use of game-based learning with children with ADHD. The last section concludes the literature review and calls for further research on the use of game-based learning with children with ADHD.

**ADHD in the Classroom**

This section discusses the implications of ADHD students in mainstream classroom settings. These students require specialized support and consideration. Educators are called upon to develop instructional methods to address the issues of ADHD students.

ADHD is an issue that is prevalent in general education classrooms, as most students with ADHD do not qualify for special education programs (Nowack & Mamlin, 2007). Academic modifications are necessary with the ADHD student population to allow for individual success and classroom order for the entire class. Common modifications include removal of privileges, homework management programs, and providing material rewards (DuPaul & Eckert, 1998; Fabiano et al., 2003). Several modifications appear to have promise, but have not been empirically tested. These include peer tutoring, strategies instruction, and computer-assisted instruction (DuPaul & Eckert, 1998; DuPaul et al., 2006).
Nowacek and Mamlin’s (2007) research indicates teachers’ general understanding of the characteristics of students with ADHD. Despite the teachers’ understanding of issues related to ADHD, inconsistent classroom modifications are offered. Generally accepted classroom modifications for children with ADHD are a necessary element in today’s schools (Evans et al., 2013). Martinussen and colleagues (2006) stress the importance of academic interventions designed especially for the ADHD population. They emphasize the high rate of success found with interventions where “students are more engaged when there are more opportunities to respond” (Martinussen et al., 2006, p. 116). Game-based learning provides this type of opportunity. Teachers, school administrators, and support staff must recognize and support students with ADHD. This population has specific learning requirements that need to be addressed to fully support successful academic outcomes.

This literature suggests the need for additional instructional strategies for students with ADHD. Although several modifications are commonly used in the classroom, none have been proven to lead to increased focus and academic outcomes. The purpose of this research study is the exploration of game-based learning as a teaching strategy that may positively affect focus and academic outcomes for students with ADHD.

**ADHD and Educational Outcomes**

This section provides information on the effect of ADHD on academic aptitude and outcomes. Numerous studies have been conducted to document the nuances and issues in the classrooms of ADHD students.

The relationship between ADHD and academic impairment has been well documented (Jitendra & DuPaul, 2007; Rapport et al., 1999; Zentall & Meyer, 1987). Academic issues
include frequent use of remedial services, lower grades, three times the rate of school drop-out, and lower standardized test achievement (Zentall et al., 2010). As noted earlier, ADHD affects a student’s ability to complete tasks that require a high degree of executive functioning, attention, and reflection. Children with ADHD have a short duration of attention compared to typically developing children (Rapport et. al, 2009). Deficits are especially found in math and reading as both subjects require a higher demand for focus and executive function (Zentall, Tom-Wright, & Lee, 2012). Antshel and associates note, “…we found that 25% of children with ADHD showed skills deficits in reading/language, 15% showed skills deficits in mathematics, and 22% showed skills deficits in written language” (Antshel et al., 2011, p. 220).

Research has found reading comprehension to be lower within an ADHD population compared with control groups (Beike & Zentall, 2010; Jacobson et al., 2011). Reading comprehension is the “who,” “what,” and “when” of a piece of literature; not the translation of symbols or sounds into words. Slower rates of reading have also been reported in children with ADHD. This can be related to the deficits in reading comprehension as passages may be re-read to ascertain meaning. Specifically, Jacobson and associates found that the deficits in working memory and processing speed in students with ADHD effected oral reading fluency and reading comprehension (Jacobson et al., 2011).

Poor performance in math scores has been reported in children with ADHD. Scores in timed addition fact efficiency (the amount of addition problems completed correctly) and subtraction fact accuracy show low performance compared to control groups of students (Bennedetto-Nash & Tannock, 1999). Fuchs and associates (2005) found that attention and working memory were also predictors of math achievement. Deficits in these areas led to lower scores compared to peers who had normally developed attention and working memory.
Research has shown interventions that add color, active response (reading problems out loud and then writing answers versus just writing), or manipulation of objects (i.e., a stress ball or toy) while solving problems lead to differential gains for students with ADHD (Zentall, Tom-Wright, & Lee, 2013). These gains have been recorded in math and reading subjects.

Current literature and research validates the deficits of ADHD students’ function and outcomes in academic subjects; specifically in reading and math (Bennedetto-Nash & Tannock, 1999; Fuchs et al., 2005; Jacobson et al., 2011; Zentall, Tom-Wright, & Lee, 2013). However, there is limited research that looks at alternative instruction methods that may better suit this population (Mautone et al., 2005; Ota 2002; Evans et al., 2013).

This action oriented study sought to test the use of game-based learning with an ADHD population of high school students to see if this instruction method leads to increased academic outcomes. Study information may inform future classroom practice for this population of students.

**Use of Video Games in Education**

This section discusses the introduction of video games as an instructional tool in the classroom. This shift from traditional teaching to a new paradigm of instruction has attracted many researchers to study the use of this teaching method.

The advent of computer gaming in the classroom has introduced teachers and students to new methods of instruction, learning and assessment. The academic computer gaming industry has grown exponentially in the past 5 years – predicted to reach a $8,958,490 mark by 2017. This is a 18% increase from $3,912,000 in 2012 (Vargus et al., 2014).
The popularity and exposure of video games has become an everyday part of children’s lives. Video games have become ingrained in American culture with 58% of households owning a gaming console in 2011 (Nielson, 2012). Classrooms have not been immune to this culture shift with the introduction of gaming as a learning tool (Squire, 2003).

Video games as classroom tools have been in existence for years, but have become more integrated and developed in recent years (Heick, 2012; Ribeiro et al., 2013). Heick explains, “Educational games have been a commonplace part of the K-12 experience since the beginning of the 1980s (and in some places well before that), with early titles introducing students to fundamental math, history, and problem solving concepts just as games do today” (Heick, 2012, para. 1). Video games have gained more attention as a valid means for instruction as they have become more interactive and emphasized cognitive thinking development.

Further research has shown that gaming in an educational setting leads to increased student motivation, as learning is seen as fun and interactive (Baltra, 1990; Ke, 2008; Ott et al, 2014; Pange, 2003). Student engagement in learning content delivered via game-based learning scores higher than traditional classroom instruction (Alan, 2011; Annetta, 2009; Ribeiro et al, 2013). Studies have also shown the use of action video games provides students with a long-term higher intensity of attention (Bavelier, 2012). Teachers also report enhanced methods for student assessment as progress is instantly tabulated as games are played (Alan, 2011).

Rizhaupt, Higgins and Allred (2011) studied the effect of modern educational games on student attitudes towards mathematics. They found that educational game play showed “significant and positive changes” (p. 277) in students’ attitudes towards mathematics. However, no significant gains in mathematics achievement were conveyed.
Ke (2008) also examined the potential of use of game-based learning. The results indicate students’ increased positive “disposition” (p. 539) towards mathematics after computer games were introduced into the classroom.

Bourgonjon and colleagues’ (2013) research indicates the necessity for teachers to understand the benefits of video games in the classroom. Teachers are hesitant to adopt the game-based learning into classrooms before they understand the specifics of the game and the complement to traditional classroom teaching.

Ritzhaupt, Higgins and Allred (2010) found that teachers are open to adoption of video games into the classroom, but successful integration is dependent on ongoing technical support and information on game usage. Furthermore, as found in Bourgonjon and colleagues’ research, teachers must receive training on the game and its benefits prior to classroom integration (Bourgonjon et al., 2010). Ribeiro and colleagues caution the introduction of games in a classroom may come with technical difficulties which can be overcome with proper training and support (Ribeiro et al, 2014). They caution teachers to practice the game prior to introduction so as not to overshadow the positive effects of the game by student frustration.

Teachers use video games to deliver course content in creative ways. Some video games were originally introduced to the market for entertainment purposes, but have been accepted as educational tools. Educational games require strategizing, hypothesis testing, or problem-solving, usually with higher order thinking rather than simple memorization or comprehension (Dondlinger, 2007; Kebritchi & Hirumi, 2008).

Games such as SimCity, Civilization, Tropico, Minecraft, DimensionM and SimEarth have been used in and out of classrooms to teach the subjects of Science, Math and Government
SimCity allows players to develop cities while learning about geography (Squire, 2002). Civilization provides players with an opportunity to run an entire civilization (Squire, 2002). Tropico affords players the tools to govern computer-based nations, while SimEarth opens the door for players to investigate complex systems like the Earth’s chemical and life cycles (Squire, 2002). DimensionM is an immersive 3-D game to teach Algebra (Kebritchi & Hirumi, 2008). All of these games develop collaborative decision-making and communication (Paraskeva, Mysirlaki, & Papagianni, 2010; Williamson Shafer et al., 2005).

The use of computer-based learning can complement traditional classroom instruction to deliver a learning environment that is engaging, fun and motivational for students (Williamson Shafer et al, 2005). Research on the comparison between learning outcomes on game-based learning vs. the traditional classroom instruction has delivered mixed results (Hainey & Connolly, 2010; Halverson, 2012; O’Neil et al., 2005). Hainey and Connolly (2010) compared the delivery of education using game-based and traditional classroom instruction. They found neither delivered better results. Furthermore, they note the need for gaming software engineers to collaborate with educators in the development of game-based learning approaches (Hainey & Connolly, 2010). They stress the need for both teaching mechanisms to be deployed in today’s classrooms.

Halverson looked at games in the classroom as an intervention worthy of its own objective research. The author calls for action based research that examines how students “navigate education” through the use of games (Halverson, 2012, p. 445). The author also calls for new teaching practices to be developed using “new technologies of teaching and learning” that will “allow for innovation, exploration and experimentation” (Halverson, 2012, p. 445).
Halverson hypothesizes that game-based learning may be the answer to this new teaching practice.

Kebritchi, Hirumi and Bai (2010) looked at the effect of modern computer games on mathematics achievement and class motivation. They found no significant achievement in a comparison of game-users vs. non-game-users. However, they found greater motivation in students who played the games in the classroom and at home (Kebrichi, Hirumi, & Bai, 2010).

Learning outcomes can be linked to computer games for many subjects (Hays, 2005). O’Neil and associates’ (2005) research on the delivery of education using video games and the effect on learning outcomes shows a positive impact on students’ abilities to apply earlier learning to more complex tasks as new levels are reached in the games. These findings also show an increase in problem-solving capabilities in students that utilized video game-based learning. The problem-solving skills are honed in games as no solution is delivered; the student must use cognitive processing to arrive at an answer.

The research of Gillispie, Martin and Parker (2010) used the video game, Dimension-M, as an intervention to determine whether it positively influenced math achievement and attitude in math. Their findings imply the game does have a positive impact. This study calls for further research on a multi-player game scenario as well as a focus on students’ cognitive processes while playing the game.

Bavelier and colleagues (2012) reviewed the aspects of attention enhanced in action video games to understand the changes in neural behavior between children who played video games (gamers) and those who did not (non-gamers). Their research measured aspects of brain activity and found a startling contrast between the two groups. The gamers showed “better
selection attention over space” and “enhanced selective attention to objects” (Bavelier et al., 2012, p. 132). They concluded that gamers hold a stronger ability to “either limit or recover faster from the distracting effect of abrupt onsets” (Bavelier, et al., 2012, p.133). In other words, they have developed an ability to keep on-task.

Other research has also shown evidence in the promise of video games as a positive effect on attention abilities (Boot et al., 2008; Green & Bavelier, 2012). Boot and associates (2008) studied the use of video games amongst players who played on a regular basis; i.e. expert gamers, and non-gamers (those that didn’t play at all). They concluded that the expert gamers manifested better attention among other positive attributes that support successful learning outcomes (Boot et al., 2008). Green and Bavelier (2012) provide evidence that video games provide a means for practicing attention skills that is transferable to an academic setting. They report action video games call upon the gamer to stay on-task and suppress irrelevant information. This skill enables gamers to adapt more swiftly to new environments or learn new skills quickly (Green & Bavelier, 2012).

Further research conducted by Admiraal and associates (2011) also concludes that game-based learning leads to better academic outcomes as students are engaged in learning content longer in more meaningful ways. This research also indicates students retain the course material for a longer amount of time due to the active learning environment it is delivered in (Admiraal et al., 2011). Cagiltay (2007) also notes that delivery of academic lessons utilizing computer-based games creates a more interesting delivery of information leading to longer-term engagement of students.
The use of technology in the classroom does not come without its detractors (Bennett, Maton, & Kervin, 2008; Frank, 2012). In a journal article dated 2008, Bennett, Maton and Kervin discuss the claim that technology is a necessity in the classroom due to students’ status as “digital natives.” A digital native is defined as the generation born between 1980 and 1994 described as living lives “immersed in technology” (Bennett, Maton, & Kervin, 2008, p.776). These students possess sophisticated knowledge of technology. The authors state that digital natives prefer education delivery via technology versus the traditional classroom. The authors further explain that this generation of students is reliant on technology for information, communication and socializing, but not for education. Bennett and colleagues (2008) contend that technology is embedded in the classroom; however, students’ and teachers’ use is not uniform, therefore it cannot be used as the only means of education.

Other studies have outlined some cautions in using game-based learning with children. They point to the propensity for some personality-types to become addicted to video games, later leading to gambling and internet addictions (Boyle et al., 2011; Chou & Chou, 1997). This is particularly concerning for persons with narcissistic and aggressive personality traits. The authors also note that the addiction can lead to diminished friendships and loss of control over time regulation.

Studies have been conducted to assess how computer games are played in education (Chou & Chou, 1997; Frank, 2012; Hays 2005). Frank (2012) conducted a study that measured gamers’ use of video games intended for education. They found players to become more focused on winning the game than reaching educational objectives. They labeled this state as “gamer-mode” whereas players become fiercely competitive looking at the achievement of “winning” as the end goal versus the obtainment of education (Frank, 2012).
Hays notes educational games are not always used in ways intended by game developers. He emphasizes the need for instructors to embed video games feedback into learning materials to ascertain the players’ understanding of learning objectives (Hays, 2005). Chou and Chou call for careful integration into education with attention to “instructional design principals” (Chou & Chou, 1997, p. 1334).

Other researchers point out the benefits of computer game play (Durkin & Barber, 2002; Piper et al, 2006). Durkin and Barber (2002) measure the effect of video game play on adolescent development. The study measures levels of aggression, leisure time and self-confidence. Results show no measurable effects on aggressiveness. This finding conflicts with other non-empirical papers that suggest video game play can lead to aggressive behavior (Do violent video games lead to Aggression?, 2006). Study participants led active social lives, albeit some of the socialization occurred online. Online friendships included children from the participants’ locale as well as locations far away. In measurements of self-concept, player participants viewed themselves higher in intelligence than non-players (Durkin & Barber, 2002).

Other researchers have noted the benefits of game-based learning in education, but caution that they cannot stand alone as an instructional method (Hwang et al., 2012; Williamson Shafer et al., 2005). Hwang and colleagues (2012) stress the importance of personalized lesson plans to address students’ individual learning needs. Williamson Shafer and colleagues (2005) stress the potential of video games "to move our system of education beyond the traditional academic disciplines-derived from medieval scholarship and constituted within schools developed in the Industrial Revolution-and toward a new model of learning through meaningful activity in virtual worlds." (Williamson Shaffer et al., 2005, p. 111).
Game-based Learning and Children with ADHD

Game-based learning and children with ADHD is a subject that has garnered limited attention in research. This section provides information on the studies that have been conducted to assess the value of game-based learning with the ADHD population.

Game-based learning for children with ADHD has been recently introduced as an academic intervention that enhances this population’s abilities (Jitendra & DuPaul, 2007). Game-based learning addresses the issues of attention-span, engagement and disruptive behavior found in the ADHD student population (Fabio & Antonietti, 2014; Houghton et al., 2004; Jitendra & DuPaul, 2007; Shaw, 2005).

Research results have shown the positive effects of videogame play on children’s attention-spans (Fabio & Antonietti, 2014; Lawrence, 2002). These findings show promise for educators working with students with ADHD, in large part because of their deficiencies in attention and executive function. Educators strive to introduce tools and methodology that provide a successful learning environment for students with ADHD. Game-based learning is a tool worth considering for this population as it enhances lengthened learning engagement, attention span effectiveness and social benefits which are issues that have been cited as obstacles to successful academic outcomes (Zentall, Tom-Wright, & Lee, 2013).

Other research has focused on the use of computer games and children with ADHD to measure inhibition and attention. Houghton and colleagues (2004) conducted a study to assess video game play in non-medicated ADHD boys and normally developed boys. Study results indicate quicker response rates by ADHD boys and better results for games that require a high working memory load (a high degree of executive function). The authors concluded, “Computer
technology in the classroom may afford children with ADHD increased opportunities to be more successful, both academically and socially, and to improve their interactions with peers” (Houghton et al., 2004, p. 31-32).

Shaw (2005) conducted a small-scale study to review the engagement of children with ADHD when using commercially available video games. Specific measures were taken to assess executive function and attention. Results of the study revealed stronger attention of the ADHD group compared to the control group. The ADHD group of children also showed a significant decrease in impulsive response compared to the control group (Shaw, 2005).

Both of the above studies do not measure the effectiveness of video game use in an academic setting, but do provide results on measurements of attention, executive function and working memory. These issue deficits are known to affect academic success in children with ADHD (Daley & Birchwood, 2009; Loe & Feldman, 2007; Rapport et al, 2009).

The use of video games and children with ADHD comes with some caution. Weiss and colleagues (2011) conducted a literature review on the correlation between use of video games and its impact on children with ADHD. The authors warn of the propensity of people with ADHD to have “addictive” (p. 331) personalities. They cite literature that indicates “internet addiction” and off-line video game addition as a disorder that makes children with ADHD more vulnerable. Citing this risk factor, they recommend time limitations on video-game play for children with ADHD.

This research study furthers the research of proponents of game-based learning in the classroom using a case study methodology to assess the impact of its use in a math classroom with children with ADHD. Research has shown the positive effect of video game play with
children with ADHD in terms of focus, attention and engagement; however, limited research has been conducted on the use of game-based learning with children with ADHD.

**Game-Based Learning in Academics**

Game-based learning with students with ADHD is a subject that has shown promising outcomes. This section provides information on the benefits of this instructional method. The use of technology in an academic setting with children with ADHD has also proven successful.

McClanahan (May/June 2012) shares the results of an academic intervention used with a child with ADHD. The child was tutored in reading using an iPad. Previous attempts at teaching the child to read at grade-level had been unsuccessful. Upon introduction of reading lessons using the iPad, the child became more engaged and on-task. The student was reading at grade level by the end of the school year (McClanahan, May/June 2012). The author calls for further research on the use of technology with ADHD students.

Other studies have indicated promise in using video-game based learning in children with ADHD (Mautone et al., 2005; Ota & DuPaul, 2002). Ota and DuPaul examined the effects of using game-based learning software to improve math performance and attention in a population of fourth to sixth graders diagnosed with ADHD. The researchers found the use of a game-based learning format showed increased in "active engaged time and decreased in off-task behaviors" (Ota & DuPaul, 2002, p. 254). The study did not measure whether the game-based intervention correlated to academic performance.

Mautone and colleagues’ (2005) study provided similar results in relation to off-task behavior and engagement. This study is limited as it has three participants identified from a larger group of children “participating in a study funded by the National Institute of Mental
Health (NIMH) aimed at improving academic performance of children with ADHD.” (Mautone et al, 2005. P. 3030). The study participants ranged in age 8 -9 and were in the second, third and fourth grades. The study utilized the software package Math Blasters 6-9 in the study.

Both studies indicate a strong improvement in engagement and decreases in off-task behavior. However, improved learning outcomes were not demonstrated by all study participants. Both papers suggest the promise for game-based learning with the ADHD population, but acknowledge the preliminary findings of their studies due to size of number of participants.

Raggi and Chronis (2006) compared the use of computer assisted tutoring using software using games and non-games. They found higher response rates and engagement with the game format with children with ADHD. The study focused on behavioral factors, but the authors surmised the benefits of computer-assisted instruction using games on academic outcomes. The authors call for further research.

Veenstra and associates (2012) conducted an exploratory multiple case study to examine how a computer game focused on improving “ineffective learning behavior” (p. 27) in children diagnosed with ADHD and or both ADHD and Autistic Spectrum Disorder (ASD) (Veenstra et al., 2012). They measured rate of mouse clicks to assess executive function of study participants. The study concluded a direct correlation between increased executive function in children with ADHD and use of action computer games. Study authors call for further research on the use of action video games developed for academic use.

Xu and colleagues completed a review of empirical studies that have “assessed the efficacy of technology as a tool for students with ADHD”. (Xu, Reid, & Steckelberg, 2002, p.
This paper reviews literature on the use of technology with children with ADHD in five categories: computer-assisted instruction (CAI), computer-based cognitive training, biofeedback training, assessment, and behavior modification. In terms of CAI, the authors noted two studies (Ford, Poe, & Cox, 1993; Kleiman, Humphrey, & Lindsay, 1981) that reported promising results for CAI with children with ADHD. The study results are limited due to research methodology and setting.

Fabio and Antonietti (2014) conducted research using “hypermedia tools” with students with ADHD. They compared results to a control group of normally developed students. Hypermedia tools are defined as “images, photos, diagrams, motion pictures, sounds, and texts are simultaneously available to activate learner’s verbal/auditory and visual channels at the same time” (p. 8). They found that these tools led to increased levels of retention of knowledge in the long-term for students with ADHD. They performed at the same level as the control group.

Research to assess the effect of game-based learning on students with ADHD’s on-task behavior, engagement and behavior is relatively abundant compared to studies on the academic outcomes for the same population. There is agreement in the literature that game-based learning does improve ADHD students' engagement, on-task behavior and behavior in the classroom (Ford, Poe, & Cox, 1993; Kleiman, Humphrey, & Lindsay, 1981; Raggi & Chronis, 2006; Xu, Reid, & Steckelberg, 2002). These factors are a known construct to successful academic outcomes. Preliminary studies have shown game-based learning as a promising instruction mode for the ADHD population (Mautone et al., 2005; Ota & DuPaul, 2002). These initial results call for further research to assess the academic outcomes in children with ADHD using game-based learning instruction.
Conclusion and Future Study

Game-based learning offers educators an opportunity to strongly engage children with ADHD in their own learning. Introducing this methodology paired with traditional classroom teaching provides these students with tools that enhance their ability to succeed in academic settings. Game-based learning affords a learning tool that increases executive function and focus while reducing hyperactivity and inattention (Houghton et al., 2004). This combination places these students at a higher rate of success in academics.

Studies indicate game-based learning in children with ADHD for math is particularly promising (Annetta, 2009; Ota, 2002). This teaching technique has shown successful behavioral outcomes. Reductions in off-task behavior and hyperactivity have been found with the introduction of game-based learning. Increases in active engagement and focus are also found. More research is needed to assess the effect on academic outcomes when game-based learning is introduced into the curriculum for children with ADHD.

Another important aspect of the use of game-based learning for children with ADHD is the acceptance of this pedagogy by the academic community. Bourgonjon (2010) concludes the necessity for educators and video game creators to collaborate on the development of video games for education is essential to overall acceptance and use. Bavelier and associates (2010) further emphasize this importance as they stress the need for appropriate content integration into action video games developed for education. Game-based learning tools must be organized to incorporate content that triggers learning in order for suitable classroom use. Kirriemuir and McFarlane (2004) also stress this point in their call for partnerships between academic and
industry game developers. If this collaboration does not take place, academic standards and requirements may be missed in the development of video games targeted for education.

Further research to assess the academic outcomes for children with ADHD when they engage game-based learning must be performed to answer questions pertaining to improvement in academic outcomes. This study enrolled participants to test the research questions noted at the beginning of this chapter.
CHAPTER 3: RESEARCH METHODOLOGY

Introduction

Chapter Three describes research design, rationale, site, population, data collection timeline, and ethical considerations of this study. The focus of the research was the use of video game-based learning and children with ADHD. The study was predicated on the hypothesis that game-based learning coupled with traditional classroom instruction increases academic outcomes for children with ADHD. This hypothesis was based on research that indicates game-based learning increases attention, decreases disruptive behavior in the classroom and leads to more meaningful academic engagement (Admiraal et al., 2011; Fabio & Antonietti, 2014; Martinussen et al., 2006).

The research questions for this study were:

What is the relationship between game-based learning and academic outcomes in Algebra One for students with ADHD?

How do teachers and students perceive the influence of game-based instruction on the academic performance of Algebra One students with ADHD?

Research Design and Rationale

This section discusses the research approach and design. This case study provides results to inform educators on a game-based intervention to teach math to children with ADHD. Creswell describes a case study as “An in-depth exploration of a bounded system (e.g., activity, event, process or individuals) based on extensive data collection” (Creswell, 2012, p. 465). The case study methodology consisted of a bounded system of 3 study participants and their Algebra One teacher.
One of the anticipated outcomes of this research was the use of the study information to further inform the teaching of students with ADHD in the classroom. Results will be shared with educators in the hopes that the game-based intervention will be used with students with ADHD.

**Flow of Research Design**

Table 1 depicts the flow of the research design for this study. Step One shows the identification of the study participants. Step Two was an interview with the teacher to understand his thoughts on the use of game-based learning. Step Three measured the pre-test results of all study participants before intervention is introduced. Step Four was the introduction of the game-based intervention and the teacher’s journaling while the intervention took place in his classroom. Step Five shows the post-test of study participants. Step Six identified the focus group with study participants and an interview with the classroom teacher who taught the lesson to study participants in her classroom.

*Table 1. Flow of Research Design*

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<th>Step One</th>
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<td>Step Two</td>
<td>• Teacher interview (pre-intervention)</td>
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<td>Step Three</td>
<td>• Pre-test</td>
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<td>Step Four</td>
<td>• Game-based intervention</td>
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<td>Step Five</td>
<td>• Post-test</td>
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<td>Step Six</td>
<td>• Focus group with study participants</td>
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<td>• Teacher interview (post-intervention)</td>
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The design incorporated a quantitative analysis of academic outcomes measured by test results. The school’s existing curriculum and assessments, i.e., tests, were used. This allowed for uniformity in testing as the students and teacher were familiar with the format. The
qualitative portion of the research gathered information from a variety of sources. It included a focus group with students in the study. The data was further tri-angulated with two interviews (pre- and post-intervention) of the teacher in the classroom. Another data set was information from a journal that the teacher wrote to capture his thoughts as the intervention was used in the classroom.

The quantitative approach was chosen to allow for comparison of test results before and after a game-based learning intervention is introduced to students with ADHD. Results indicated the effect of the game-based intervention on math achievement of study participants. This portion of the study is included as a basis to further inform the discussion. The assessment results cannot be considered statistically valid as the sample size is too small. This is discussed further in the Recommendations section of Chapter 5.

A qualitative component of the study assessed feedback received in a focus group with students who participate in the study. The focus group with student study participants who receive the intervention assessed their experiences with game-based learning. The teacher’s perceptions of game-based learning is explored to further understand the practicality of use in the classroom through pre- and post-test interviews as well as his journal kept throughout the intervention.

**Research Questions and Related Methodology**

Table 2 outlines the research questions and the corresponding research methodology employed to gather appropriate data.
Table 2. Questions and Related Methodology

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The researcher established a goal to review whether there is a causal relationship between game-based learning and academic outcomes in children with ADHD. Previous small-scale studies have indicated this instruction method shows promise in children with ADHD (Mautone, 2005; Ota, 2002). Both the Mautone and Ota studies had 3 participants each. Neither study included academic assessments as a part of the research design.

Method

This author further explored the findings from the Ota and DuPaul, and Mautone, DuPaul and Jitendra studies. The researcher also considered Hess and Gunter’s (2013) study that compared academic outcomes and learning experiences of students who used game-based learning in an online course with those who were instructed in the classroom (Hess & Gunter,
Study authors used a mixed methods triangulation convergence model (Creswell et al., 2003) where quantitative analysis of academic outcomes was conducted with a qualitative study of teachers’ and students’ motivation and engagement in the instruction methods. Neither study measured whether game-based learning as a complement to traditional classroom teaching led to better academic outcomes for students with ADHD.

Hess and Gunter used the Self-Determination Learning Theory (SDT) social theory as a basis for their research (Hess & Gunter, 2013). Deci and Ryan (2000) describe this model as the belief that humans have an innate need for growth and motivation who “strive to master ongoing challenges and to integrate their experiences into a coherent sense of self” (p. 68). Active learning is an expression of this theory. Game-based learning is considered active learning as it calls upon players, i.e., students, to engage in learning by continuous decision-making, collaboration, and scaffolding of knowledge to achieve higher levels. Hess and Gunter contend “In educational settings, the goal of the theory is to enhance those intrinsically motivated behaviors while addressing innate student psychological needs” (p. 375). Byman and Kansanem (2008) note the theory will be successful if students are placed in an academic setting that motivates and interests.

The Hess and Gunter study “informs instructional designers, teachers, education stakeholders and educational game designers by providing research-based evidence related to the learning experiences and outcomes of the serious game-based online course” (Hess and Gunter, 2013, p. 372). The research methodology for this study provided information on the learning experiences of students (qualitative) while measuring the learning outcomes of the students (quantitative). Although Hess and Gunter’s study did not focus on the ADHD population of
students, it does provide a statistically significant (184 study participants) review of game-based learning and academic outcomes.

This study also took into account the research of Ke in which a mixed methods study delivered results that show the specific type of game affects students’ motivation and engagement in game-based learning. In Ke’s study, a summer cohort of 4th and 5th graders used game-based math programs to facilitate cognitive math achievement (Ke, 2008). The study highlights the value of learning activities within a game-based program. Results show an increase motivation, but no significant increase in cognitive achievement in math.

Ke’s study underscores the importance of game-based program choice for this study. A game proven to engage students while providing a challenging scaffolding lesson environment is imperative. Kebritch and Hirumi analyzed modern games that are in the education market. They note, “…little has been done to synthesize information on how established learning theories and instructional strategies are being applied to design educational games to guide research and practice” (Kebritch & Hirumi, 2008, p. 1729 -1730).

Due to the research site’s IT firewall system, an individual player game was deemed the most appropriate solution for this study. The school’s Information Technology Department did not allow for firewall access due to the stress of a multiplayer game on the bandwidth and the potential security threats from a multiplayer game. This threat has been documented in literature including Sinha, Mitchell and Medhi’s article which states multiplayer games “pose a great challenge to the existing network infrastructure in order to satiate its requirements” (2005, p. 71).

Reviewing the literature, which included online reviews of various Algebra apps, and conferring with colleagues led to the choice of Algebra Champ as the most appropriate game.
The game is described as providing “practice in solving equations in an entertaining, game-like format. Student may reinforce their algebraic thinking skills by solving one, two and multi-step equations and becoming the “Champ” (Apps for Algebra, 2015). Appendix A provides an overview of the game outlining the benefits and constraints. Given the site and population for this study, the game was deemed to be a reasonable tool for use in this study. The game is free of charge and is accessible via iTunes.

Algebra Champ is a game that “offers introductory algebra skills practice” with “timed rounds, high scores, and a caged fight theme” (West, 2016). The game allows players to choose their “fighter” (Figure 2) and difficulty level (Figure 3) to solve basic Algebra equations while a timer streams at the top of the screen (Figure 4). It is a game that provides practice for basic Algebra concepts.

*Figure 2. Algebra Champ Game Set-Up (West, 2016).*
This study employed one Algebra One class at a private school focused on students with learning differences. The school utilizes Gardner’s Theory of Multiple Intelligences as a basis for instruction and curriculum design. For example, students in the Algebra One sections demonstrate their understanding of the Order of Operations through a modality of choice, e. i., music, drawing or writing.
Students identified as ADHD as a primary diagnosis by medical and/or neuropsychological testing were recruited as potential study participants. The determination of a diagnosis of ADHD by an outside medical or mental health provider is school policy.

Pre- and Post-test results were compared to assess whether game-based learning had a positive impact on learning. Copies of the pre- and post-assessments are found in Appendix B.

Site and Population

Site Description

The site for this study was a private nonsectarian co-educational college-preparatory high school in a suburb of Boston, MA that specializes in teaching students with learning differences. The school website describes the teaching approach as:

“Our multiple intelligences approach to teaching, along with support seamlessly integrated into the classroom, creates a transformational learning experience for students” (school name not cited to protect confidentiality, 2015).

School X has a 2015-2016 total enrollment of 175 students. The enrollment was 55% boys and 45% girls. There was a 1:5 faculty to student ratio. The school was comprised of 55% day students with the remaining 45% boarding. The 2015-2016 school year tuition was $39,200 for day students and $53,750 for boarding students. The school describes itself as respecting “ethnic, cultural, and intellectual diversity, we teach and live in an atmosphere of mutual respect for differences” (school reference not cited to protect confidentiality, 2015). The enrollment had 25% international students from 12 different countries. Thirty percent of the students were categorized as “students of color.” Approximately 30% of the students had ADHD as their primary diagnosis of learning difference. Classes were 75 minutes in length allowing for a “deeper learning environment”.
The site was chosen due to the author’s knowledge of the schools’ specialty for teaching students with learning differences. The school prides itself on its “creative approach to teaching and learning” (school viewbook, 2015). Upon initial inquiry the researcher was directed to the schools’ Program Director of the 9th and 10th grades. He expressed interest in the study and secured participation of the Algebra teacher. The school requested an in-service of research results to the faculty once the study is finished.

The school had a higher than average population (30%) of students with ADHD compared to the average public school (11%) (CDC, 2015). Prior to the study, the researcher’s stance included a belief that if the study hypothesis was proven correct, results may provide teachers with new instructional methods for the ADHD population of students. This enhanced the students’ learning and created a new platform for successful academic outcomes.

The study was limited to the subject of math allowing for a systematic and pragmatic approach. There were five math teachers at the school across four grades (School Web Site, name redacted to protect for confidentiality, 2015). One of the teachers of Algebra One agreed to participate in the study. He taught two sections of Algebra One. All students had iPads as a school requirement. iPads were used as teaching tools across subject areas. The game-based intervention for this study was a web-based application. It could be accessed by all study participants via their personal iPads. There was no charge to access the game.

**Study Participants**

Prospective research participants were identified by School X’s administration. The school facilitated the communication with parents/guardians. The teacher coded test results with a unique identifying number to protect student confidentiality. School administration predicted
4-5 student study participants with ADHD as a primary diagnosis in each Algebra One class. Students’ secondary diagnoses, if existing, were not tracked.

Study participants were recruited using a purposeful sampling method. Creswell (2013) defines purposeful sampling as, “intentionally selecting individuals or sites to learn or understand a central phenomenon” (p. 206). Further, Harsh (2011) states, “The logic and power of purposeful sampling lie in selecting information-rich cases for study in depth. Information-rich cases are those from which one can learn a great deal about issues of central importance to the purpose of the inquiry…” (p. 63).

All students enrolled in Algebra One of the participating teacher’s classes were eligible to use the game-based intervention. Although non-traditional in research methodology, this format had been requested by the school administration to minimize classroom disruption that could be caused by differential teaching methodologies, specifically, one group of students using game-based learning vs. those that do not. The teacher only shared data for the students that had ADHD as a primary diagnosis who consented to participate in the study.

Letters were emailed home by the school to parents/guardians of students with ADHD as a primary diagnosis; requesting permission for their student to participate in the study. Email is the preferred delivery system as many prospective participants were international students and regular mail could have added weeks to the study protocol. Parents/Guardians were asked to complete a consent form and return it to the researcher within two weeks of receipt. A secondary reminder email was sent after ten days of the initial communication.
Questions pertaining to the study were directed to the researcher. The informed consent provided information on the study methodology and included the access for all study participants to game-based learning after the pre- and post-tests have been completed.

Parents/guardians were asked to discuss study participation with their students. The study protocol was shared with the teacher and students. Once permission was received from parents/guardians of the student, the teacher approached students whose parents/guardians had granted permission to discuss the research study. The teacher obtained student assent to participate in the study. They were reassured that they had the right to withdraw from the study at any time.

Pre- and post-test results were shared with the researcher. Students were identified by number to protect confidentiality. This allowed for data to be analyzed without the concern of specific student outcomes known by the researcher.

**Teacher Collaboration**

An important component of this study was the collaboration of the School X Math teacher. This teacher assisted in the facilitation of the study through the introduction of the game-based intervention as well as the facilitation of game-based learning time in the classroom.

His participation added credibility to the study as it is seen as an endorsement of the importance of the information that is reported at the conclusion of the study. The teacher has access to study results. The teacher was viewed as a partner in research for this study as he facilitated the classroom, gave the tests, graded the tests, and shared test results with the researcher.
This teacher’s participation in the interview framed the results of the qualitative portion of the study. His observations and thoughts shaped this portion of the study by providing constructive feedback on students’ usage of game-based learning tools as well as his reflection on the value of the instruction tool. Appendix D provides the list of questions for the interviews.

**Data Collection**

This section provides a description of the quantitative and qualitative data collection tools used for the study. Both data sets were used to draw conclusions on the use of game-based learning and students with ADHD.

**Pre- and Post-Tests**

This study collected data from pre- and post-tests. These tests provided a baseline of students’ knowledge and a measurement of gains. It provided two data points used for comparison and review.

The tests were ten questions presented in a paper format. They were administered at the beginning of the class period. They consisted of single variable problems which tested concepts found in the Algebra Champ game. There were no test time restrictions, but all students completed it within 30 minutes.

School X had class periods of 75 minutes during which experimental learning was often included into instruction. Fifteen minutes at the end of each class for a period of three weeks were designated for game-based learning. The teacher was the lead educator in the classroom. He delivered the traditional Math lesson and facilitated the game-based learning.
Focus Group

The researcher requested a mutually agreeable time for a focus group with study participants. Refreshments were offered as a small incentive for focus group participation. Use of designated school space was requested to provide the most comfortable setting for this larger meeting.

Teacher Interviews

Two interviews were conducted with the teacher. The first was conducted prior to the intervention. Questions were focused on the teacher’s pre-intervention perception of game-based learning. They also assessed his anticipated outcomes of the intervention. The questions were carefully worded so as to not create a “reactive effect” (Schmitz, 2006) to the study. A reactive effect is created when pre-test or pre-intervention questions may lead a study participant to conclude the results of the research before it has been completed. In doing so, the study participant may behave differently in the research.

A second interview was conducted with the teacher to understand his observations of the game-based intervention in his classroom. The quantitative study results served as a basis for discussion in the interview.

Teacher Journal

The teacher kept a daily journal to capture his thoughts throughout the time of the intervention. This allowed for real-time perceptions, observations, and thoughts to be documented, thus diminishing the necessity to recall such events during the post-intervention
interview. The journal entries served as a discussion topic during the post-intervention teacher interview.

**Quantitative Research**

**Pre- and Post-Tests**

The quantitative portion of the study consisted of a pre- and post-test to compare students’ understanding of lessons before and after the intervention. These tests were administered by the classroom teacher utilizing the Math XL® tool. The specific tests were a part of the current assessment method at the school.

The school did not follow a specific curriculum for math. The researcher’s school contact noted, “As an independent school, we do not use prescriptive or standardized curricula and our teachers have more leverage to adjust curriculum than in a public school” (N. Cronin, personal communication, July 23, 2014). Due to the situation, there were no test validity scores available. Another classroom teacher from the school described the lesson assessments as, “One is ‘formal’, meaning on paper with a pencil, be quiet and show me your work. One is generally collaborative, meaning a team game, work with a partner or interact with me or another student to demonstrate understanding. One part is either creative or introspective, meaning find an alternate way to show me you understand the concept (picture, artwork, analogy, photography etc.) or include a written portion trying to assess your own skill, confidence and/or accuracy.” (K. Sokolow, personal communication, August 8, 2014).

The school used an online math curriculum enhancement tool, Math XL®. Math XL®’s website described the tool as:
“MathXL® for School is the essential online addition to any core curriculum that provides personalized instruction and practice for middle and high school students of all levels. Tied directly to more than 300 Pearson mathematics and statistics texts, teachers can easily create, edit, and assign homework and tests.” (Math XL, 2014).

MathXL® is a Pearson product that incorporates quizzes which allow the teacher to further assess students’ understanding of course material. The teacher offered to adjust his curriculum to integrate Math XL® quizzes at the beginning and end of the timeframe of the research study to provide pre- and post-test data.

All study participants were administered a pre- and a post-test to compare results of the intervention. Results were compared to assess whether the study participants had academic gains after the intervention.

**Data Analysis**

Analysis of pre- and post-test results were done using a simple math equation to assess the comparisons of scores between pre- and post-intervention tests. The sample size was too small to allow for further analysis.

**Qualitative Research**

**Focus Groups**

A qualitative portion of this study was conducted using a focus group. Maxwell (2013) notes the importance of focus groups in terms of in-depth information that can be garnered through the approach. The focus group invited all study participants to share their thoughts on the use of game-based learning in conjunction with traditional classroom teaching. The pros and cons of game-based learning was assessed. Appendix C provides a list of questions for the
Student Focus Group. The questions were open-ended to capture respondents’ initial thoughts while allowing for follow-up questions.

**Algebra Teacher Interviews**

Two interviews were conducted with the Algebra teacher who hosted the research. He was questioned on his perceptions of the game-based learning before and after the intervention. He was also questioned on the engagement, motivation and interest of students during the intervention.

**Interview Protocols**

The focus group and the teacher interviews were recorded to allow for later transcription. All participants were advised of the recording devices. All information was used solely for this research study and not shared with anyone other than the study author, dissertation committee or Drexel University IRB (if necessary).

Interviews were held during a time that was convenient for the teacher and students. A lunch time was suggested to eliminate the teacher and students committing extra time before or after school. Separate interviews were scheduled with the teacher and the student study participant group.

An iPhone device was used to record the interviews. The iPhone recording was used to transcribe the interviews. Immediately after the interview, the iPhone was transported to the researcher’s home office. Upon arrival, the file was transferred to the password protected laptop dedicated to the researcher’s school work. Once the files were downloaded, it was deleted from the iPhone to protect for privacy. The files were sent to an external company for transcription.
The researcher also took notes throughout the process to capture participants’ body language and expressions. The notes were matched up to the transcription to create a richer interpretation of the data.

Study participants were asked to contribute their thoughts and observations on their use of game-based learning. Although the entire class received the game-based intervention, Question 2 for this research focused on the perceptions of the group identified as students with ADHD.

An interview with the participant teacher was held pre- and post-intervention to assess his perceptions of the effect on students. Appendix D outlines the questions for his interviews. The answers help to shape the conclusions drawn for Question 2.

**Data Analysis**

Data analysis of the focus groups followed Creswell’s advice on the Case Study Methodology (Creswell, 2013). Once the transcription was complete, it was read and notes were written in the margins. The process of open coding was followed (Merriam, 2009). These notations reflected bits of data found in the interview that was relevant to the research questions.

The data was then color coded to reveal the initial themes found in the dialogue. Once the color coding was finished, the themes visually emerged by reviewing the amount of highlights by color. The strongest themes received the most highlights and the less important themes received smaller amounts. The themes were then grouped into categories to allow for patterns to inform the answer to Question 2 of the study (Merriam, 2009).
The teacher’s journal was also analyzed using an open coding methodology. A similar color coding system was used to look for themes of his thoughts and observations during the intervention period.

The data was then axial coded to allow for categories to be grouped together to analyze for streams of events and theories.

**Timeline**

Table 3 shows the timeline of this study. This study initially began in December of 2014, but was postponed due to technical difficulties between the school’s firewall and the original game choice. The study was started again in October of 2015 with a newly recruited group of students. It provided a three-month timeframe for the game-based intervention to be introduced and assimilated into classroom teaching.

*Table 3. Study Timeline*

<table>
<thead>
<tr>
<th>Date</th>
<th>Action Steps</th>
<th>Responsible Party</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 2014</td>
<td>Contact School X Principal to discuss study</td>
<td>M. Carr</td>
</tr>
<tr>
<td>May 2014</td>
<td>Submit research to School Administration for approval</td>
<td>M. Carr</td>
</tr>
<tr>
<td>Fall 2014</td>
<td>Drexel Proposal Review</td>
<td>M. Carr and Committee</td>
</tr>
<tr>
<td>Fall 2014</td>
<td>Submit research to Drexel University Institutional Review Board (IRB) for approval following proposal approval</td>
<td>M. Carr</td>
</tr>
<tr>
<td>November 2014</td>
<td>Pass IRB proposal hearing</td>
<td>M. Carr</td>
</tr>
<tr>
<td></td>
<td>Solicit School X Math teacher collaboration</td>
<td>M. Carr and School X</td>
</tr>
<tr>
<td>Month</td>
<td>Activity Description</td>
<td>Responsibilities</td>
</tr>
<tr>
<td>---------------</td>
<td>--------------------------------------------------------------------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>May 2015</td>
<td>Revised IRB approval</td>
<td>M. Carr</td>
</tr>
<tr>
<td>September 2015</td>
<td>Work with School X to identify potential study participants</td>
<td>M. Carr and School X</td>
</tr>
<tr>
<td>October 2015</td>
<td>Solicit study participants through mailing to parents/guardians.</td>
<td>M. Carr and School X</td>
</tr>
<tr>
<td>November 2015</td>
<td>Assess response to initial mailing; send out reminder if necessary</td>
<td>M. Carr</td>
</tr>
<tr>
<td>November 2015</td>
<td>Conduct pre-intervention teacher interview</td>
<td>School X</td>
</tr>
<tr>
<td>December 2015</td>
<td>Conduct pre-lesson test</td>
<td>M. Carr and School X</td>
</tr>
<tr>
<td>December 2015</td>
<td>Classroom and game-based instruction proceeds</td>
<td>School X</td>
</tr>
<tr>
<td>December 2015</td>
<td>Post-lesson test administered</td>
<td>M. Carr and School X</td>
</tr>
<tr>
<td>December 2015</td>
<td>Focus groups with game-based learning students and teacher interview</td>
<td>M. Carr</td>
</tr>
</tbody>
</table>

**Ethical Considerations**

The researcher sought Institutional Review Board (IRB) approval from Drexel University. The principals of The Belmont Report were followed. The Report was published in 1978 by The National Commission to Protect Human Subjects of Biomedical and Behavioral Research (The National Commission) to provide moral principles on the ethical considerations of behavioral and biomedical research (Beauchamp, 2008). This study fits within the parameters of the covenants of the report.

The three guiding ethical principles of the Belmont report are respect for persons, beneficence, and justice (National Commission for the Protection of Human Subjects of
Biomedical and Behavioral Research, 1978). In following these principles, the researcher did seek informed consent from all participants. They were fully informed on the study protocol, risks and benefits. Study participants were informed of their right to withdraw from the study at any time.

**Study Specific Ethical Considerations**

There are several ethical considerations for this study. The considerations include the researcher’s personal interest in the research, the various instructional methods of the study, the inclusion of minors in the study, and role of the teachers in the study.

**Inclusion of Minors**

Special consideration was given to the informed consent and study participants’ rights throughout the study. The informed consent document stressed the protocols followed to protect the anonymity of minors (see sections on Data Collection and Data Security).

**Role of Teacher**

Another ethical consideration was the central role of the teacher in the study. The role of teacher was twofold. The teacher had the responsibility of pre- and post-test administration. He was asked not to share his opinion on the different instructional delivery throughout the study to avoid study influence.

The teacher also had an active role in the interviews and journal. His opinions shaped the outcome of the qualitative portion of the study. This information is important in study results and may inform future instruction in School X as well as others schools who use this research.
**Data Collection**

All quantitative data were protected and only shared between the school and the researcher. Test results were reported to the researcher by the teacher. Students were assigned a number by the teacher to protect confidentiality. The researcher reported results by student number.

Qualitative results from the focus groups were reported as themes. Specific comments are not attributed to speakers by name. Focus group participants were notified of this plan at the beginning of each session.

**Data Security**

All data and recordings were stored on the researcher’s laptop which is stored in a home office. Data was password protected for further security. The files were also saved on a flash drive which is locked in a safe at the researcher’s home. Data will be saved for seven years after the study has finalized.

The data on test results were scrubbed for identifying student characteristics by School X before submission to the researcher. Students were identified by number. This further protected students’ confidentiality.

**Study Rigor**

The design of this case study research took into account the suggested frameworks from noted qualitative researchers (Creswell, 2012; Maxwell, 2013). The research has the inclusion of several data elements including a student focus group, pre- and post-intervention teacher
interviews, a teacher’s journal and data from pre- and post-intervention assessments (Oliver, 2011).

The research design is connected to the theoretical framework outlined in Figure 1 in that it seeks to further understand the effect of a game-based intervention on a population of students with ADHD in a classroom setting. All of the streams of research outlined in Figure 1 are investigated using qualitative research methodologies. The use of differential measures further adds to the rigor of this study.

The four elements of trustworthiness were considered during the evaluation of rigor. Billups discusses the four elements of trustworthiness as: “credibility (truth), dependability (consistency), transferability (applicability), and confirmability (neutrality).” (Billups, 2014, p. 10).

The element of “credibility” was triangulated through the use of the teacher interviews and journal; and the focus group to collect data on the experience of using game-based technology in the classroom. Although the teacher and students offered differing perspectives, they corroborated several findings.

Dependability was validated through several sources to conduct an external audit. The researcher’s Dissertation Chairperson reviewed the study on numerous occasions. The remaining Dissertation Committee Members also reviewed the manuscript at two points. The manuscript was further reviewed by the researcher’s colleague who has a Ph.D. in Special Education.

All of these reviewers reviewed the research procedure and findings to assess for consistency of the research process and validation of the findings. They further reviewed the
manuscript to ensure the data was reported in a manner which provided a description of the events of the study using sufficient detail.

The transferability of the findings was considered throughout the study, but most notably during the post-test teacher interview and during the student focus group. The teacher expressed concern that the specific classroom technology of the school in this study may not be duplicated in other school settings. He noted that the school has a one to one iPad program; whereas other schools may not have the same technology. The uniqueness of the school’s teaching methodology also led to deliberation when considering transferability. This is discussed in the Chapter 5 in the Study Limitations section.

A clear audit trail is available for this study strengthening the confirmability of data. The researcher has recordings of the focus groups and teacher interviews as well as the transcribed notes. The teacher’s journal, and pre- and post-test results are also clearly documented.

This study included strategies to support the “trustworthiness” of this case study research (Billups, 2014, p. 12). These strategies strengthen the rigor of this study as a whole, not individually.
Introduction

Chapter Four presents the findings, results, and interpretations of data from this study. The first section discusses the findings from the qualitative components of the study. The second section reports the results of the quantitative portion of the study. The third section discusses the interpretations of both sets of data.

Study Introduction

The study intervention was introduced to the entire class so as not to disrupt the class by providing just the students with ADHD the opportunity to play the game. The comments and data in this paper pertain only to the three study participants who are students identified with ADHD.

The game intervention was introduced by the teacher and students were asked to play the game for 10 minutes in each math class period over a three-week duration. The class met three times a week. The teacher used the first class during the study duration to introduce the study. The students did not play the game during this class. The total study duration amounted to eight class periods or a timeframe of 80 minutes total.

Qualitative Results

This section discusses the findings of the qualitative portion of the study. Data points include pre- and post-intervention teacher interviews, a student participant post-intervention focus group and an assessment of a journal kept by the teacher during the intervention.
Pre-Intervention Teacher Interview

A one-hour interview was conducted using the questions listed in Appendix D. The meeting took place one week prior to the introduction of the game-based intervention in the classroom. The teacher had verbally explained the research study to the study participants and gauged their interest. Permission slips had been distributed to parents/guardians. He had also spent time playing the game used in the intervention to become acclimated with the operations of the game.

The following discusses the teacher’s answers to questions found in Appendix D and summarizes the emergent themes from the interview.

He was asked to discuss and provide examples of measures he uses to teach students with ADHD. Specifically, he was asked to share of examples of what has worked and what has not worked.

The teacher relies on numerous class transitions to continuously engage his students with ADHD. He uses different modalities to deliver lessons. For example, he transitions from a “lecture approach to a hand-on approach to group work”. He works with students to develop strategies for time management as they transition from one class component to the next. He introduces “different perspectives” which allows for interesting ways to deliver a lesson. Each 75-minute class block is “an amalgamation of different approaches”.

The teacher noted “kinetic lessons” seem to have a high success rate for students with ADHD. A recent example was an assignment to measure a lounge area of the school to teach graphing. The students were asked to work in groups to measure the space and graph it. They were given meter sticks and graph paper as tools. In doing so, the students were moving around,
drawing and working as a group. One noted drawback was the distractions that took place due to the social aspect of the setting.

The teacher noted the “iPad adoption” of the school has been beneficial for students with ADHD as it provides another mechanism for lesson delivery and information. However, he noted it can also serve as a distraction if the student goes “off topic” with things other than schoolwork.

If he finds a student using the iPad for non-coursework, he re-engages them through questioning on the lesson. This gives them reason to pay attention and keeps their focus on the math lesson. He finds that this brief change is a built in “unofficial break” for the student.

The teacher cited word problems as one of the hardest material for students with ADHD to grasp. He said they can be “very overwhelming.” He does not assign more than two or three at a time. He finds the students struggle with “translating English into Math” and it “plays into all their weaknesses.” Word problems also require a lot of focus.

The teacher stressed the importance of connecting math lessons to “real world applications.” Students lose focus if they do not understand how the math can be used in the “real world setting” and are hesitant to learn unless they see how it will be used outside of the classroom.

He said students need to have a direct connection between the classroom work and the outside world to make it “worth their effort.” If this is not clearly defined, they lose the motivation to learn and “don’t see the point.” He said the “practicality of it needs to be transparent.” The more abstract the process, the harder it is for them to focus.
The teacher was then asked to shift his focus to the study. He was asked to consider the inclusion of game-based learning into his math curriculum; and share his feelings about the introduction to his class. This teacher spent time “trying out” the game prior to the interview. He noted some students may have “difficulty doing the mental math.” He decided he needed to work to make sure the students select the appropriate level of the game so as they aren’t under- or over-challenged. The level needs to meet their ability. He viewed one of his roles to encourage the students to choose the right level.

He further emphasized the need for the “appropriate level” to allow for realistic feedback from the students. If a student chooses a level that is too easy, they won’t show any improvements. However, if a student chooses a level that is too hard, they may become frustrated and stop playing.

He said the students were very enthusiastic about trying the game. The students showed a lot of curiosity and looked forward to beginning the study. He said the fact that they were engaged and eager to start is a great step with his students with ADHD.

The teacher expressed disappointment that more parents had not consented to the study (there were 8 prospective students). He hoped that the findings are beneficial. He also noted the study limitation of not having a control group as it may be difficult to discern between the benefits of game-based learning and the classroom learning.

The teacher expressed confidence that games will enhance the students’ ability to engage more in math. He knew game-based learning will make the subject “fun” and may offer another tool for students to “absorb” the material. He emphasized their “baseline will be drastically
improved” through this type of learning. He noted it may be of particular use for students with “math anxiety” because it makes math fun and relaxing.

**Themes.** There are three major themes that emerged from this interview. The first theme is concern about the study design. The second theme is game-based learning as an additional tool for teaching students with ADHD. The third theme is differential learning styles of students with ADHD.

Themes were categorized utilizing Merriam’s data analysis methodology (Merriam, 2009). A deductive coding methodology was used. Recordings and transcripts were color coded to count the number of times categories were mentioned in the interview. Categories with the highest number of counts were identified as themes. Table 4 provides a count of the themes.

**Table 4. Themes of Pre-Intervention Teacher Interview**

<table>
<thead>
<tr>
<th>Category</th>
<th># of References</th>
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<tr>
<td>Study Design</td>
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</tr>
<tr>
<td>Game-based Learning as Teaching Tool</td>
<td>10</td>
</tr>
<tr>
<td>Differential Learning Styles of Students with ADHD</td>
<td>7</td>
</tr>
</tbody>
</table>

The first theme that emerged was the study design. As noted in the question summary, the teacher expressed disappointment that several parents had not granted permission for their child to participate in the study. There were eight potential study participants. After receiving the initial study introduction letter, the teacher reached out to them to discuss the study. Despite a commitment to return the letter, the parents did not follow through; thus the study number of three participants. The teacher expressed concern that the low student participation would affect the study design.
The researcher explained this study limitation would be discussed in the paper and the study would be considered a precursor to future research.

The second theme centered on the teacher’s anticipation of the use of game-based learning with students with ADHD. During the interview, he expressed the typical modifications he makes in his teaching for students with ADHD. Given their differential learning styles, he expressed curiosity on the use of game-based learning as he thought it would be beneficial.

The third emergent theme was the differential learning styles of students with ADHD. The teacher provided specific examples of strategies used to maintain focus, continuous engagement and motivation for his students with ADHD.

**Student Post-Intervention Interview**

Study participants were interviewed following the game intervention. Two students self-identified as “gamers” and the third stated games, either educational or recreational, were not a big part of her life.

The following is provides a summary of students’ answers to the questions listed in Appendix C. This is followed by the themes of the interview.

The students indicated an optimistic outlook on the use of game-based learning in addition to classroom instruction. One student noted, “I think having different approaches to learning, like trying to find different ways to help students is a good thing. Not just paper and pencil.” They appreciated the creative approach to learning and teaching. Two out of the three had used games in the classroom prior to this study.
The students initially answered the question regarding game-based learning and the effect on focus with complaints about the game itself, Algebra Champ. They discussed the game design and noted the single player function. They would have preferred a multi-player game. The group commented on the lack of “cool graphics” and the timer feature built into the game. The timer was of particular issue as it “made it very stressful”. They stated the teacher told them the time did not affect their scores or game outcome, but it was an overall distraction.

The researcher asked the students to set aside their feelings on the game design and to focus on the use of a game as an addition to regular instruction. Once the question was positioned in this way, the students said the game was a tremendous help in terms of “recall” and “fun”. One student provided the analogy, “It’s like taking a long walk with a friend. You’re having fun talking and you don’t realize you’re getting the benefit of exercise too. Game based learning is having fun while you’re learning too. It provides a great distraction.”

Another student noted the benefit to those students who “have math anxiety”. When questioned about the term “math anxiety”, the student reported having a reaction to math that caused severe physical symptoms including headaches and stomach aches. This prevented her from “doing math” or gaining the confidence to complete assignments or assessments to show her understanding of the subject. She said the game provided an easy and interesting way to “practice math” that wasn’t stressful. It also allowed her to get engaged in the game and not focus “other things.” The students said the game was a good support to what they had learned via conventional classroom instruction. They did not feel they learned “anything new” using the game. However, they stressed it was very useful to help with the material “recall” and to gain a better understanding of the “process.” Overall, the students felt it was a good complement to classroom instruction.
One student shared that she had transferred from a school that had relied heavily on game-based learning. She said each student was “matched” to games that were best suited for their “learning issues” and abilities. In her experience, this was a great way to use game-based learning as it provided an individualized learning plan that was best suited for the student. In this case, she was motivated to play the game and she felt it helped in her understanding of the subject.

All of the students supported the use of game-based learning as a regular part of math curriculum. However, they continued to stress their dislike of the game used in this intervention, Algebra Champ. Of particular note was the students’ frustration with the game set-up; particularly the lack of playing level choice at start-up and the continuous timer which they found distracting and anxiety provoking.

The students said game-based learning would make math “more fun” and “interesting.” It also allowed for another way to “focus” on the material. They stressed the importance of game choice noting the game should be “a good fit for where you are in math” and “not boring”.

They also noted their teacher was “cool” for introducing game-based learning into their classroom. They voiced appreciation that he had been willing to try something new to make “learning fun”.

Themes. Two themes emerged from the focus group with the students. The first theme centered on the game design. The second theme showcased the students’ desire to have a complementary teaching tool that is “fun” and beneficial in terms of focus and recollection of material.
Table 5 shows the two themes that emerged after completion of deductive coding of transcripts.

Table 5. Themes of Post-Intervention Student Participant Focus Group

<table>
<thead>
<tr>
<th>Category</th>
<th># of References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Game Design</td>
<td>21</td>
</tr>
<tr>
<td>Teaching tool</td>
<td>35</td>
</tr>
</tbody>
</table>

As noted, the students were disappointed in the game design of Algebra Champ. They found the game “boring” and “not challenging”. Given this situation, the researcher asked the students to think about game-based learning in a broader context. This led to a discussion on the overall use of game-based learning and the benefits it may bring. Students cited examples from their own experience.

The students did note that the game provided benefits in terms of practice of existing course knowledge and recall. Those with experience stressed the importance of game choice.

The second theme that emerged was the benefit of game-based learning in terms of “making learning fun.” The students felt game-based learning is a creative way to join education and fun in a way that is beneficial to students. They also noted the way in which games engage and make them stay “more in tune” with the subject matter.

**Teacher Journal**

The teacher kept a journal throughout the duration of the study. He provided descriptions of students’ reactions, frustrations and a description of the operations of the classroom. The journal provides insight into the students’ feelings pre- post and during the intervention. The teacher also shared his feelings throughout the intervention. Upon completion of the intervention, he sent it to the researcher. The journal was color coded by theme.
The themes that emerged from the teacher’s journal reflected those that arose in the student post-intervention focus group. The teacher reported student feelings of being “nervous” due to the timer component of the game. The teacher reported that he assured the students the timer did not affect their game score and it was not an indicator of their math skills.

One of the major themes found in the teacher’s journal was the students’ negative feelings about Algebra Champ. He reported that within three days of the intervention the students “grumbled” that they had to continue to play the game. However, they did ask for a different game. He noted, “A couple of them expressed an interest in finding another game.” He stated that at the end of the intervention (day 8), the students “seemed bored” with the game.

Of particular note is the teacher’s note that “most everyone seemed to have put forth earnest effort in playing Algebra Champ …”. The game choice will be discussed as a study limitation in Chapter 5.

Teacher Post-Intervention Interview

A post-intervention interview was conducted with the teacher. It occurred one week after the classroom intervention had finished. The student post-intervention focus group had been conducted.

The interview questions can be found in Appendix D. Following is a discussion of the teacher’s answers. The themes are discussed at the end.

The teacher was questioned on his future plans for game-based learning after the completion of the intervention. The teacher noted his plan for the inclusion of game-based learning into his curriculum. He noted the benefits of using a game to create a “more relaxed
and receptive” environment for learning. He added that the addition of a game made it “easier for them to learn.”

The teacher also emphasized the game choice was a challenge in terms of keeping the students engaged due to its “simplicity.” Several students referred to the game as “corny.” However, he noted that they still “couldn’t help themselves by to get involved and became competitive.”

He suggested a game without a timer feature would be more beneficial as students became hyper-focused on the timer vs. playing the game and using math skills. He noted this was especially concerning for those students with math anxiety.

The teacher noted it was hard to comment specifically on student engagement due to the students’ unhappiness with the game format. He said “it will depend greatly on the game format and how individual reacts to that in determining if it’s going to increase engagement or discourage engagement”. However, he noted that the use of a game was helpful for study participants as they “couldn’t help but get sucked into” the game play and didn’t focus on the game goal of learning. They looked at it as a way to have fun. Game choice is discussed in Chapter 5 as a study limitation.

The teacher noted the ongoing challenge of keeping students with ADHD engaged and on-task during a lesson plan. He observed the study participants remained on-task and “involved” in the game compared to other methods he’s used in class.

The teacher summarized that providing students with ADHD an opportunity to focus on something that is “constructive and applicable to the curriculum” is a benefit. It provides a conduit to have students focus on the “right material and actually progress in the curriculum.”
The teacher was asked to comment on game-based learning in terms of academic achievement and learning. There was an improvement between the pre- and post-test quizzes. The teacher noted his relief to see these results. He suggested the improvement came from a combination of classroom teaching and the activity of playing the game.

The teacher was asked to comment on how this study will help educators and students with ADHD. He noted the boundaries that may be in place in schools in terms of funding for game apps, computers devices and classroom time. However, he noted, “I believe that incorporating game-play into a Math curriculum, whether it be a computer game or a physical game, any kind of game, I think it is beneficial to help learning.”

He stressed the benefit for students with ADHD as it’s an important way to engage them in the learning process. He shared his plan for his class next year where he will add a game-based app to the supply list for each of his classes. He noted that the related cost can be afforded by all of his students due to the one-to-one computer and the family demographics.

**Themes.** Four themes emerged from the post-intervention teacher interview. The most prevalent theme was student engagement. The second theme was math anxiety. The third theme was fun in a learning environment. The fourth theme was game design.

Table 6 shows the themes and number of times mentioned in the interview.

*Table 6. Themes of Post-Intervention Teacher Interview*

<table>
<thead>
<tr>
<th>Theme</th>
<th># of References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student engagement</td>
<td>14</td>
</tr>
<tr>
<td>Math anxiety</td>
<td>4</td>
</tr>
<tr>
<td>Fun in a learning environment</td>
<td>4</td>
</tr>
<tr>
<td>Game design</td>
<td>3</td>
</tr>
</tbody>
</table>
The theme of student engagement carried throughout the interview. The teacher continuously cited the connection with student learning and engagement with the use of game-based learning in his classroom. He provided specific examples of his students and their increased attention during the study intervention. He stressed the potential benefits of using a game that could advance learning in a fun and interactive way.

The theme of math anxiety was woven into the teacher’s commentary on the way the study intervention was seen by students. Due to the game design incorporating a timer into play, some students experienced increased anxiety. Once they understood the timer did not affect score outcomes, the anxiety decreased, but was still exhibited. However, the teacher observed a more relaxed approach to math with some students as they viewed the game as a fun way to learn math.

As noted above, fun in a learning environment was a theme that emerged from the post-intervention teacher interview. The teacher stressed the benefit of introducing game-play to his curriculum as it created a fun and healthy competitive environment.

The fourth theme that emerged was the design of the game. As noted in the student focus group, the students did not care for the game design. It became a strong factor in student gameplay. The teacher felt this could have hindered their game engagement and would look to another game if he permanently introduced game-play into his curriculum.

**Axial Coding**

Once the open coding was analyzed, an axial coding process occurred. Bloomberg and Volpe (2008) describe axial coding as a means “to generate theory from the data or modify or extend existing theory” (p. 33). They state,
“Study participants would have experienced the process, and the development of theory might explain practice, or provide a framework for further research. A core component is that theory development is generated by or “grounded” in data from the field – especially in actions, interactions, and social processes.” (Bloomberg and Volpe, 2008, p. 33).

Further, Kendall (1999) describes axial coding as a means to formulate a theory from the categories identified. Kendall states:

“Whereas open coding fractures the data into categories, axial coding puts the data back together by making connections between the categories and subcategories. Axial coding focuses on the conditions that give rise to a category (phenomenon), the context (specific set of properties) in which it is embedded, the action/interactional strategies by which the processes are carried out, and the consequences of the strategies” (p. 793).

This process allowed for a systematic organization of the themes presented from the student focus group; and teacher’s journal and interviews. Four identified open coding themes were axial coded to further understand the phenomena found. The themes include: student engagement, game design, teaching tool and learning fun. The themes were further grouped into related categories to “further refine the category theme” (Merriam, 2009, p. 200).

One category, Game Design, stood alone as it brought forth negative connotations for study participants. Their comments are noted in the earlier discussion of this study. Figure 5 shows the axial coding for this category.
Figure 5. Axial Coding of Game Design Category

Figure 5 shows the causal conditions created by the game company that designed Algebra Champ. The game designers chose to add the timer element and did not allow for the “gamer” to choose the appropriate level of challenge at the beginning of the game. At game introduction, these game elements created stress and boredom in study participants. This is labeled as the context in the figure.

Continuing along the stream of the causal condition created by the timer element of the game, it becomes clear that it invoked math anxiety for some study participants. Study participants with self-described “math anxiety” found the condition exacerbated by these game
elements. The teacher employed strategies to lessen these conditions through reminders and prompting during game play. Despite the teacher’s attempt to reduce anxiety, the consequence is the students’ request for a different game.

A similar stream is found in the context of study participants’ labeling of the game as “boring.” The teacher tried to encourage them to re-engage in game play, but the final consequence also led to the students’ request for a different game.

This analysis provides evidence that game choice is an important element in game-based learning as students may have limited engagement if the game is not considered entertaining or has design elements that have negative consequences. The choice of Algebra Champ for this study is discussed in chapter five as a study limitation. The importance of game choice is also discussed in Chapter 5.

Figure 6 shows the interconnectivity of the remaining categories found through the open coding exercise.

*Figure 6. Axial Coding for Related Study Categories*
Figure 6 shows the connection between the remaining three categories found in the open coding. Using game-based learning as a teaching tool influences student engagement and learning fun. Students reported an increase in focus on math when game-based learning was used. The teacher commented on the benefit of “making math fun” when adding game-based learning to his classroom.

The students also commented on the effect of game-based learning and “fun” in math and in the classroom. They also commented on their increased focus using game-based learning. This is of particular note with students with ADHD as focus and attention span are particularly challenging and can effect academic outcomes (Zentall et. al, 2009).

The axial coding lends itself to a grounded theory approach as supported by Charmaz (2006). The formation of the categories emerges from that actions observed, data collected and analysis of codes. Whereas, the theory is the outcome of the analysis of the aforementioned combined data.

**Quantitative Data**

This section discusses the quantitative portion of the study.

The study participants were given a pre- and post-intervention quizzes to assess their knowledge of specific algebra equations. Each quiz consisted of ten questions worth one point each. The quiz questions were 10 single variable equations which paralleled those introduced as practice problems in the Algebra Champ game. The questions were not the same, but assessed the students’ understanding of the same concepts.
The relationship between game-based learning and academic outcomes for students with ADHD is examined in this study of N=3 students. Pre- and post-intervention quiz scores, as well as the difference, were recorded for the three students and are shown in Table 7.

**Table 7. Pre- and Post-Quiz Scores for Student Participants**

<table>
<thead>
<tr>
<th></th>
<th>Pre-Intervention Quiz</th>
<th>Post-Intervention Quiz</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student #1</td>
<td>8</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>Student #2</td>
<td>8</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>Student #3</td>
<td>5</td>
<td>10</td>
<td>5</td>
</tr>
</tbody>
</table>

Students scored higher on the post quiz than the pre quiz.

**Themes Related to Research Questions**

This section organizes the emergent themes in relation to the research questions.

**Question 1.** What is the relationship between game-based learning and academic outcomes in Algebra One for students with ADHD?

The first question is best answered with quantitative data, but as noted earlier, the N for this study did not allow for sufficient analysis to provide statistical analysis of collected data. This study does not provide any qualitative data to support this question. Therefore, there are not any themes that emerged to answer this question.

**Question 2.** How do teachers and students perceive the influence of game-based instruction on the academic performance of Algebra One students with ADHD?
Themes that emerged in relation to this question include the use of game-based learning as a teaching tool to complement traditional classroom learning; game-based learning as a means to make learning fun; and increased student engagement due to game-based learning. These themes were reported by all study participants—the teacher and the three students.

All participants reported positive attitudes of game-based learning in relation to Algebra One teaching and learning. However, these attitudes were overshadowed by the game choice for this study. The students’ answers focused on the benefit of game-based learning in terms of it being something new and interesting compared to regular classroom teaching and assessments. The teacher viewed game-based learning as a modality to support classroom teaching; not as a replacement.

**Summary**

This chapter discussed the information gathered through the qualitative and quantitative methodology outlined in Table 2. The data was gathered from one classroom teacher and three study participants.

There were four methods used to collect data for the qualitative portion of the study. These included pre- and post-intervention teacher interviews, analysis of the teacher’s journal kept during the intervention and the post-intervention student focus group.

The quantitative data was points taken from pre- and post-intervention quizzes taken by the study participants. The quizzes measured the students’ understanding of specific algebraic expressions that were taught using direct instruction and through the Algebra Champ game (study intervention).
The qualitative portion of the study indicates students with ADHD are more engaged and motivated in Algebra when game-based learning is used as a complementary teaching platform. This is supported through the teacher’s post-intervention interview and journal. It is further supported through the post-intervention focus group with the study participants. The axial coding further confirms this theory.

The quantitative portion of the study is statistically inclusive as the N in the data calculation is too small to allow for statistically significant results. However, the raw data indicates there was an increase in academic outcomes after the study intervention.
CHAPTER 5: INTERPRETATION, CONCLUSION, AND RECOMMENDATIONS

Introduction

The purpose of this study was to determine the relationship between game-based learning and academic outcomes in Algebra One for students with ADHD. This case study sought to further the research of Ota and DuPaul which measured the academic engagement of students with ADHD when game-based learning was introduced (Ota & DuPaul, 2002); and of Mautone, DuPaul and Jitendra which used a case study to research the effects of computer-assisted instruction on children with ADHD.

This case study found similar results to those of Ota and DuPaul in terms of an increase in academic outcomes and on-task behavior of study participants. Like the Ota and DuPaul study which also had a small number of participants, the findings are worthy of further research. Although this study used different measures for academic outcomes and focus, results were similar in terms of positive effects on study participants.

This study further corroborated the research of Gardner, Kolb, and Houge Mackenzie, et colleagues which indicates students identified with different learning styles; i.e. multiple intelligence, benefit from a learning environment that matches their learning style (Gardner, 1999; Houge Mackenzie et al., 2014; Kolb, 1984). All of these researchers discuss the importance of carefully aligning selected teaching modalities with a students’ specific intelligence strength to actively engage in the learning process.

The study participants in this study explicitly stressed the importance of teaching modalities that supported their individual learning styles. Although none used the academic
terminology of “multiple intelligence”, they did describe the need for making learning “fun” and “interesting” while considering their individual learning needs.

They also expressed appreciation of their teacher’s willingness to try a new concept to “try a new thing”. One student noted, “I think having different approaches to learning, like trying to find different ways that help students is a good thing, not just pencil, paper, here’s a test”.

The quantitative component of this research sought to measure the academic outcomes of study participants by comparing pre- and post-intervention quiz scores. The raw data shown in Table 7 from the pre- and post-assessment indicated an increase in scores; however, it was statistically insignificant due to the low number of study participants.

Conclusions

The research questions posed for this case study sought to test the researcher’s hypothesis that game-based learning coupled with traditional classroom instruction increases academic outcomes for children with ADHD. The research questions are noted below:

**Question 1.** What is the relationship between game-based learning and academic outcomes in Algebra One for students with ADHD?

The answer to this question was inconclusive due to the low number of study participants. This is discussed in more detail in the Recommendations section in this chapter. This number was lower than expected after study recruitment was finalized.

Overall, as shown in Table 7 students scored higher on the post assessment than the pre assessment. One student increased her results by 5 points and two increased by one point. The
raw data indicates a relationship between game-based learning and academic outcomes for Algebra One students with ADHD. However, this difference was not statistically significant.

**Question 2.** How do teachers and students perceive the influence of game-based instruction on the academic performance of Algebra One students with ADHD?

The study participants and teacher indicated a positive attitude towards game-based learning and math. This was measured through a student focus group, the teacher’s journal, and pre- and post-intervention teacher interviews.

The teacher reported an increased level of engagement with math when the students used game-based learning to practice math concepts taught in class. As a result of this study, the teacher plans to include game-based learning into his curriculum for next year.

Study participants also indicated a positive perception of game-based learning associated with math. They reported a higher level of engagement and interest in math when game-based learning complemented traditional classroom teaching. They projected that their interest in game-based learning would lead to better academic outcomes as they would be more engaged in math “practice”.

**Lessons Learned**

This research process provided several lessons to the researcher. These lessons will shape future research and should be considered in future study designs. These lessons may lead to greater amounts of data and a richer study.

The first lesson involves the recruitment of study participants. This researcher assumed all parents/guardians who were approached would consent to the study. The teacher assumed the
same. As it turned out, only three out of eight student’s parents consented. This small number influenced the findings for question 1 of the research questions; leaving the researcher with little data to consider. Future research will seek to invite a larger number of study participants to allow for greater amounts of data.

The teacher asked to lead the recruitment efforts for this study due to his familiarity with the students’ parents. However, results may have differed had the researcher done follow-up communication to the teacher’s initial email to parents. The teacher had other responsibilities that superseded study recruitment; therefore the process was not consistent with the study design in terms of timing between the initial study introduction and the reminder email.

The second lesson reflects on the qualitative components of the study design. The focus group with students allowed for a greater understanding of their attitudes, experience and opinions on game-based learning. However, a deeper understanding may have been gained through individual interviews with each student.

Individual interviews may have allowed students to expand on their initial thoughts and allowed the interviewer to ask questions focusing on the student’s unique experience. The interviews would have also allowed the quieter students to have an equal amount of time to express their opinions; whereas they may have felt overshadowed by more outgoing students in a group focus group setting.

The third lesson involves game choice. As noted, the game choice was limited to a single player game due to the school’s firewall system. The choice of Algebra Champ was made after an informal poll to colleagues and online research. However, additional research to other school districts may have identified another game that may have provided a better experience for the
study participants. Time limitations of the study and researcher prevented this step from taking place.

**Recommendations**

This study informs future research on the connection between game-based learning and academic outcomes in children with ADHD. In doing so, researchers need to consider the limitations of this research along with the key findings.

The following recommendations should be considered during the design phase of future research. In doing so, future studies may lead to findings that are more informative to educators and the research community.

**Sample size:** In a methodological review of on the comparison of research on training simulators in Emergency Medicine, Lineberry and associates discuss the issue of duplicative studies using small sample sizes in quantitative research. The authors suggest, “…rather than having many underpowered and uncoordinated studies, it would be preferable for researchers to collaborate and conduct coordinated experiments across multiple sites” (Lineberry et al., 2013).

Given the small sample size (N=3), it is recommended that future studies involve greater sample sizes (N>30) in order to increase statistical power. However, a larger sample size may be difficult to obtain due to the specificity of the population and the necessity to keep other variables consistent.

Other studies have overcome this obstacle through recruitment of study participants at a number of schools within a district, state or geography. Evans et al., had 107 participants from 3 schools in Virginia (2015). The study measured game-based learning in math and student
engagement. The researchers were able to achieve the larger number of participants through recruitment at more than one school.

Houge Mackenzie and associates discuss the issue of small sample sizes in studies on experiential education by noting:

“…Gillis, Gass, and Russell (2008) highlight the dearth of quantitative, longitudinal, and randomized controlled studies in EE (experiential education). Ewert and Sibthorp (2009) argue that self-selection (rather than randomly assigned treatment and control groups), small sample sizes, and a range of confounding variables hinder the development of evidence-based practice, empirically validated models of experience, and the holistic understanding of underlying psychological processes” (2014, pp. 77-8).

The issue of statistical significance has long been discussed in relation to psychological and education research (Harrison, Thompson, & Vannest, 2009; Kehle et al., 2007; Thompson, 2004). Harrison, Thompson and Vannest’s continued use of null hypothesis statistical significance testing (NHSST) can lead researchers to easily reject a null hypothesis as the results are not reported objectively.

In addition, in educational research interventions cannot be easily replicated under the same conditions; i.e., teaching styles, student relations. Therefore the rejection of a null hypothesis may not be consequential for educators.

In juxtaposition, Borg and Gall note the benefit of a small sample size in qualitative research:

“In many educational research projects, small samples are more appropriate than large samples. This is often true of studies in which role-playing, in-depth interviews, projective measures, and other such time consuming techniques are employed.... A study that probes deeply into the characteristics of a small sample often provides more knowledge than a study that attacks the same problem by collecting only shallow information on a large sample.” (1989, 236-237).
Borg and Gall’s discussion supports the qualitative work done in this study. The data gathered through the student focus group, teacher interviews and journal, is informative towards the conclusions. The accompanying data coding and analysis is time consuming and impractical for a large scale study, but was informative in this study.

**Game Choice**: The choice of the game-based intervention is an important component in this study design. As noted earlier, the researcher was limited to single-player games as the school’s firewall did not provide access for web-based multi-player games.

Ribeiro et al. outline the issue of multi-player game integration in school settings due to firewalls (Ribeiro et al., 2013). They note, “Don’t underestimate the technical challenges…” (p. 432) associated with specific game designs.

The study intervention game, Algebra Champ, did not receive positive reviews from the study participants due to the game design. The students found some design elements including the timer to be a distraction. Despite their negativity towards the game design, the students did report a positive experience using game-based learning in their Algebra One class.

Bourgonjon and colleagues stress the importance of “ease of use” for games to be successful in the classroom. They state:

“Students like games better when the level of sophistication is high (Vivou, Katsionis & Matsos, 2008). Games that are too easy or too hard will put students off. This stresses the need to consider ease of use as a critical variable when studying video game acceptance in a learning context” (2010, p. 1147).

The choice of game is the foundation for success with game-based learning and children with ADHD. Bavelier and associates note the game must be engaging, challenging and full of
action to increase focus and filter out irrelevant information for children with ADHD (Bavelier et al., 2011). The game must be appealing to the users to meet the intended objectives of the educational process.

Ribeiro and associates discuss the use of game-based learning with students with different learning styles (students with ADHD falling into this category). They note:

“Some of the main reasons outlined to explain this increase applied to learning contexts are the actions rather than explanations, the creation of personal motivation and satisfaction, the accommodation of multiple learning styles and abilities, the fostering of decision-making and problem-solving activities in a virtual setting.” (Ribeiro, et al., 2013, p. 427).

The game must be carefully reviewed to assess effectiveness for learning in a meaningful context. There needs to be a relation between the computer game and the classroom curriculum. The teacher must also assess the game for its age appropriateness and game design. Bourgonjon, et al. note this is “an important predictor of student success” (Bourjongon et al., 2010).

**Teacher Acceptance.** Teacher acceptance is of paramount importance when game-based learning is introduced to a classroom. The teacher must be accepting of the concept of game-based learning and knowledgeable about the game design. Ketelhut and Schifter note the importance of teachers’ efficacy prior to classroom introduction:

“From our research, care needs to be given to supporting teachers as they develop efficacy in using the innovation. Suggestions include giving teachers time to develop personal comfort with and ownership over the technological intervention, and provide teachers with models of successful implementation, as well as just-in-time support. Further, researchers and designers need to take care to understand and engage the school community” (2011, p. 545).

In this research, the classroom teacher was accepting and had familiarity with game-based learning in association with Math. However, he had not used Algebra Champ prior to this
study. His pre-acceptance was an important component that assisted in the positive introduction to the study participants.

Ritzhaupt, Higgins and Allred (2010) stress the importance of a disciplined and careful introduction of game-based learning in a classroom. Teachers must have professional development support prior to the integration of game-based learning into a classroom for it to provide intended benefits to students. Teachers must be trained on the proper “curriculum integration strategies” (2010, p. 198) to ensure success in the classroom.

The teacher in this study confirmed this during the post-intervention interview when he discussed his plan to integrate game-based learning into his curriculum design for next year. He noted the need to “further explore” game options that would properly align to his lesson plans and learning goals.

School Information Technology Infrastructure. The study site’s information technology infrastructure should be considered during a study design. As in this study, if a school has a firewall that does not allow for a multi-player game; choice is limited. If the study site does not have these restrictions, additional games are available for use in the study (Ahmad et al., 2010). This may provide a different experience other than reported in this study.

Limitations and Future Research

There are a number of limitations to this study. Firstly, the number of study participants did not provide enough information for a statistically analysis to provide useful data. This has created a limitation of data for Question 1. Secondly, the game choice was limited due to the school’s firewall system. Thirdly, the study results may not be applicable to all schools due the
study setting of an independent school. Fourthly, the study results may not be applicable to students in all age ranges.

One of the most influential study limitations is the low number of study participants. As discussed, this led to insufficient data for a strong statistical analysis to be performed. Future research studies on this topic should include a recruitment mechanism with a higher number of study participants (<30).

The game choice is a variable that is highly influential in this study. The students’ negativity associated with the game design affected the qualitative portion of this study as they dedicated a large portion of the focus group to their game design complaints. Future research should include a game that has been pilot tested in terms of game design. This is of particular importance in a study with students with ADHD as negative feelings related to game design can become distracting and influence the study outcomes.

As noted in Chapter 3, Ke (2008) stresses the importance of appropriate game choice in study design. The game must be engaging and aligned with students’ abilities to be a good fit. A game choice that is not aligned can create a distraction and de-motivate students from playing.

The third study limitation is the applicability of this study’s findings to a broader population of schools. This study was performed at an independent school with resources that allow for a one-to-one computer device initiative. This is not the situation in every other United States high school. Therefore, this limits the broader application of game-based learning in all school settings.
The fourth study limitation is the age range of study participants. The setting is a high school, thus the study participants are high school aged. The findings from this study may not be applicable to school aged students in lower grades.

Summary

This study shows game-based learning has a positive effect on students with ADHDs’ engagement and interest in Math. This further supports the work of Ota and DuPaul (2002) and Mautone, DuPaul and Jitendra (2005). The analysis of the data from the qualitative portion of this study lends itself to a grounded theory approach indicating game-based learning is an important consideration in curriculum development for students with ADHD.

Further research must be done to further explore the connection between game-based learning and children with ADHD and academic outcomes. This preliminary research indicates promise, but must be implemented on a larger scale to further test the hypothesis presented. Although small in scale, this study will contribute to the literature on students with ADHD and game-based learning.
REFERENCES


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N. Cronin. (personal communication to author, July 23, 2014)


APPENDIX A: SUMMARY OF ALGEBRA CHAMP VIDEO GAME

APPS FOR ALGEBRA

Home
HMH Fuse Algebra I
HUP Exponents
IXL.com
Algebra Champ

Algebra Champ provides practice in solving equations in an entertaining, game-like format. Students may reinforce and extend their algebraic thinking skills by solving one, two and multi-step equations and becoming "Champ".

Benefits
Algebra Champ is a free, one-player game that allows students to practice solving one-step, two-step and multi-step one-variable equations. Students may self-select their level of difficulty and personalize the learning experience by choosing from a variety of avatars and creating their own fighter name. This would appeal to reluctant learners who otherwise might be disengaged in textbook-based learning environments. In addition, as this is a timed game, it would allow students to improve their speed in solving equations.

Constraints
Algebra Champ has several limitations that prevent it from being an effective tool in the regular classroom setting. First, it has no instructional context to guide students towards solving equations—it is only a game. As a result, this will frustrate learners who are struggling with the concepts associated with this app. Second, the game provides no feedback when students answer incorrectly. The wrong answer flashes on the screen and students are left to figure out why they were mistaken. Third, this is a multiple-choice process of elimination game, which will lead to random guessing by disengaged students.
APPENDIX B: PRE- AND POST-ASSESSMENTS

PRE-ASSESSMENT

Student: ___________________________  Instructor: Will Bailey  Assignment: Pre-Quiz
Date: ___________________________  Course: Algebra 1 A-block
Time: ___________________________  Books: *Algebra 1 Common Core (2013)

1. Use mental math to find the solution of the equation.
   
   \[ x - 5 = 8 \]
   
   \[ x = \square \]

2. Tell whether the equation is true, false, or open.
   
   \[ 10x + 7 = 13 \]
   Choose the correct answer below.
   
   ○ False
   ○ Open
   ○ True

3. Determine if the given value is a solution to the equation.
   
   \[ 6x - 1 = 5; x = 1 \]
   
   Is \( x = 1 \) a solution of the equation \( 6x - 1 = 5 \)?
   
   ○ No
   ○ Yes

4. Determine if the given value is a solution to the equation.
   
   \[ 3x - 9 = 6; x = 5 \]
   
   Is \( x = 5 \) a solution of the equation \( 3x - 9 = 6 \)?
   
   ○ No
   ○ Yes

5. Use mental math to find the solution of the equation.
   
   \[ x - 2 = 10 \]
   
   \[ x = \square \]
6. Use mental math to find the solution of the equation.

\[ 18 + d = 23 \]

\[ d = \square \]

7. Use a table to find the solution of the equation.

\[ 8a - 14 = 34 \]

\[ a = \square \]

8. Use a table to find the solution of the equation.

\[ 9x + 10 = 55 \]

\[ x = \square \]

9. Use a table to find the solution of the equation.

\[ 7a - 15 = 13 \]

\[ a = \square \]

10. The equation \[ 19 + 0.15p = c \] gives the cost \( c \) in dollars that a store charges to deliver an appliance that weighs \( p \) pounds. Use the equation and a table to find the weight of an appliance that costs $43 to deliver.

The appliance weighs \( \square \) pounds.
1. Use mental math to find the solution of the equation.

\[ x - 5 = 14 \]

\[ x = \square \]

2. Tell whether the equation is true, false, or open.

\[ 6 + 7 = 13 \]

Choose the correct answer below.

- True
- False
- Open

3. Determine if the given value is a solution to the equation.

\[ 5x - 9 = 1; \ x = 2 \]

Is \( x = 2 \) a solution of the equation \( 5x - 9 = 1 \)?

- No
- Yes

4. Determine if the given value is a solution to the equation.

\[ 8x - 2 = 17; \ x = 2 \]

Is \( x = 2 \) a solution of the equation \( 8x - 2 = 17 \)?

- Yes
- No

5. Use mental math to find the solution of the equation.

\[ x - 4 = 9 \]

\[ x = \square \]
6. Use mental math to find the solution of the equation.

\[18 + d = 24\]

\[d = \square\]

7. Use a table to find the solution of the equation.

\[5a - 10 = 15\]

\[a = \square\]

8. Use a table to find the solution of the equation.

\[6x + 7 = 49\]

\[x = \square\]

9. Use a table to find the solution of the equation.

\[6a - 7 = 11\]

\[a = \square\]

10. The equation \[24 + 0.35p = c\] gives the cost \(c\) in dollars that a store charges to deliver an appliance that weighs \(p\) pounds. Use the equation and a table to find the weight of an appliance that costs $73 to deliver.

The appliance weighs \(\square\) pounds.
APPENDIX C: FOCUS GROUP QUESTIONS FOR STUDENTS

1. What are your thoughts on using game-based learning as a complement to your teacher’s instruction?
2. Do you think game-based learning helped you focus more on the math curriculum?
   a. If so, how?
   b. Did you feel you were actively involved in decision-making during this game?
      Can you give an example?
3. Do you think game-based learning helped you to better understand the material?
   a. If so, how?
   b. Were you more or less motivated by the game-based learning? Why do you think that was?
4. Should game-based learning be a regular part of your math learning? Why or why not?
APPENDIX D: RESEARCH QUESTIONS FOR TEACHER

Pre-Intervention

1. Research has shown students with ADHD fall behind acceptable levels in subject areas; most notably math and reading. Supportive interventions can assist students with struggles with executive function. What types of measures have you seen work? What hasn’t worked?

2. What are the greatest difficulties in dealing with academic motivation for students with ADHD?

3. Describe your feelings about the inclusion of game-based learning into your math curriculum?
   a. Are you hesitant to introduce it? Why or why not?
   b. Are you excited to introduce it? Why or why not?

4. Do you think game-based learning will be helpful for your students with ADHD in terms of academic achievement and learning?

Post Intervention

1. Now that the intervention has taken place, describe your feelings about the inclusion of game-based learning into your math curriculum?
   a. Did you find it a good tool? Why or why not?
   b. Were you excited to introduce it? Why?

2. Did you find it helpful for your students with ADHD in terms of engagement?

3. Did you find it helpful for your students with ADHD in terms of on-task behavior?

4. Did you find it helpful for your students with ADHD in terms of academic achievement and learning?

5. Did you find this particular game, Algebra Champ, a good tool? Why or why not?

6. How will this research help the ADHD population and educators?