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EFFECT OF DIGITAL GAME BASED LEARNING
ON NINTH GRADE STUDENTS' MATHEMATICS ACHIEVEMENT

A DISSERTATION APPROVED FOR THE
DEPARTMENT OF EDUCATIONAL LEADERSHIP AND POLICY STUDIES

BY

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ABSTRACT

This experimental study examined the effect of an educational massive multiplayer online game (MMOG) on achievement on a standards-based mathematics exam. It also examined the interaction of student characteristics (gender and socioeconomic status) with digital game play on mathematics achievement. Two hundred eighty ninth grade students from a large rural high school located in the United States Midwest participated in the study. They were randomly assigned to “treatment” or “control” group, whoever played or did not play the interdisciplinary MMOG. A standards-based pretest was administered followed by digital game play on the MMOG A posttest was given after playing the MMOG for 14 class periods over a seven week period. A sequential regression analysis was conducted on the data. No statistically significant results were found in the mean posttest results between the control and treatment. Nor were statistically significant results found by gender. However, statistically significant main results were found between socioeconomic groups, and the interaction of group (control or treatment) with low socioeconomic students scoring much lower than non-low socioeconomic students. A sequential regression analysis was also conducted only on the treatment group to determine if statistically significant relationships may be contributed to the amount of time immersed in digital game play and the interaction of digital game play with student characteristics (gender and socioeconomic status). Statistically significant results were indicated on time (minutes of play) and the interaction of time and socioeconomic status. Results implied for every minute a student is engaged in playing an interdisciplinary MMOG, posttest scores may increase .11 points. However, if a student is low socioeconomically, posttest scores may decrease by 11.24 points if engaged in digital game play. These results will enable educators to draw upon the implications for including an interdisciplinary MMOG as an instructional tool and integrating it within the curriculum.

CHAPTER 1: INTRODUCTION

Advances in technology have occurred exponentially during the lifetime of current students (Scheidlinger, 1999; Stewart, 2010), who have always had access to computers, the internet, cell phones, portable music devices, and digital games. Digital games are played on computers, gaming consoles, hand held devices, and cell phones (Rideout, Goehr, & Roberts, 2010). Cell phones have become *smart* allowing instant access to information via the internet on students' smart phone. Music, books, and games may also be downloaded on smart phones. However, entering the classroom many students are asked to turn off and put away their *smart* tool and begin a learning process that was created for the late nineteenth century (Jacobs, 2010b; November, 2010; Prensky, 2007).

Background of the Study

Twenty-first century skills

Global citizens currently live in a *flat world* in which opportunities that once were considered to be available only to industrialized nations such as the United States are available to anyone with internet access, education, and an innovative mindset (Friedmen, 2005; Stewart, 2010). Information and skills need not be located in the same part of the globe to be utilized and accessed efficiently. Employers today are looking for employees with *21st century skills*. According to the Partnership for 21st Century Skills (2009), "Employers across the United States cited professionalism/work ethic, oral and written communications, teamwork and collaboration, and critical thinking and problem solving as the most important skills" (p. 12) for high school graduates and college graduates to possess in order to be productive members of a company and successful in their careers. Public education has been challenged to prepare the work force of tomorrow not only to utilize the technology of today, but to develop critical thinking and problem-solving skills to enable them to adapt to the technology of the future (Casner-Lotto & Barrington, 2006; Cuban, 2001; Hopper, 1999; Lezotte & McKee, 2006; Rotherham & Willingham, 2009; Stewart, 2010).

Background of education

The purpose of public schools in the United States (U.S.) since their inception was to produce an "educated citizenry capable of participating in discussions, debates, and decisions to further the wellness of the larger community and protect the individual right to 'life, liberty, and the pursuit of happiness' (Jefferson as cited in Glickman, 1998). An educated citizenry and a democracy were one and the same, the lack of one would imperil the other" (Glickman, p. 8-9). When educational entities abroad were educating a selected populace, the U.S. decided early in its history that a free education should be provided to all its citizens. Goldin (1999) reported that U.S. enrollment in primary school per capita had surpassed Germany by the 1840s. The U.S. was considered the "best-educated people" of the world's richest nations (Goldin, 1999). Many of Europe's educational concepts were utilized by the U.S. and modified to fit the needs of its people. U.S. schools were "more practical and applied than those of Europe" (Goldin, p. 1). Goldin

(1999) wrote that *three transformations* occurred in American education that brought the majority of youth to higher levels of education. The first transformation occurred during the nineteenth century when common or elementary school (through eighth grade) became available to the masses. The second transformation occurred during the first half of the twentieth century when most youth were able to attend secondary or high school. Goldin (1999) recognized the third transformation is still on-going, that of four-year higher education. Just as education has gone through transformative periods, technology has been through times of transformation.

Technology

Global Foresight (2004) identified information and communications technology as the most transformed technology between 1950 and 2000 (as cited in O'Hara-Devereaux, 2004). It was predicted that the years between 2000-2025 would see rapid transformations in "biotechnology and other likely technology combinations across disciplines" (Ibid, p. 20). Advances in technology over the last 75 years are greater than the advances of the previous two thousand years (O'Hara-Devereaux, 2004; Scheidlinger, 1999). The world has been introduced to the theory of relativity, quantum theory, and the genetic code. Scientists explored our solar system by use of telescopes and interplanetary probes. They split the atom and nuclear power became available. The United States has landed a man on the moon and cooperatively manned a space station. Microscope accuracy and telescope accuracy have increased by several orders in magnitude, in some instances from 1 part per 10^4 to 1 part per 10^{13} (Scheidlinger, 1999). Music was enjoyed on phonographs, record players, 8-track tape players, cassette tape players, portable cassette players (e.g. Walkmans), compact disk players, MP3 (MPEG-1 Audio Layer 3) players, and cell phones. The first analog computer, "differential analyser" (Ciolek, 2010), was invented and weighed 100 tons. Computers, of much smaller scale, are available to the masses, and take on many forms: desktop, laptop, netbook, and cellular phone. Connectivity has evolved from telegraphs to telephones then to the Internet. Communication via the information highway has global access through satellites, fiber optics, and cellular phones (Friedmen, 2005, Rideout, Goehr, & Roberts, 2010; Scheidlinger, 1999). Communities are no longer restricted by geographic location or the physical world, but also exist in a virtual world where friendships, organizations, education, and business occur as in the physical world (Zhao, 2009). Games have evolved from holes and scratches on the ground where the players must be in the same location to sophisticated virtual games where players either challenge or collaborate with each other in a virtual society.

Digital games

Currently students spend an average of approximately 7 ½ hours (7:38) a day consuming media not including texting. With the addition of multitasking, the number of hours of media actually being consumed rises to over 10 ½ (10:45) hours. The proportion of multitasking with media is 29 percent (Rideout, Goehr, & Roberts, 2010). Among the media consumed are video games.

Video games have become more sophisticated and may be played on computers, games consoles, handheld video players, cell phones, and virtually via computers. With the variety of platforms, many being mobile, there is a rise in time playing video games each day. The average time spent playing video games in 1999 was 26 minutes with an increase in 2004 to 49 minutes and increasing yet again in 2009 to an hour 13 minutes (Rideout, Goehr, & Roberts, 2010).

Problem Statement

Digital game-based learning has been receiving increased attention from educational researchers due to its potential to provide the type of authentic learning environments suggested by the theories of situated cognition (Brown, Collins, & Duguid, 1989) and learning theories inspired by constructivism (Duffy & Jonassen, 1992). Despite the many premises about the benefits of digital game-based learning (e.g., Barab et al., 2005; Gee, 2003; Prensky, 2006; 2007; Schaffer, 2006; Steinkuehler, 2008), little empirical evidence exists as to the suggested impact on K12 education. There are very few empirical studies on digital game-based learning (e.g., Squire, 2004; Tuzun, 2004; Warren & Dondlinger, 2009) and existing studies do not adequately address the relationships between effective dimensions of integrating digital game-based learning in a high school curriculum and students' mathematics achievement.

Purpose and Research Questions

The purpose of this study was two-fold. First, the study aimed at investigating the effects of an interdisciplinary massive multi-player online game (MMOG) on high school students' mathematics achievement. Secondly, the study examined the interactions of student characteristics and digital game based learning in an effort to identify which student characteristics may impact student achievement with digital game based learning. The questions that guided this study were:

1. What effect does digital-game play have on student mathematics achievement as measured by a district created standards-based exam?
2. Are there statistically significant differences in mathematics achievement between students who play an interdisciplinary MMOG and students who do not play an interdisciplinary MMOG?
3. To what extent do students' gender, SES, and the relationship of playing or not playing an interdisciplinary game have on ninth grade students' mathematics achievement?
4. Is there a statistically significant relationship between the amount of time playing the MMOG and mathematics scores among ninth grade students who played the interdisciplinary MMOG?

Significance

The study explored the effects of an interdisciplinary educational MMOG on students' mathematics achievement. Additionally, the study explored the effects of gender and socio-economic status, along with game play in a digital game-based environment on students' mathematics achievement. Claims have been made that digital game-based learning is an effective learning tool (e.g. Gee, 2003; Squire, 2004; Warren & Dondlinger, 2009), yet little empirical evidence exists to support this claim (Hays, 2005). The study will provide empirical evidence to the effectiveness an interdisciplinary MMOG on students' mathematics achievement in a rural high school environment. This study may indicate which students, based on gender and/or socio-economic status (SES), may learn better in a situated virtual environment through MMOG play.

Context

A rural high school in the United States Midwest was selected for this study. Participants were from a ninth grade transition class entitled Leadership. Leadership's purpose was to teach learning strategies, promote a cooperative/team spirit, and promote school/community involvement. Different tools are used in Leadership to engage students as they are taught learning strategies including; summarizing and note taking, use of graphic organizers, questioning techniques, and academic vocabulary strategies (Marzano, Pickering, & Pollock, 2001) along with team building activities. Leadership was selected because every first-time ninth grade student was enrolled, it promoted collaboration, it taught study skills and learning strategies, and each Leadership class was in the same time block. Within the context of the MMOG, collaboration was encouraged and the scheduling of this class provided that every student would have peers to collaborate with in the virtual world. Conducting this study during this required transition course allowed regular math classes to continue. The mathematics within the context of the game either reviewed content previously taught, supported content currently being taught, or introduced content that would be taught later in the school year. This study may indicate whether the use of an interdisciplinary MMOG is an effective learning tool to support mathematics achievement.

Overview of Method

This experimental study was designed to utilize quantitative methods to obtain data to evaluate the effectiveness of an interdisciplinary MMOG on students' mathematics achievement as measured by a standardized mathematics test. Participants in the study were first year ninth grade students from a transition class in a large rural high school in a U.S. Midwestern state. Students were randomly selected to participate in a control group (no game play) and treatment group (play MMOG).

Standardized pretest and posttest were developed to determine whether playing an interdisciplinary MMOG supported mathematics achievement. Questions on the tests were released test items and sample test items from eighth grade mathematics and Algebra 1 end-of-course tests and considered valid by the state department of education. A pilot study was conducted to determine the validity of the instrument. Cronbach's Coefficient Alpha was used to assess internal consistency and reliability.

Data were collected from student demographics provided by the high school and from pretests and posttests. A sequential regression analysis was used to determine the relationship of digital game play on a MMOG, gender, and socio-economic status on 9th grade students' mathematics achievement. The purpose of a regression analysis may be to make a prediction or to identify characteristics that impact an outcome (Shavelson, 1988).

Limitations of the Study

This study is limited to a rural high school with a moderate student population of approximately 1,250 located in the United States Midwest. Therefore, the use of this population may limit the generalizability of this study to small rural high school, suburban or urban high schools. The location may also limit its effectiveness to other regions of the U.S. The study examined the impact of one interdisciplinary MMOG targeting mathematics, language arts, science, and social studies. Because ninth grade students are at different mathematics skill levels upon entering high school, students were enrolled in Algebra I, Algebra I with a support class, Algebra II, or Geometry. The study did not take place within the math classes and was conducted in a ninth grade transition class which may have impacted the outcome of test results. In addition, the researcher was an assistant principal at the school in which the study was conducted. It was imperative that the researcher bracket herself when conducting the study and the analysis of the data.

Summary

Chapter 1 presented an overview of the 21st century skills needed in the global community, a brief background of education in the United States, and a brief background of technology. Student daily use of digital games was also briefly discussed. One purpose of this study was to provide empirical data regarding the use of an interdisciplinary MMOG on student mathematics achievement. The second purpose of this study was to examine the interaction of student characteristics with MMOG-play on students' mathematics achievement. The significance of the study, context, and methodology were briefly discussed.

CHAPTER 2: REVIEW OF THE LITERATURE

Introduction

The end of the 20^{th} century and the beginning of the 21^{st} century experienced an explosion of technological advances that led to changes in the way nations conduct business. These formative years of a globalized workforce and marketplace are unlike any other time in human history. When technological advances allowed businesses to collaborate using resources such as business conference calls, instant messaging, and email many corporations saw positive financial implications. Add to those resources video teleconferencing tools which bring groups together both aurally and visually. It is no longer necessary to confine a business workforce in the same locality, region, or country. Corporations have gone global and conduct business utilizing technological advances that continue to be perfected and continue to rapidly change. Students of the 21^{st} century are global citizens therefore, must be prepared to interact and collaborate with individuals of other cultures. They must also adapt to and use technology that continues to change. The ability to be successful in businesses of the 21^{st} century requires not only the academic skills of the traditional subject matter but other skills known as 21^{st} century skills.

Professors of higher education and employers seek individuals with certain skills and thinking processes that are critical for the challenges employees will face in a global society. Public schools are constantly challenged to provide current students with 21^{st} century skills (Bassett, 2005;

Casner-Lotto & Barrington, 2006; Friedman, 2005) and to prepare students that will compete for occupations which may be accessible to anyone on the globe (Friedman, 2005; Jacobs, 2010b; Stewart, 2010). In a recent study, seventy-five percent of employers surveyed indicated that it is the responsibility of the K-12 institutions to provide the basic knowledge skills and the applied skills necessary for employees entering the workforce (Casner-Lotto & Barrington, 2006).

Skills needed in the 21st century are more involved than rote memorization of facts and figures. In the November 18, 2008 address to the State Educational Technology Directors Association (SETDA), Tony Wagner stated there were seven survival skills that students should have before graduating: (1) problem-solving and critical thinking, (2) collaboration across networks and leading by influence, (3) agility and adaptability, (4) initiative and entrepreneurship, (5) effective written and oral communication, (6) accessing and analyzing information, and (7) curiosity and imagination (as cited in Stansbury, 2008). These skills are necessary for a global workforce and citizenry. Wagner's statement is supported by the research of Casner-Lotto and Barrington (2006) who reported on the skills that employers expect new graduates to possess as they enter the 21st century workforce. The desired skills indicated by employers of employees include: professionalism/ work ethic, teamwork/collaboration, oral communications, ethics/social responsibility, reading comprehension, English language, critical

Table 1

21st Century Skills: Basic Skills and Applied Skills with Description

Basic Skills	
English Language (spoken)	Government/Economics
Reading Comprehension (in English)	Humanities/Arts
Writing in English (grammer, spelling)	Foreign Languages
Mathematics	History/Geography
Science	

Applied Skills with Brief Description
Critical Thinking/Problem Solving – use sound reasoning and think analytically; solve problems by using knowledge and data
Oral Communications – able to articulate thoughts and ideas clearly and effectively, have public speaking skills
Written Communications – clearly and effectively write memos, letters and complex technical reports
Teamwork/Collaboration – a collaborative culture with both colleagues and customers, able to work in diverse teams, able to handle differences in opinions
Diversity – able to work with individuals from diverse cultural backgrounds including ethnicity, gender, religions, etc.
Information Technology Application – choose and use technology that is appropriate for the situation/task
Creativity/Innovation – show inventiveness and originality, discuss new ideas, integrate information from different areas/disciplines
Lifelong Learning/ Self Direction – be willing and able to continue to learn new skills and acquire new knowledge, determine new knowledge needed for the job, learn from one's own mistakes
Professionalism/Work Ethic - demonstrates personal accountability and effective work habits such as punctuality, working with others productively,and manage time and workload
Ethics/Social Responsibility – a person of integrity and good ethics, make decisions with the larger community in mind
Leadership – use others strengths to accomplish tasks, develop and coach others

Adapted from Casner-Lotto and Barrington, 2006.

Table 2

21st Century Skills Desired of New Graduates by Employers

Basic Knowledge/Skills	High School	2-Year College/ Technical	4-Year College
	Employers Response – Rank & Percentages		
English Language (spoken)	6 - 61.8	7 - 70.6	7 - 88.0
Reading Comprehension (in English)	5 - 62.5	5 - 71.6	8 - 87.0
Writing in English (grammer, spelling, etc.)	11 - 49.4	10 - 64.9	6 - 89.7
Mathematics	14 - 30.4	15 - 44.0	15 - 64.2
Science	17 - 9.0	16 - 21.2	16 - 33.4
Government/Economics	18 - 3.5	18 - 6.7	18 - 19.8
Humanities/Arts	20 - 1.8	19 - 4.4	20 - 13.2
Foreign Languages	16 - 11.0	17 - 14.1	17 - 21.0
History/Geography	19 - 2.1	20 - 3.6	19 - 14.1
Applied Skills			
Critical Thinking/Problem Solving	7 - 57.5	4 - 72.7	5 - 92.1
Oral Communications	3 - 70.3	3 - 82.0	1 - 95.4
Written Communications	9 - 52.7	6 - 71.5	4 - 93.1
Teamwork/Collaboration	2 - 74.7	2 - 82.7	2 - 94.4
Diversity	10 - 52.1	12 - 56.9	14 - 71.8
Information Technology Application	8 - 53.0	9 - 68.6	11 - 81.0
Leadership	15 - 29.2	14 - 45.4	10 - 81.8
Creativity/Innovation	13 - 36.3	13 - 54.2	12 - 81.0
Lifelong Learning/ Self Direction	12 - 42.5	11 - 58.3	13 - 78.3
Professionalism/Work Ethic	1 - 80.3	1 - 83.4	3 - 93.8
Ethics/Social Responsibility	4 - 63.4	8 - 70.6	9 - 85.6

Adapted from Casner-Lotto and Barrington, 2006.

thinking/problem solving, and written communications (See Table 1 and Table 2).

Public education has been challenged to prepare the work force of tomorrow not only to utilize the technology of today, but to develop critical thinking and problem-solving skills to enable them to adapt to the technology of the future (Casner-Lotto & Barrington, 2006; Cuban, 2001; Hopper, 1999; Lezotte & McKee, 2006; Rotherham & Willingham, 2009; Stewart, 2010). Technological advances have again indicated a critical need for science, technology, engineering, and mathematics (STEM) careers which are vital to our nation's future (Jackson, n.d.). Yet women and people of disadvantaged backgrounds are grossly under-represented in STEM careers. Mathematics is a critical component of the careers responsible for many of the technological advances experienced in the growing global economy. STEM career opportunities are built on a solid foundation of mathematics.

Public Education and Mathematics

Students leaving public schools are still required to have the skills known as *the three Rs*: reading and 'riting and 'rithmetic (Stephens, 1888) along with other core disciplines such as science, geography, and social studies. However, new *three Rs* have been recommended. Sternberg (2006) suggested the following: Reasoning – including analysis, critical thinking, and problem solving skills; Resilience – the ability to be flexible, adaptable, and self-reliant; and Responsibility – wisdom, applying intelligence, creativity, and having the knowledge for a common good. Wagner, et al. (2006) identified the “three Rs” as: Rigor – not to make content too difficult to master but to encourage students to understand how and where to use what they know; Relevance – understand how to connect what is learned to future work environments or future studies; and Respect – the promotion of respectful relationships between students and school staff that will “foster academic and social competence” (p. 2). The Star Tribune (2010) reported that Joel Barker and his wife created a “21st-century curriculum founded on not just learning the ABCs, but also the ‘EFGs’: Eco ed (‘How do we interact with the planet?’), Future ed (‘How do I shape my future?’), and Global ed (‘What is my relationship with other human beings?’). These authors posit that implementation of the new three Rs and the EFGs along with the original three Rs will prepare better prepare students for future challenges.

Early Mathematics Education and Equity

The origins of the discipline of mathematics and the awareness of number and form cannot be traced to any certain time or culture. Historians only conjectured the origins of mathematics prior to 2500 BC. There is evidence that mathematics was essential as early as 9000 BC as trade routes began to emerge and perhaps even earlier as indicated in cave drawings dated 30,000 BC (Ciolek, 2010). By 3000 BC large stone buildings were being constructed and sailing vessels were crossing small seas (Ciolek, 2010; Osen, 1974). However, there is little evidence to how this knowledge developed.

As civilization developed, mathematics began to play a necessary part in the development. As early as 4700 BC, the Babylonians were very mathematically competent (Ciolek, 2010). Property owners were taking inventory of their wealth and setting boundaries. The Babylonians (and the Chinese) are known to have used the *Pythagorean numbers* at least 1000 years before Pythagoras' time for use in surveying (Olsen, 1974). The Egyptians had a calendar as early as 4241 BC and had a mathematical text, the Ahmes papyrus, approximately 1650 BC (Ciolek, 2010; Osen, 1974). The Egyptian culture also devised mathematical games as a type of family entertainment (Osen, 1974).

Mathematics was a vital component in the studies, or philosophies, of the ancient Greeks. Typically only the male socially elite were allowed to study. Pythagoras, for whom the Pythagorean Theorem is named, established a Dorian colony known as the Order in Southern Italy. His policy of allowing women to join his Order, allowing women to be educated, and allowing women to study mathematics was taboo in that society. Because Pythagoras rejected the cultural norms, he became known as the feminist philosopher (Olsen, 1974). Both Pythagoras and Plato allowed women not only to study in their schools but also to teach in their schools (Osen, 1974).

Greek culture typically allowed only men of high social standing any education. Women, of any social standing, and men of low social standing were not allowed an education (Null, 2007; Olsen, 1974). Although Plato did allow women to learn and teach in his Academy, it was only women of the socially elite. According to Null (2007) Plato's *Republic* revealed Plato's ideal state. Plato believed that:

- education was not for all;
- guardians (the socially elite) should convince citizens to be satisfied with their lower position in life;
- people were created for different purposes and one class is not to meddle in the other class;
- some people are educable and others are only trainable;
- it was the philosophers responsibility to determine which curriculum or training, was appropriate for different children to follow; and
- the best curriculum “cultivated the gift of reason” (p. 47), which some could do and others could not. (Null, 2007)

Plato believed that mathematics provided the best training for the mind and was instrumental in its development. Above the door of the Academy was written, “Let no one unversed in geometry enter here” (Osen, 1974). Plato championed education for socially elite men and women but did not extend his support to men or women of the lower classes.

After the fall of Rome in 476 AD and through the Middle Ages, there was a general decline in the science of mathematics and this did not begin to relent until the beginning of the Renaissance (Olsen, 1974). Women and people of lower classes were denied even the most fundamental forms of education, such as reading, and writing because they were believed to be a source of temptation. The prejudices against the lower classes and women continued on throughout the history of all civilizations and in some places continue today.

The traditional method of teaching (lecture) was born during the Ancient Greek period. As indicated earlier, the ancient Greeks had education systems in place as early as 539 BC which included Pythagoras' Order and schools. Osen (1974) indicated that the Greeks had a great thirst for knowledge and sharing of knowledge at least 1000 years before Pythagoras. For the ancient Greeks, mathematics changed from being a discipline situated in everyday circumstances or needs, to become a method of developing the mind. The method of espousing their knowledge was through lecture, the birth of traditional teaching.

The thirst for knowledge did not die with the Greeks. Travel through time approximately two centuries and education has been recognized as a civil right particularly in the United States (U.S.). This civil right developed with much controversy, many battles, and many bad policies. Barr and Parrett (2007) summarized policies of approximately 200 years that moved the U.S. to provide education to all students. Six policies of significance could be separated into three areas; access to education, equal educational opportunity and high achievement for all (Barr & Parrett, 2007).

A policy that provided access to education was the Creation of Massachusetts Board of Education of 1837 which provided education through the elementary grades. The decision of *Brown v.Topeka Board of Education* of 1954 provided equal opportunities and access to a quality education for African American students (Barr & Parrett, 2007).

The Elementary and Secondary Education Act (ESEA) of 1965 provided “equal access and treatment for poor students and minority students” (Barr & Parrett, p. 2). Included in this legislation was the compensatory program of Title 1 which supports the disadvantaged and minority student. Another program added to ESEA that buttressed opportunities for an equal education was Title IX. Title IX provided equal treatment for women in public education (Barr & Parrett, 2007).

The policies that support high achievement for all is the 1974 Education for All handicapped Children Act: and No Child Left Behind. The first required equal access and treatment for students with disabilities and the latter established a national goal requiring all students, regardless of gender, race, educational program, or economic status to be proficient in reading, math, and science (Barr & Parrett, 2007).

United States Educational System

Students living in the first decade of the 21^{st} century are in a world of constant change (Friedman, 2005; Stewart, 2010). Advances have been made in industry, medicine, communications, entertainment, and many others. These advances could not have occurred had these entities not embraced the technological advances that initiated change. However, the very entity in which change should occur, public schools, is very resistant to change (Hord, Rutherford, Huling, & Hall, 2004; Lezotte & McKee, 2006).

The United States (U.S.) educational system continues to reflect the agrarian and industrial societies of the late 19^{th} and 20^{th} centuries. Most U.S.

schools have roughly “180 instructional days based on an agrarian calendar and a six-hour day with eight subjects” (Jacobs, 2010b, p. 9) reflecting an industrial factory model (Abbott & Ryan, 1999). Many public schools continue to embrace educational practices that were in place at the turn of the 20^{th}century (Dean, 2009). Lezotte and McKee (2006) expressed the problem well by stating “. . . the world has changed dramatically in terms of its needs and expectations for educating our youth. Unfortunately, public education has not” (p. ii). Basset (2005) laments the fact that 21^{st} century skills are difficult to learn in a 19^{th} century classroom environment. The current education system was designed to prepare students to be successful members of an industrialized workforce. However, most industry jobs are outsourced to other countries with a cheaper workforce (Friedman, 2005; Prensky, 2007). It is imperative that U.S. educational institutions prepare 21^{st} century students for a 21^{st} century workforce that is in constant change.

The learning theory that dominated education during the late 19^{th} and early 20^{th} century was generally behaviorist (Abbott & Ryan, 1999; Cook, 2006). Much like the ancient Greeks, behaviorist teachers were the “keepers of knowledge” and their revelation of that knowledge was the focus of the classroom (Iran-Nejad, 2001). In behaviorist classrooms students were expected to be the receptors of knowledge and passively *learn* the information that was determined to be necessary for success. Students were expected to listen to lectures, expected to memorize facts, participate in drill and practice (sometimes known as *drill and kill*), and to answer questions at the back of the book.   With the invention of the mimeograph machine and copy machine, teachers ran countless worksheets for students to answer. In a behaviorist learning environment students were generally passive as didactic instruction occurred (Abbott & Ryan, 1999). Many teachers in today's classrooms still embrace behaviorist practices. This practice is seen much more in schools with a high percentage of disadvantaged students (Smith, Lee., & Newmann, 2001).

Poverty and Education

Research of students in poverty cites many disadvantages they experience. Barton (2003) reports several factors that correlate with student achievement. Hunger is experienced by families of poverty and their nutrition is often poor. This may lead to low birth weight which is experienced more by children of poverty and may lead to developmental delays. These students are more likely to be enrolled in special classes, repeat a grade or fail, and drop out. Parent availability is less in disadvantaged homes because of various factors. Therefore, children of poverty are read to less than children not in poverty. Many of these children watch six or more hours of television. Many disadvantaged students are highly mobile resulting in many school changes. High mobility may lead to: lower achievement levels, slower academic pacing, and a greater risk of not completing high school. Smith, Lee, and Newmann (2001) report that schools with a high level of disadvantaged students are more likely to be taught with didactic instruction which leads to disengaged students.   Barr and Parrett (2007) contend that the most important thing a school could do for children who fall behind is to provide them with teachers who are highly qualified and experienced with high expectations of students' ability to learn. Schools with high poverty and minority populations are twice as likely to have teachers with three or less years of experience generally leading to these students falling farther behind students of advantage (Barton, 2003).

Students of poverty can add technology to the many disadvantages they experience in life. Stevenson (2009) referred to the lack of technology for underprivileged students as the digital divide. His summary of research acknowledged the digitally divided may be specifically defined by

> "demographic variables including geography (rural, urban, central cities), education, income, family type (single parent, two parents, numbers of children), race, age, disability status, and gender . . .[T]he digitally divided are constituted as poor (earning less than $15,000 per year), lacking education (with less than high school), and are often unemployed or under employed. . . They are most likely Black, Hispanic, or Native American and living in a city's center or a rural setting" (p. 13).

Lewis (2007) stated that disadvantaged children depend on schools to provide access to the Internet. The National Center for Education Statistics (NAES) reported 60 percent of disadvantaged students depend on schools for computer access and Internet access compared to less than a third of students of advantage. Only 37 percent of disadvantaged homes have computers at home (Lewis, 2007).

Again, schools are the called upon and urged to provide access to these services to disadvantaged students to ready them for an ever changing technological world. Barton (2003) reported that schools with a high poverty enrollment had 11 percent of technology availability compared to 71 percent of schools with low poverty enrollment. Technology-assisted instruction benefits disadvantaged students. Barton (2003) indicated that the effect of technology-assisted instruction ". . . was consistently positive and considerable, and strongest for students of lower socioeconomic status and for students who were low achievers" (p. 16). Proper implementation of technology has been identified as a viable tool to improve student learning yet programs assisting disadvantaged student access to these resources are often not maintained or cut. Stevenson (2009) lamented,

> "[t]he representation of the digitally divided as a collection of demographic variables is discursively significant, especially in light of government discourses that, on the one hand, promote access to and use of the new ICTs [information and communication technology] as fundamental to life in the new economy, and on the other hand cancel programs designed to ensure subsidized access for America's poor to the network" (p. 13).

When financial resources are cut, schools must find resources within the community to supplement the funding. Partnerships with industry and business have helped many schools with funding for technology. However, this is particularly difficult for schools with high levels of disadvantaged students.

Gender and Education

The Title IX of ESEA legislation emerged during a critical time in U.S. history. Before and during this time period the quality of learning opportunities for girls was the focus of concern for educators and researchers (Wiens, 2006). Societal norms were for women to become mothers and housewives. If a woman pursued a career, her choices generally included secretary, teacher, or nurse. As the feminist movement grew and educational policies ensued, women began to demand more of themselves and society. Women began to move out of the occupations that society tended to delegate and move toward the occupations once believed to those once believed to belong to men. Women understood that education was the great equalizer.

There is a plethora of research on gender issues. Research is important to denounce many suppositions that at one time were implied as fact. Griffin (1984) reported two: (1) an educated woman was dangerous, "masculinized, immoral, pernicious" (p. 33) and (2) women were not able to learn more than basic literacy. She cites an American doctor saying "Woman has a head almost too small for intellect but just big enough for love" (Griffin, p. 33). Therefore true research to study gender and their differences was imperative to provide equity and close achievement opportunities and gaps.

Interestingly, current research (Wiens, 2006) aligns educational success to be "sex-typed as female among poor and working-class populations" (p. 17).

Notable research on gender issues involves gender differences in educational settings. In 1992, the World Press Review reported that prejudices within the classroom generally favored boys. Boys were called on more frequently than girls. Boys received more attention by being called on or criticized more often. Boys tended to make fun of girls, interrupt girls, and make fun of girls' contributions in class. Finally, boys were described by teachers as "intelligent, interested, and creative, while girls are called conscientious, clean, orderly, and diligent" (Schnitt, p. 50). It is not unreasonable to understand the need for Title IX of ESEA to provide equal treatment for girls. Because the quality of learning opportunities for girls were the focus of concern for educators and researchers, Wiens (2006) feared that the emphasis on serving girls may have seriously impacted academic achievement of boys. Since that time period, the equity gap has consistently closed between the genders. Some insist that there has been a 180 degree turn in the treatment of the genders. So much that in 2006, a civil rights complaint was filed in Milton, Massachusetts alleging that boys were experiencing discrimination. This caused researchers and apparently parents, to believe there is a "new gender gap" (Wiens, p.11) and girls are winning the academic race.

Research has given educators more insight into gender differences. The area of the brain that is associated with verbal intelligences, including spelling and reading, develop faster in girls than boys (James, 2007) and according to Wiens (2006), six years earlier. So girls talk sooner and speak clearer earlier than boys. Therefore, boys enter the first grade two years behind girls in reading and writing (Salomone, 2003). Without intervention boys will continue to lag behind girls, leading to discouragement and acting out.

Boys' vision is better than girls' because the retina is thicker in men (James, 2007). This may lead to stronger spatial perception and provide the ability to mentally manipulate shapes or objects (James, 2007). Therefore boys have an edge over girls in the studies of geometry and engineering. Interestingly, brain activity at rest in girls is more active than the brain activity in boys at peak performance (James, 2007). James (2007) also reported that boys' brains will go into a rest state after 10 minutes of lecture impeding learning in the traditional classroom.

Girls spend more time doing homework than boys as they grow older. The United States Department of Education (1996) reported that 12th grade girls do homework four times more than boys (Wien, 2006). Academic success is predicted by the grades of secondary schools. Boys in middle school and high school earn 70 percent of the Ds and Fs. Boys underachievement and lack of engagement cause them to fall behind girls achievement, even in the traditional male-dominated studies of math and science (Wien, 2006).

Boys are more kinesthetic than girls. In many cultural settings this is advantageous for boys. Kinlon and Thompson (2000) asserted:

> The average boy's gifts are wrapped in high activity, impulsivity, and physicality . . . These qualities serve boys beautifully on the playground, where there is room and respect for bold strokes of action and impulse. In the classroom, however, alongside girls – who are typically more organized, cooperative, and accomplished school learners – those "boy qualities'" quickly turn from assets to liabilities (as cited by Wiens, p. 15).

Thus it is imperative to help boys by providing learning activities that involve movement. Wiens (2006) suggested using technology in the classroom including "computer animations, web-based activities, and mechanized data-gathering tools (p. 22) which utilizes their preferred learning strengths of movement, coordination, and visual processing. These learning tools help boys focus better while encountering difficult cognitive tasks.

An integral part of the U.S. educational system with accountability as outlined in No Child Left Behind (NCLB) is standardized testing which began in the early twentieth century (Jacobs, 2010b). Such testing compels many U.S. educators to remain in a behaviorist *teach to the test* system (Jacobs, 2010a). Tony Wagner (2008) emphasized that preparation for future work situations requires teaching learners "'to use their minds well' rather than testing them reductively" (as cited in Jacobs, 2010b, p. 11). Abbott & Ryan (1999) insisted, "Education that focuses on specific outcomes and national curriculum targets does not support genuinely creative or entrepreneurial learners. An ever-increasing pace of change has made the ability to learn far more important than any particular skill set" (p. 69). The educational philosophy of constructivism focuses on students using their minds well, developing the ability to learn, developing the ability to think, and collaborating with others.

Constructivist Philosophy in Education

Classrooms are filled with students from diverse backgrounds who generally have no control of the environments in which they are exposed. Some students have a plethora of opportunities while many of their classmates have few. Students with fewer opportunities enter education two or more years behind in ability (Smith, Lee, & Newman, 2001). This does not mean that these students cannot learn. It means that the environment from which they have come may significantly lower opportunities for basic skills to be learned (Barton, 2003; Payne, 2003). Many researchers describe constructivism as knowledge or meaning that is not fixed but is constructed through individual experiences in particular contexts (Airasian & Walsh, 1997; Boethel & Dimock, n.d.; Brooks & Brooks , 1993; Cook, 2006; Honebien, Duffy, & Fishman ,1993). Things that occur in students' lives daily are the contexts of which researchers refer. John Dewey (1938) wrote that changes in society will require the restructuring of education to meet society's needs. He insisted that children must construct and relate learning in authentic ways, that life should be the context for learning. Constructivism can dramatically impact student learning (Boethel & Dimock, n.d.; Brooks & Brooks, 1993;

Honebien, Duffy , & Fishman ,1993) but has yet been embraced by many U.S. schools.

Central to constructivism is student learning. Constructivism emphasizes "learning as an adaptive activity, learning as situated in the context, knowledge as constructed by the learner, the role of experience and prior understanding, resistance to change, the role of social interaction in learning" (Boethel & Dimock, nd). Thomas Carroll (2000) asserted:

> What we are moving toward is authentic, long-term projects, asynchronous learning, knowledge-work and nonlinear learning, "just-in-time" consumable information used for specific purposes, instead of "just-in-case" facts packed into our heads at an early age that few of us can recall. (p. 136)

Overall, constructivist learning environments are more effective than traditional learning environments (Rosen &Solomon, 2007).

Constructing learning environments of public schools to allow for students to investigate authentic problems (i.e. learning contextually) allow students to have a better understanding of the content. Specifically these learning environments:

- Are technology-rich
- Provide opportunities for students to inquire into the phenomena they are learning and not simply receive information about the phenomena

- Support student in participating in, not didactically hearing about, domain-related practice
- Are designed to support the process of learning
- Establish rich environment (studios, workshops, and construction spaces) where students work collaboratively
- Immerse students in a context that grounds their understanding to local environmental particulars. (Barab, Hay, Barnett & Squire, pp. 449-50)

Constructivism powerfully informs educational practice because the central role in constructivism is that changes in learners' schemas impact their cognitive growth. However, many educational practices still reflect behaviorist theories where the students are passive learners. Research has indicated that there is a learning gap of 20 percent between didactic instruction and interactive instruction (Smith, Lee, & Newmann, 2001). Therefore, teachers' practices and the environments they create must go through dramatic transformation to accommodate a constructivist learner. Barab, Hay, Barnett, and Squire (2001) stated that participatory learning environments "immerse students within contexts that challenge; ground; and ultimately, extend their understanding" (p. 449).

Constructivism in Mathematics Education

Andrew (2007) noted that the traditional mathematics classroom instruction takes a predictable course of action. The teacher introduces a new concept through lecture, works several examples of problems with the new concept, and then students are assigned problems. As the students begin to work the assignment, the teacher circulates and monitors students work, occasionally stopping to answer questions or guide students through a problem. Andrews (2007) stated, “Learners who do well in mathematics classes often have difficulty transferring that knowledge to contexts outside of school.”

The inability to transfer what is learned in a mathematics classroom to the very environments to which it applies is unacceptable. Newman and Wehlage (1993) reported that authentic instruction leads to authentic achievement steeped in constructivist practices and insisted that restructuring classroom instruction was necessary. The three criteria necessary to improve student learning; (1) students must construct meaning to produce knowledge, (2) to construct meaning students must use disciplined inquiry, and (3) the target of their work is products, performances, or products of discourse that have meaning or value beyond the classroom (Newman & Wehlage, 1993.).

There is a growing body of research supporting a constructivist learning environment (National Council of Teachers of Mathematics [NCTM], 2000). Children come to school with mathematical ideas constructed by their own reasoning and thinking. If children are permitted to build from their informal ideas through their own thinking, they will come to understand ’or come to know mathematics conceptually (Wood, 2001). Wood (2001) reported that the thinking and reasoning process developed in situations of confusion allowing students to struggle are the types of constructivist mathematics classrooms is that develop a deeper level of knowledge and understanding. Yet, many teachers continue to use traditional behaviorist methods in the classroom which is not consistent with constructivism (as cited by Andrew, 2007).

There are several reasons that for this disconnect between constructivist research and practice. First, there is pressure for all students to perform at high levels on state standardized tests. This leads to teachers focusing on performance standards that will be tested. Second, teachers tend to teach as they were taught and most have not been taught with constructivist methods either in K-12 or university level. Finally, professional development in constructivist methods is lacking in many schools (Airasian & Walsh, 1997).

Pennington (2000) implied a problem with constructivist approaches – standardized testing. Often students do not transfer the learning from solving problems utilizing constructivist practices to the format of problems on standardized tests. With the accountability system promoted by the legislation of No Child Left Behind, many schools have chosen to focus on the core curriculum to insure students make adequate yearly progress (AYP) (Jacobs, 2010b). Each state has developed curriculum standards for subjects such as math, language arts, science, and social studies. State standardized end-of-instruction exams have been developed to assess student mastery of the curriculum content standards. Many teachers eliminate teaching content in a manner that is stimulating, encouraging 21st century skills and fall back into a didactic teaching method that does not fit students or the current (or future) work culture (Jacobs, 2010b; Stewart, 2010). This may lead to an unprepared population entering the workforce both nationally and globally.

Newman and Wehlage (1993) insisted that public schools deliberately change two persistent problems of inauthentic behaviorist environments: (1) Often work students are assigned does not allow them to use their minds well. (2) Assignments have no intrinsic meaning or value to students beyond achieving success in school. Barab, Hay, Barnett, and Squire (2001) stated that participatory learning environments "immerse student within contexts that challenge; ground; and ultimately, extend their understanding" (p. 449). Situated learning environments currently available that immerses students in participatory learning are digital games.

Digital Games to Engage Students in Learning

Digital games are participatory learning environments immersed in constructivism (Dickey, 2006).   Students today (2011) have been playing digital games their entire lives (Beck & Wade, 2004; Hayes, 2005; Prensky, 2005, 2006, 2007). They have embraced a method of learning that is totally different from the way their parents or teachers have learned. Beck and Wade (2004) stated "Gaming has created an entirely different learning style, one that:

- Aggressively ignores any hint of formal instruction
- Leans heavily on trial and error (after all, failure is nearly free; you just push 'play again')

- Includes lots of learning from peers but virtually none from authority figures
- Is consumed in very small bits exactly when the learner wants, which is usually just before the skill is needed" (p. 159).

These facts bring to the classroom an entirely different student than those of the past (Beck & Wade, 2004; Prensky, 2005, 2006, 2007). Students of other generations were somewhat *respectful* of the constraints of the traditional method of learning. Students today resist sitting, listening, and filling out worksheets. They have been in charge of their learning, in the digital context, and do understand that learning can be carried out as needed in situations, bit by bit. They are resistant to the inactivity of traditional learning (Prensky, 2005). Clark and Ernst (2009) report that students play games daily. Educators can reach students by embracing the tool of digital games. Digital games "engage students in the construction of products requiring practices that embody complex concepts, necessitate collaboration, and contextualize learning within contexts in which problem solving and inquiry are fundamental aspects of the learning process" (Barab, Hay, Barnett & Squire, p. 48). Gamers are active learners and resent the didactic approaches of traditional teaching.

Many have claimed (e.g., Barab et al., 2005; Gee, 2003; Prensky, 2006; 2007; Schaffer, 2006; Steinkuehler, 2008) that the next era of teaching will be digital game-based learning. Digital games are used by the military, industry, businesses, and the medical profession as efficient, cost-effective learning tools. Entertainment Software Association (2008) reported that games have been developed to train employee for American Express, Bank of America, Canon, IBM, JP Morgan Chase, Nokia and Pfizer, among others. It appears that the military and industry have embraced digital game-based learning because games (and simulations) can be developed to support specific objectives. If given the opportunity, Clark and Ernst (2009) believe students will spend more time learning on their own with digital games because gaming captivates their interest.

Digital Games and Equity

Ninth grade students currently in public schools were born early 1990s. Since their birth, video gaming industry has grown tremendously (Hayes, 2005) and is seen as a having great potential as a learning tool (ESA, 2008; Gee, 2003, 2005; Hays, 2005; Prensky, 2006, 2007 ; Shafer, 2006; Squire, 2002; Warren & Dondlinger, 2009). According to Entertainment Software Association (ESA, 2008) 63 percent of the U.S. population plays video games. Video games as a family source of entertainment, is growing with 67 percent of heads of households playing digital games, of which half play with their children (ESA, 2008).

Digital Games and Gender

The dominant gender playing digital games are male (Dickey, 2006; Hayes, 2005; Royse, et.al., 2007; Williams, Yee, & Caplan, 2008). ESA (2008) reports that the fastest growing demographic group of players is women, which are currently reported at 40 percent. Williams, Yee, and

Caplan (2008) reported in their study of *Everquest 2* gamers, that approximately 80 percent were men and 20 percent were women. Royse, et.al. (2007) reflected on a study by Consalvo and Treat (2002) that reported 75 percent of men and 51 percent of women in their study played video games. However, when reporting those who played over 20 hours per month, called "power users" (Royse, et.al, p. 557), 42 percent of the men and only 15.6 percent of the women played at this level. Williams, Yee, and Caplan (2009) reported that women who played *Everquest 2* averaged 29.31 hours of play per week while men played an average of 25.03 hours per week. This is unlike most reports about time play by gender. Bonanno and Kommers (2005) reported that the average time spent playing digital games per week by men and women were 6.7119 hours per week and 2.4917 hours per week respectively. Greenburg, et.al. (2008) reported that men played 18.56 hours per week and women played 8.16 hours per week. Carr (2005) explains that high profile games are developed with males in mind and that more money is spent making and selling games to a male audience.

Implied by the statistics, digital game play is embraced more by males than females. What is not evident is the reasoning behind the difference in the amount of digital game play between the genders. Hayes (2005) describes three problems in the bias of theories about gender differences in digital game play. The first theory inferred there are "types" of games that men and women play or prefer. Greenburg, et.al. (2008) reported the male preferred genre was physical games (e.g., action, racing, sports) and the female preferred genre was traditional games (e.g., classic board games puzzles). Bonanno and Kommers (2005) reported that males preferred games such as “first person shooters, roleplaying games, and sport and strategy games” (p. 36) which fulfills the needs of “challenge and social interaction” (Bonanno & Kommers, p. 36). They reported that females liked “puzzle, adventure, fighting, and managerial games” (Bonanno & Kommers, p. 36) because of “challenge and arousal” (Bonanno & Kommers, p. 36). The problem with this theory is the limited exposure to different types of games and their past experience, and knowledge of different genres (Bonanno & Kommers , 2005; Hayes, 2005). A study of an all-girl school state school in the United Kingdom found that the girls in the study indicated a specific game as a favorite but after exposure to different types of games and genres many favorites completely changed (Carr, 2005). During the study girls were given different platforms and games to play as part of a *club*. Hayes (2005) stated that many girls and women talk about how “game consoles were purchased for their brothers or placed in their brothers’ rooms” (p. 24) indicating that playing digital games is a “masculine practice” (Ibid, p.24). Findings indicated that the lack of women exposure, for various reasons, to many games and genres may be why women do not play games as much as men.

A second theory that Hayes (2005) finds faulty is the theory that explains gender play patterns are because of theories based on biological or psychological gender differences. Bonanno and Kommers (2005) reported that games preferred by men “demand a higher visuospatial ability involving localization, orientation, mental rotation, target-directed motor skills, greater reaction speed, increased aggression, and greater risk taking" (p. 36). They continued to report that women tend to enjoy games that require retrieval of stored information rather than finding new approaches to meet different challenges. Dickey (2006) reported that research of gender and what women want in digital game play "is too often predicated on the notion that gender is a static construct and can be easily quantified by observation and survey" (p. 789). Hayes (2005) reported that aggressive and competitive play is encouraged more for men. Women are "encouraged to engage in more sedate, nurturing types of activities" (p. 24).

The third problem according to Hayes (2005) about the research of "gender and gaming is that diversity among women as well as among men is typically ignored in favor of making global distinctions between the sexes" (p. 24). This is supported by the research of Royse, et.al. (2007) that reported three different types of women gamers: power gamers, moderate gamers, and non-gamers. Power gamers are women who "appear to combine [feminine] sexy attributes with [masculine] characteristics like 'strength' and 'intelligence'" (p. 564). These women enjoy multiple genres and take pleasure from mastering the skills required in the game and enjoy the competition from other players in the games. Digital game play is about "pleasure, mastery and control" (Royce, et al., 2007). Different genres allow power players to "challenge gender norms by exploring and testing their aggressive potentiality" (Royce, et al., 2007). These women object to the gender bias in games, such as the female characters, generally have weaker power levels. Moderate players tend to reject violent genres and embrace more games that “provide more opportunity to win” (Royce, et al., p. 566). They like being in control and beating games by analyzing or predicting the proper moves to win. Moderate gamers like the mental challenge that games provide and like to lose themselves in games to distract themselves from their daily lives. Moderate gamers do consider gaming more of a male domain. Non-gamers see games as a “waste of time” (Royse, et.al., 2007) . They consider themselves more “grounded in reality, interpersonally competent and with their priorities set on things that matter” (Ibid, p. 569). This indicates that non-gamers believe those who play digital games believe they become the character in the game, that gamers are solitary beings that lack interpersonal skills, and that gamers waste their time in games therefore their priorities are askew. Non-gamers tend to express concerns over the “sexualized representations of women” (Royce, et al., p. 571) and fear that women stereotypes of women in computer games will encourage and promote sexism in the real world. The difference in women gaming preferences reported by Royse, et.al. (2007) supported Hayes’ (2005) concern of making global distinctions between gender. Carr (2005) stated, “preferences are situated, conditional, and changeable” (p. 473). This acknowledged that gaming preferences can change based on the exposure or offerings of different genres.

Digital Games and the Disadvantaged

There was a dearth of information connecting digital games and the disadvantaged. In the discussion of the disadvantaged in the section titled *Poverty and Education,* research indicated that disadvantaged students do not have the same access to technology as students of advantage (Stevenson, 2009). Broad statements implying that all students play digital games should be analyzed based upon this fact. Many games currently being developed involve Internet usage of which most disadvantaged students do not have access unless they are at school (Ibid.). One study of the massively multiplayer online game (MMOG) *EverQuest 2 ,* reported that *EverQuest 2* players were from wealthier backgrounds than the average U.S. citizen. The mean income for *EverQuest 2* players' average income was $84,715 per year, compared to the general U.S. population average income of $58, 526 (Williams, Yee, & Caplan, 2008).

Summary of Digital Games and Equity

There are problems with broad statements about gender or the disadvantaged in relation to digital game play. It appears that exposure and opportunity to explore the various genres serves as the catalyst of gender differences and may be the same for the disadvantaged. Limitations for game play definitely effects players preferences and abilities. With this knowledge both educators and game designers may wish to follow the recommendations of Hayes (2005):

1. Avoid stereotypes.

2. Don't assume women [men, or the disadvantaged] are all alike.
3. Provide scaffolding for new gamers.
4. Do consider overall game design, not just particular elements in isolation.
5. Do create a supportive social context for gaming-to-learn. (pp. 27-28)

Hayes (2005) indicated that the methods of designing a digital game for women, and are good for learning, are the same methods of "designing good games in general" (p. 28). Game designers must remember that gamers come with various levels of experience, ability, and knowledge. Games for educational or leisure, must consider these facts to design a successful stimulating product.

Educational Leadership in a Digital World

Educational leaders may go through a paradigm shift as they consider digital games as an instructional tool. Many may consider digital games as violence filled wastes of time instead of tools filled with educational opportunities (Shafer, Squire, Halverson, & Gee, 2005). Digital game based learning is immersed in constructivist practices that can engage students in authentic situations in a virtual environment. Studies by "Rieber (1996), Squire (2003) and Dickey (2005, 2006) indicate that many of the strategies, tactics and methods employed in digital game design may provide compelling strategies for the design of interactive learning environments" (Dickey, 2006, p. 786). It is important to identify games that will contribute to students learning in more authentic ways, even in a virtual capacity. Massively multiplayer online games (MMOG) have three-dimensional designs that immerse players in the virtual environment where they move, manipulate objects, make decisions, and interact with others. "[D]epending on the genre, many games now include interactive challenges, which require players to synthesis, analyze and evaluate multiple modes of information and use critical thinking skills to form strategies and solve problems" (Dickey, 2006, p. 791). It is an environment in which constructivist practices can occur without fear of failure and learning can flourish. However, an educational leader must consider the implications of integrating digital games within the curriculum.

Educational leadership is a leading factor of schools that impacts student learning, second only to teaching (Leithwood, Louis, Anderson & Wahlstrom, 2004). Great instructional leaders are important to all schools but are critical to schools whose students who have fallen behind. If schools are to incorporate new technology and digital game based learning into instructional practices, it will take an educational leader that understands the power and potential of these learning tools. This leader must also be able to share this knowledge with stakeholders of the school. Leithwood, Louis, Anderson and Wahlstrom (2004) have identified three leadership practices that set great educational leaders apart from all others: setting directions, developing people, and redesigning the organization.

Setting Directions

Setting directions has the most impact for leaders of all types of organizations (Collins, 2001; Leithwood, Louis, Anderson, & Wahlstrom,, 2004). This is true with educational leaders. As educational leaders become aware of practices that can impact student learning in powerful ways, it is important to have a vision for what the practices can do for their schools. Incorporating digital game based learning into school curriculum requires leadership that identifies it as a viable tool and articulates a vision with teachers, parents, and other community members. As instructional leaders consider implementing digital game based learning within the school's curriculum, they may have to work to develop a new paradigm for many within the school. Digital games have been considered by many adults as addictive devices on which children waste too much time. It is important to work with teams within the school to gain buy-in from all stakeholders. Holding fast to high expectations for performance, communication is critical in setting directions as performances are monitored (Leithwood, Louis, Anderson, & Wahlstrom, 2004).

Developing People

Implementing digital game based learning within the school curriculum will require the instructional leader to help develop teachers to effectively use this instructional tool. Ongoing teacher training will be critical for effective implementation of digital game based learning within the classroom environment. Clark and Dede (2008) discussed the importance of scaffolds for teachers as they incorporate digital games within the curriculum. They provided various types of training that included face-to-face training, train-the-trainers, just-in-time webinars, and monthly online training sessions (Clark & Dede, 2008). Teacher development and individual support to incorporate digital games is fundamental to proper implementation.

Redesigning the Organization

Many high schools are still designed with a six hour day and eight subjects (Jacobs, 2010). Endogenous games are not conducive to a 45 to 50 minute class period. Halverson (2005) explained that endogenous games "connect game design and domain content by integrating relevant practices of the learning environment into the structure of the game. Mastering the learning environment is itself the learning outcome; it is not merely a means to an ulterior goal" (p. 1). It is difficult to provide the time necessary for full immersion into an endogenous game (i.e., MMOG) toward mastery in a class period. Leithwood, Louis, Anderson, and Wahlstrom (2004) reported that strong educational leaders may modify organizational structures to better enable student learning. Halverson (2005) suggested that instructional design should encapsulate game design principles. "When school leaders and teachers begin to appreciate the compelling nature of gameplay and the powerful learning principles embedded in games as positives, they then can consider how games might inspire alternative approaches to learning, both within the existing contexts of schooling and in the development of new learning environments" (Halverson, p. 1).

Effective instructional leaders recognize that teacher input is critical when developing effective organizational design. Providing time for teachers to collaborate and experience new technologies is important for buy-in and proper implementation (Halverson, 2005; Leithwood, Louis, Anderson, & Wahlstrom, 2004). This is important when developing a curriculum that embraces digital game based learning as part of the curriculum. With thoughtful implementation and support, digital games can enhance learning for students as a classroom learning tool.

Summary

This chapter provided an overview of the literature relevant to the study. The areas in the literature review were: 21st century skills; public education and mathematics; digital games to engage students in learning; and educational leadership in a digital world. The review indicated the importance of students being prepared to enter the workforce with the skills necessary to compete and collaborate globally. The literature of 21st century skills recognizes that challenge of public schools to implement constructivist theoretical practices to meet the needs of students and prepare them to develop those 21st century skills. The tenets of constructivism closely align with the tenets of digital games in which today's students are daily immersed. Very few empirical studies exist on digital game-based learning (e.g., Squire, 2004; Tuzun, 2004; Warren & Dondlinger, 2009). Existing studies do not adequately address the relationships between effective dimensions of integrating or supplementing digital game-based learning into a high school curriculum and students' mathematics achievement. This study should give additional insight into the significance of digital game-based learning on mathematics achievement.

CHAPTER 3: DESIGN

Introduction

In a world experiencing rapid technological changes, employers are demanding a workforce with 21st century skills. The literature review made the connection between 21st century skills, mathematics education, and digital game-based learning. The purpose of the current study is two-fold. First, this study aimed at investigating the effects of an educational massive multi-player online game (MMOG) on high school students' mathematics achievement. Secondly, this study examined the interactions of student characteristics and digital game-based learning in an effort to identify which student characteristics may impact student achievement with digital game-based learning.

The questions that guided this study were:

1. What effect does digital-game play have on ninth grade student mathematics achievement as measured by a district created standards-based exam?
2. Are there statistically significant differences in ninth grade student mathematics achievement between students who play an interdisciplinary MMOG and students who do not play an interdisciplinary MMOG?

3. To what extent do students' gender, SES, and the relationship of playing or not playing an interdisciplinary game have on ninth grade students' mathematics achievement?
4. Is there a statistically significant relationship between the amount of time playing the MMOG and mathematics scores among ninth grade students who played the interdisciplinary MMOG?

Context

The high school selected for this study is situated in a large rural community in the United States Midwest with a population of 26,175. The community is located within 40 miles of the state capital but is surrounded by farmland, oil and natural gas wells, industry, and tribal lands. Many residents of the community are employed in many of the businesses within and surrounding the community. Others commute to the state capital which has a plethora of employment opportunities including a military base. One of the oldest industries in this community is a milling company which processes many crops from the surrounding farms, providing employment for residents within the community and support for farmers. Some of the newest industries within and surrounding the community are tribal gaming industries which also provide many employment opportunities.

The community contains two private universities within the city limits and is within 55 miles of the two state flagship universities. A career technology center is also located within the city limits. The city is served by a school district (the district) that offers grades PK – 12 with one early childhood center, four elementary schools, one middle school, and one high school. The ethnicity composition of district's schools is 8 percent African American, 1 percent Asian American, 60 percent Caucasian, 4 percent Hispanic, and 27 percent Native American. Seventy-four (74) percent of the district qualify for free or reduced lunches (F/R) according to Federal standards.

The site chosen for this study is the district's single high school (the high school), with grades 9 – 12. The high school has a well-rounded curriculum with basic core curriculum, fine arts, business classes, computer technology, foreign languages, and other elective classes. Several advanced placement classes are offered and the high school provides rooms for a state college to offer college level classes both at night and during the school day. Students have the opportunity to enroll concurrently in college or university courses and to enroll in career technology classes. The high school has a rich tradition both academically and athletically. The community strongly supports the high school through committee membership, parent organizations, scholarships, individual donations, and presence at school events.

The district's early childhood center feeds into the district's four elementary schools, which in turn feed into the district's one middle school. Five schools feed into the high school, the district's middle school and four elementary school districts (formerly called dependent districts). The four elementary districts, containing grades PK – 8, may attend any public high school upon completion of the eighth grade of which five are located within ten miles of each school, including the high school. Part of each of the elementary school districts are in the high school's transportation district. Two of the elementary districts' facilities are within the city limits. Student enrollment for the high school is 1,343 as reported in the accreditation report submitted to the state department of education. According to the accreditation report, 25 percent of students that enter the ninth grade will leave the high school to move to another district, leave to get their GED, leave to be homeschooled, or they just drop out. The student data for the graduation class of 2007 as collected by Nichols (2007) indicated the 2003-2004 school year 321 freshmen were enrolled. By the start of their sophomore year, 75 students left the school for "various reasons (transfers, pregnancy, GED, truancy, etc.)" (p. 9), 42 left before the junior year, and 18 before their senior year. Nichols (2007) estimated that ten more students would leave before the end of the senior year. The graduation rate for the 2007 senior class was 79 percent and the four-year graduation rate was 67 percent.

Neild, Stoner-Eby, and Furstenberg (2001) reported the transition year between middle school and high school is critical for students. In an effort to reduce the drop-out rate and increase the four-year graduation rate, the high school has implemented strategies supported by the research of the Southern Regional Education Board (SREB) and DuFour, DuFour, Eaker, and Karhanek (2004) such as providing incoming ninth grade students math support classes, centralizing most of ninth grade classes in a wing of the school (Freshman Academy), Summer Bridge for struggling incoming ninth grade students, and a transition class.

The freshman class (Leadership) was developed to ease the transition of students who were coming from the District's middle school and the four elementary districts into the high school and to guide ninth grade students to be successful in high school. Leadership's purpose was to teach learning strategies, promote a cooperative/team spirit, and promote school/community involvement. Training in Capturing Kids Hearts (Flippen Group, 2006) provided the foundation upon which Leadership is built. The mission of Leadership, like the Flippin Group (2006) is "[t]o win their hearts and to lead them to their personal best" (p. i). Curriculum focused on study skills, career exploration, portfolio development, school pride, building self-esteem, and building community within each class and outside each class. All Leadership classes met daily during the same class period, which allowed for class meetings and special activities to occur during that time slot.

The principal of the high school has been in the district for 12 years, having served as assistant principal for 3 years and principal for 9 years. He is a leader that believes that teachers should have a voice in the decisions of the school and shares leadership with the faculty. He is a person of strong principles, high expectations, and has a passion for student success. He allows for release time for his faculty by providing substitutes and at times supervises large numbers of students so teachers may attend trainings or collaborate.

The ninth grade assistant principal was hired the summer of 2006. She has a passion for learning and believes that learning should be fundamental for each member of the school, not only students, but teachers and administrators. Before coming to the high school, she was an elementary principal in a small rural community within the same state. While an elementary principal, she participated in leadership training from the K20 Center of the University of Oklahoma called OK-ACTS (Oklahoma: Achievement through Collaboration and Technology Support.). Only superintendents and principals could participate in this leadership training and were awarded a laptop to be used in their schools. Leadership training focused on the ten practices of high achieving schools (O'Hair, McLaughlin & Reitzug, 2000) which she shared with her staff. Upon completion of OK-ACTS, the school identified three of the practices to implement or improve within the schools and applied for an Oklahoma Education Technology Trust (OETT) grant. The OETT grant was awarded to the school and provided $50,000 for technology, $25,000 in professional development, and $4,000 for substitutes for staff release time. All teaching personnel were trained by the K20 center in technology integration. The assistant principal brought with her a passion for shared leadership and life-long learning. She also brought a belief that technology should be integrated into classrooms to provide students with the tools to successfully learn within and beyond the classroom.

The high school and its administration have a close relationship with the University of Oklahoma. Both entities have a passion for effective practices for student learning and student success. Through this partnership, the high school has been involved in research for effective classroom practices, technology integration, student engagement, and student learning with the University.

The K20 Center received a $4.2 million Star Schools Grant (STAR) by the United States Department of Education. The purpose of the grant was to explore the effects of digital game based learning on math and literacy achievement of eighth and ninth graders utilizing a Windows based mobile platform. To examine the integration of playing a MMOG within the curriculum, a large study was conducted by researchers and practitioners through the process of lesson study.

The high school agreed to pilot the STAR study of the K20 Center. September 2006. The high school received 50 ultra-mobile personal computers (UMPC), two wireless routers, a server, professional development, and access to an interdisciplinary MMOG being developed by the K20 Center during the pilot of the STAR study. The K20 Center provided training in Lesson Study for a team of six, five teachers from the subject areas of language arts, mathematics, science, social studies, and a special education teacher and the assistant principal. This team, with the guidance of K20 Center personnel, collaborated to develop three cross-curricular lessons using the lesson study method during the 2006-2007 school year. The team debriefed after each lesson by discussing their observations of student engagement and strategies to enhance the lesson. The MMOG was in its initial development and was not available until January 2008.

The summer of 2007, the high school conducted the first Summer Bridge (Bridge) program targeting incoming ninth grade at-risk students with reading and mathematics difficulties. There were six teachers teaching the Bridge curriculum including two teachers from the original lesson study team. Each teacher immediately integrated the UMPCs into curriculum content. The teachers received two half-day trainings in lesson study during the summer with the original two lesson study team members acting as mentors. This new team of teachers prepared a lesson integrating the UMPCs into an activity and utilized the lesson study method. After the lesson was taught the teachers met to debrief. Only one lesson study lesson was planned for Bridge, but the UMPCs were integrated daily into the curriculum. The MMOG was still being developed and was not utilized during Bridge.

Pilot of the Present Study

A pilot for the present study was conducted at the high school from January to April, 2008. The K20 Center was developing an interdisciplinary educational MMOG. During the pilot of the present study, the MMOG was in its beta stage. One of the responsibilities of the high school students and staff was to play the MMOG and give feedback to the K20 Center. Lesson study was not part of this research pilot because of the difficulty of planning time with the cross-curricular teams during the school year. However, teachers of Leadership met bi-weekly to discuss curriculum and this time could be utilized to discuss issues with the UMPCs and the MMOG. Leadership class also provided an ideal avenue to conduct this research pilot because the class met daily during the same time period and covered curriculum such as teamwork, study skills, critical thinking skills, and problem solving. Those objectives were integral to the development and implementation of the MMOG.

The K20 Center planned three days of half-day teacher training with the treatment class teachers, four teachers in the morning and four teachers in the afternoon. One objective of the training was to familiarize the teachers with the MMOG so they could integrate it into their classes. Another objective was to immerse the teachers in the MMOG so they could identify the academic standards from the core curriculum areas as they were playing. However, problems with the bandwidth and other equipment problems lead to the cancelation of the trainings after one and a half days. Therefore, short trainings were conducted by the researcher to familiarize the teachers with the UMPCs which were used in their regular classes, activities in Leadership, and the MMOG. Teachers never had the opportunity to totally immerse themselves in the MMOG to fully understand what students were encountering. Upon receipt of parent consent and student assent forms (Appendix A), and taking a mathematics pretest, students began to engage in the MMOG virtual environment.

Students were excited about the prospect of learning in a different manner by playing the MMOG. The STAR schools team placed students into teams of four or five students representing research teams. Because all Leadership classes met at the same time, a research team may consist of students from different classrooms. A chat feature was included as a feature of the MMOG. They were to use the chat feature to collaborate as a team in moving through the game activities

Another purpose of conducting a pilot study was to determine the reliability of the mathematics section of the pretest and posttest instruments (See Appendix B) prepared by the researcher and a mathematics teacher highly familiar with eighth grade math and Algebra I priority academic student skills (PASS) standards. The posttest was a parallel form of the pretest. The mathematics section of the instruments consisted of 20 multiple choice questions that were copied and adapted from released 8^{th} grade mathematics and Algebra I state core curriculum test (CCT) items and from sample CCT items from the state department of education's website and considered valid. The questions reflected the PASS standards that were reported to be included in the STAR SCHOOLS Game Content Standards (Appendix C). The validity was considered by three mathematics teachers' expertise and as determined by the state department of education of the individual items placed on the CCT high stakes tests.

Cronbach's Coefficient Alpha was used to assess internal consistency and reliability of the pretest and posttest items. Cronbach's alpha measures the internal consistency of the test instruments through item analysis. If the inter-item correlation is high, implies high internal consistency. If the inter-item correlation is low, indicates that the underlying construct is not truly being measured. The Cronbach's Coefficient Alpha for the pretest and posttest instruments were found to be 0.81 and 0.79 respectively and is considered acceptable.

Instrumentation

Standardized pretest and posttest (Appendix B) were developed to determine whether playing an interdisciplinary MMOG supported mathematics achievement. The pretest and a posttest developed by the researcher and a mathematics teacher used in the pilot mentioned earlier, were used to determine the effects of digital game play using an MMOG on mathematics achievement. The first part of the instruments included a background survey determining student involvement in digital game play, the types of games played, the amount of time spent playing games daily, and what a game must contain to keep one engaged. It also included questions about the mathematics class the student was taking that semester. The second part of the instruments was developed by a math teacher and the researcher highly familiar with eighth grade math and Algebra I priority academic student skills (PASS) standards. Twenty multiple choice test items were constructed from released eighth grade math and Algebra I state test items and from sample test items from the state department of education's website. Test items included PASS standards of solving linear equations using a variety of methods, graphing and interpreting the solution to linear equations with one or two variables, determining the effect of change in slope, analyzing the relationship of slopes of lines in a plane, solving real life problems using rational numbers, and others. The math test structure was similar to the state's high-stakes tests, 8th grade mathematics CCT and the Algebra I CCT. PASS standards of each test item were reported by the K20 Center to be included in the STAR SCHOOLS Game Content Standards (Appendix C).

The posttest was a parallel form of the pretest with changes in the degree of difficulty, such as, changing an integer to a rational number within an equation, changing from a rectangular prism to a cylinder, or changing from a one-step problem to a two-step problem. Results from an ANCOVA supported that the tests were parallel forms, with the pretest resulting in $F(1, 205) = 134.95$, $p < 0.01$, and the observed power = 1. Validity of the instruments was considered by the math teachers' expertise and by statistical analysis of the student responses. Reliability of the instruments was considered by Cronbach's Coefficient Alpha which is used to assess internal consistency and reliability of the pretest and posttest and found to be 0.81 and 0.79 respectively. In-field observations notes were compiled, including teachers' comments and observations, and students' comments which provide qualitative data as secondary modes of data collection. In this study, the purpose of the qualitative data collection was to better explain the potential results of the quantitative data.

Population & Sample

The population of the study was ninth grade students. The sample was first year ninth grade students participating in Leadership classes of the high school. The sample was divided into two groups and randomly assigned to treatment group (game play) and control group (no game play). Demographic information provided by the high school of the ninth grade class were 49 percent male, 51 percent female, 11 percent African Americans, 1 percent Asian Americans, 51 percent Caucasian, 5 percent Hispanic, and 31 percent Native Americans, 53 percent of the students were on free and reduced lunch (F/R), 1 percent were English language learners (ELL), and 9 percent were students special education students. Parents and students of Leadership were informed of the study to be conducted. Written parent consent and student assent forms were signed and submitted from participating students before the study began. Data was collected from September to December, 2008.

Methods

This experimental study was designed to utilize quantitative methods to obtain data to evaluate the effectiveness of an interdisciplinary MMOG on students' mathematics achievement as measured by a standardized mathematics test. Participants in the study were first year ninth grade students from a transition class, entitled Leadership, in a large rural high school in a U.S. Midwestern state. Students were randomly assigned to participate in a control group (no game play) and treatment group (game play).

The current study is an extension of the original STAR pilot and permission was granted by the high school to conduct the study. The Institutional Review Board (IRB) of the University of Oklahoma was contacted to modify the STAR research IRB for determining the effects of digital game based learning on student mathematics achievement (Appendix A). The modification to the STAR grant study included changing the first part of the pretest and posttest instruments which consisted of background information. The mathematics section of the pretest and posttest developed by the researcher and a math teacher was not changed. Test items were from the State Department of Education's released test items from the eighth grade and Algebra 1 CCTs (Appendix B). Demographic information was provided by the High School with student identifiers removed to assure anonymity. All parents and students of the Leadership were informed of the study and the use of the MMOG. Written parent consent and student assent forms were signed and collected from participating Leadership students before the study began. The study was scheduled to begin September, 2008 in Leadership classes. Leadership classes were randomly assigned by the researcher (by drawing teachers' names) to the treatment group (game play) and control group (no game play). Students were randomly assigned to each class by a scheduling software program at the beginning of the school year. Therefore, the assignment of students may be considered random.

This study examined a web-based interdisciplinary educational MMOG which aims to immerse learners in situations that could develop subject-related knowledge in purposeful ways (Garris, Ahlers, & Driskell, 2002). The game (the MMOG) chosen was a MMOG developed by the K20 Center. The MMOG was developed to reinforce PASS standards in reading, mathematics, social studies, and science in an interdisciplinary manner (Appendix C). The students choose to play scenarios in the MMOG as a member of a team or worked on each scenario individually. The MMOG required a setup to be downloaded on any computer with a Windows platform. The download was not granted to students for home use. For the purposes of this study, access was granted only at the school site during Leadership class.

To achieve this purpose, gamers were informed that a new planet has been identified that has earth-like characteristics and atmosphere. An eclectic billionaire has funded a newly developed form of travel that will transport passengers at the speed of light. He is looking for a team of researchers to send to this planet to investigate research, inhabit the planet, and make preparations for future inhabitants. Students were asked to play the role of researchers competing for the honor of being the first people to inhabit the new planet. The researchers were taken to a virtual uncharted, uninhabited island to test their survival skills by locating necessary resources. Gamers completed a series of tasks as they played through a series of scenarios by working together, applying math, science, social studies, and reporting (language arts) while maneuvering through the game. The goal of the game was to successfully work through the task scenarios and be a part of the winning team of researchers to be sent to colonize the newly discovered planet. The scenarios included situations and tasks designed to be aligned to the standards of eighth and nine grade standards of mathematics, language arts, science, and social studies as outlined by the State Department of Education (e.g., measuring and determining the area of the settlement). As the students maneuvered through the scenarios, directions or hints were embedded within the context of the game. The game design included pleasantly frustrating (challenging, but solvable) problems and repeated cycles of skill practice and mastery (Gee, 2005).

In August, 2008 all 16 Leadership teachers (including four new to Leadership), attended a one-day professional development workshop designed to give the teachers a working knowledge of the UMPCs and how to incorporate them into their Leadership class. They were also given access to the MMOG to familiarize themselves with the scenarios and tasks the students were to experience while involved in the game. Another purpose of the training was to help the teacher supervise the implementation process of game-play.

Before giving the pretest, an anticipatory set was provided to students via “news” video clip that provided the storyline of the MMOG. Students took a pretest, which included a survey and a 20-question math assessment, in one 50 minute class period prior to the treatment (game-play). To provide access to the UMPCs and to ensure that bandwidth did not become an issue, each treatment group was engaged in the MMOG for two days per week (four classes on Monday and Tuesday and the other four classes on Wednesday and Thursday) and engaged in the regular Leadership curriculum the other three days. The control group and students not participating in the study continued to follow the regular Leadership curriculum every day of the week. The study continued for seven weeks. The posttest was administered after the seven week period. All aspects of this study, including playing the MMOG, occurred in Leadership class. There was no disruption of the regular mathematics classes or math support classes.

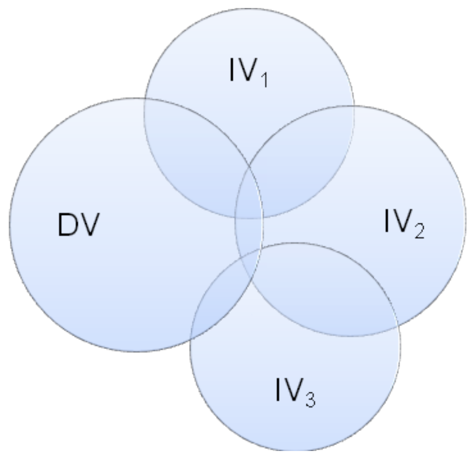
Data collected from student demographic information provided by the High School and from pretests and posttests were compiled, calculated and analyzed using SPSS (version 15) Statistical Software. To answer the first question, “What effect does digital-game play have on ninth grade student mathematics achievement between students who play an interdisciplinary MMOG and students who do not play an interdisciplinary MMOG?”, descriptive statistics were compiled on pretest scores and posttest scores, compared, and reported.

Original plans to answer question two and three were to use factorial analysis of covariance (ANCOVA) to examining posttest scores, using pretest scores as a covariate to account for the different starting points of the subjects. This approach computes estimated posttest scores (while holding pretest scores constant) and tests for differences between the groups on the estimated marginal mean (posttest) scores (Tabachnick & Fidell, 2007). The independent variables for the analysis were to be: group, control and treatment; gender; socio-economic status (SES), low-SES (LSES) and non-low-SES (NLSES). Question 4, “Is there statistically significant relationship between the amount of time playing the MMOG and mathematics score among ninth grade students who played the interdisciplinary MMOG?” was added when the researcher observed differing amounts of time playing the game by members of the treatment group during the pilot study. The amount of time played in the game for the treatment group was to be organized into the following time frames: less than 90 minutes, 91 minutes to 180 minutes, and over 180 minutes. The Bonferroni method was to be included onto the analysis of questions two through four allowing confidence intervals to be constructed and providing maintenance of the overall confidence coefficient.

When conducting the tests for assumptions, it was found that the assumption of homogeneity of variances test was violated for the study group. If the assumptions test is violated, ANCOVA results may not accurately reflect the relationships of the variables (Green & Salkind, 2005). Therefore sequential regression analyses were conducted to investigate the relationship between a direct variable and several independent variables (Tabachnick & Fidell, 2007) after tests for assumptions had been validated. The direct variable (DV) for the analysis was posttest score. The independent variables (IV) for the analysis were: pretest score, group, control and treatment; gender; and socio-economic status (SES), economically disadvantaged (LSES) and non-LSES (NLSES). Because of the observation of different levels of engagement from the pilot study, the researcher questioned if the amount of time playing the game would impact students' mathematics achievement and added a fourth question to the study and added the IV, minutes played, to the analysis. The pretest score was used with each regression analysis to act as a covariate to account for the different starting points of the subjects. This approach computes estimated posttest scores while holding pretest scores constant.

Figure 1

Sequential Regression



Adapted from Tabachnick and Fidell, 2007.

Sequential regression analyses were conducted as part of this study. To conduct the sequential model, often called hierarchical regression (Tabachnick & Fidell, 2007), IVs are "entered into the regression equation in an order specified by the researcher. Each IV (or set of IVs) is assessed in terms of what it adds to the equation at its own point of entry" (Tabachnick & Fidell, 2007, p. 138). The order of entry is determined by theoretical or logical consideration (Tabachnick & Fidell, 2007). The first IV entry will receive more degree of importance, the second, lesser degree of importance to the last entry receiving the least degree of importance. Figure 3.1 illustrates a sequential regression model. The area encompassing the intersection of the DV with IV_1 is credited with the impact of this IV on the DV. The impact of IV_2 is indicated by the area of the intersection of the DV and IV_2 less the area included in the intersection of IV_1 and the DV indicated earlier. As each IV is added, only the area of intersection with the DV and the IV less previous intersection of IVs with the DV is considered the impact of the added IV. In each analysis using SPSS, pretest was the first IV entered into the regression format, allowing the researcher to use the pretest as a covariant holding constant the initial differences in mathematics ability (Tabachnick & Fidell, 2007).

To answer the second question, “Are there statistically significant differences in mathematics achievement between students who play an interdisciplinary MMOG and students who do not play an interdisciplinary MMOG?”, the sequential regression analysis was conducted to determine if significant differences in mathematics posttest scores resulted from students playing an interdisciplinary MMOG. Using SPSS, posttest scores were entered as the direct variable with pretest scores and group (control or treatment) as independent variables.

The sequential regression analysis was utilized to investigate student characteristics along with playing a MMOG, resulted in significant differences in students’ mathematics posttest scores to answer the third question, “To what extent do students’ gender, SES, and the relationship of playing or not playing an interdisciplinary game have on ninth grade students’ mathematics achievement?”. Using SPSS to compute the sequential regression analysis, the direct variable was posttest scores with independent variables entered in the following order: pretest scores, group, SES, and gender.

Another sequential regression analysis was conducted only on the treatment group examining the effect of the amount of time playing the MMOG on student mathematics achievement to answer the fourth question “Is there a statically significant relationship between the amount of time playing the MMOG and mathematics scores among ninth grade students who played the interdisciplinary MMOG?”. Time was determined by the difference in the time that a student logged into the MMOG and time logged out of the MMOG. It does not reflect time engaged in the various tasks of the game. Conducting a sequential regression using SPSS with posttest as the direct variable, pretest and time in the game were used as independent variables. To also examine the effect of the amount of time in the MMOG along with student characteristics on ninth grade student mathematics achievement expanded question four to give a more complete understanding of the interactions of time in the MMOG with student characteristics. The independent variables SES and gender were added and entered in the following order: pretest scores, minutes in MMOG, SES, and gender.

Summary

The focus of Chapter 3 was the overall research design of the study. The chapter focused on five components of the research design: introduction to the study; context of the study including descriptions of the community, school district and school involved in the study; the population and sampling procedures; the instrumentation of the mathematics pretest and posttest; and method of data analysis used to address the study. Design and methodology are essential factors when analyzing data for the study. This chapter prepares the reader for the next chapter, Chapter 4, Research Findings.

CHAPTER 4: RESULTS

Introduction

The purpose of this study was two-fold. First, the study aimed at investigating the effects of an interdisciplinary massive multi-player online game (MMOG) on high school students' mathematics achievement. Secondly, the study examined the interactions of student characteristics and digital game based learning in an effort to identify which student characteristics may impact student achievement with digital game based learning. The following research questions that guided this study were:

1. What effect does digital-game play have on ninth grade student mathematics achievement as measured by a district created standards-based exam?
2. Are there statistically significant differences in ninth grade student mathematics achievement between students who play an interdisciplinary MMOG and students who do not play an interdisciplinary MMOG?
3. To what extent does students' gender, socioeconomic status, and playing or not playing an interdisciplinary MMOG have on ninth grade student mathematics achievement?
4. Is there a statistically significant relationship between the amount of time playing the MMOG and mathematics scores among ninth grade students who played the interdisciplinary MMOG?

Pretests and posttest designed for the study contained 20 standardized mathematics questions that were compiled and adjusted from released state core curriculum test (CCT) items and sample test items for 8th grade mathematics and Algebra I. Students took the pretest prior to treatment and took the posttest after treatment. Data were collected and statistically analyzed to generate the findings of this study. The current chapter presents these findings

Summary of Pilot Study

A pilot was conducted to assess the validity of the pretest and posttest and to ensure their reliability. The pilot included 214 first year ninth grade students, who did not participate in the major study, participating during a 50 minute class period. Students were randomly assigned to 18 Leadership classes at the beginning of the year. The researcher randomly selected the treatment (game play) group by drawing nine teachers' names. The other nine classes were the control (no game play) group. Students were randomly assigned to the classes by the school's scheduling software. Therefore, the samples may be considered random.

Pretest and posttest were developed by the researcher and a mathematics teacher to determine the effects of digital game play with a MMOG on mathematics achievement. The math teacher and the researcher, a former math teacher, were highly familiar with eighth grade math and Algebra I state standards. Twenty multiple choice test items were constructed from released eighth grade math CCT items and Algebra I CCT items and from sample CCT items from the state department of education's web site. The test items have been determined to be valid as part of the CCT testing program required by every district in the state. Test items selected consisted of state content standards that would be integrated into the MMOG as reported by the game developers. Test items included solving linear equations using a variety of methods, graphing and interpreting the solution to linear equations with one or two variables, determining the effect of change in slope, analyzing the relationship of slopes of lines in a plane, solving real life problems using rational numbers, determining the surface area and volume of an object, and others. The math test structure was similar to the state's high-stakes tests, eighth grade and the Algebra I core curriculum test (CCT). The posttest was a parallel form of the pretest with changes in the degree of difficulty, such as, changing an integer to a rational number within an equation, changing from a rectangular prism to a cylinder, or changing from a one step problem to a two-step problem. Results from an ANCOVA supports that the tests were parallel forms, with the pretest resulting in $F(1, 205) = 134.95$, $p < 0.01$, and the observed power = 1. Cronbach's Coefficient Alpha was used to assess internal consistency and reliability of the pretest and posttest and found to be 0.81 and 0.79 respectively.

Participants

The population of the study was ninth grade students. The sample was 280 first year ninth grade students participating in a required elective class, Leadership, of the High School. The sample was randomly assigned into two groups, treatment group (game play) and control group (no game play). Demographic information provided by the High School of the ninth grade class were 49 percent male, 51 percent female, 11 percent African Americans, 1 percent Asian Americans, 51 percent Caucasian, 5 percent Hispanic, 31 percent Native Americans, 53 percent of the students were on free and reduced lunch (F/R), 1 percent were English language learners (ELL), and 9 percent were students receiving special education services. The quantitative data from pretests and post-tests were collected and analyzed. The statistical software, *Statistical Package for the Social Sciences* (SPSS), was used to collect descriptive information of the independent variables mentioned above and another variable, time playing the MMOG. Data were missing from 56 students on the pretest and 60 students on the posttest. The statistics program, SPSS, excludes participants with missing data, leaving the sample size of the pretest and posttest 224 and 220 respectively.

Analytic Procedure

Descriptive data were compiled on the raw scores for test results and were disaggregated much as the CCT test results are for the State Department of Education. To answer the first question, the descriptive results were compiled for the study groups. The descriptive results for the entire study group are summarized in Table 3. Table 4 and Table 5 contain the descriptive results for the control group (no MMOG) and treatment group (MMOG-play), respectively.

Sequential regression analyses were conducted to answer the last three study questions concerning the impact of playing an interdisciplinary MMOG on students' mathematics achievement measured by a district created standards based mathematics test. The first multiple regression analysis determined if the pretest and posttests were parallel forms and if the pretest would impact the results of the posttest. The sequential regression analysis tested the impact of playing an interdisciplinary MMOG on students' mathematics achievement. The direct variable was posttest score with the independent variables (predictors) were pretest scores and group (no MMOG-play or MMOG-play). The sequential regression analysis conducted also tested the impact of playing the MMOG along with the demographics of SES, and gender on students' mathematical achievement. Last, a sequential regression analysis was conducted to test the influence of the amount of time playing the MMOG and student characteristics on students' mathematics achievement.

Results by Question

Results for Question One

To determine the effect of digital-game play on ninth grade students' mathematics achievement as measured by a district created standards-based exam, descriptive statistics were computed. Table3contains the descriptive data results from both control and treatment groups including gender, SES, ethnicity, and education program, contain. Table 4 and Table 5 contain the descriptive data for the control group and treatment group, respectively. The

Table 3

Descriptive Statistics of Raw Data

Variable	$\bar{x}$ Pre	$\bar{x}$ Post		*sd* Pre	*sd* Post		n Pre	n Post
Gender								
Male	37.69	44.62	↑	22.69	18.54	↓	108	106
Female	41.98	49.52	↑	22.70	19.97	↓	116	114
Socio-Economic Status								
Low SES	37.94	44.30	↑	20.61	17.95	↓	114	115
Non- Low SES	41.95	50.29	↑	24.69	20.51	↓	110	105
Ethnicity								
African American	40.77	45.00	↑	23.27	18.48	↓	26	24
Asian American	46.67	41.67	↓	33.29	7.64	↓	3	3
Caucasian	42.44	49.46	↑	22.92	19.90	↓	119	120
Hispanic	49.29	41.11	↓	22.81	25.35	↑	7	9
Native American	33.97	44.77	↑	21.35	18.14	↓	68	64
Education Program								
Special Education	33.06	32.37	↓	19.41	11.59	↓	18	19
Regular Education	40.51	48.56	↑	22.96	19.43	↓	206	201
Group								
Control (No Game)	40.83	47.20	↑	22.70	19.50	↓	96	93
Treatment (Game)	39.25	47.13	↑	22.84	19.41	↓	127	127

Note: ↑ - Indicates an increase in $\bar{x}$ or *sd* ↓ - Indicates a decrease in $\bar{x}$ or *sd*

descriptive statistics of students in this study indicate that mean posttest scores overall increased by 7.25 points (*M* = 47.16). Mean posttest scores increased for both male and female groups, 6.93 ($\bar{x}$ = 44.62) and 7.54 ($\bar{x}$ = 49.52), respectively with females having a higher mean by 4.9 points.

Students on free and reduced lunch increased the mean posttest scores by 6.36 points ($\overline{x}$ = 44.30) while those not free and reduced lunches increased the mean posttest scores by 14.70 ($\overline{x}$ = 50.29). A difference between the SES mean posttest scores was 5.99 points higher for the non-low SES. African Americans, Caucasian, and Native Americans increased their mean posttest scores by 4.23 points ($\overline{x}$ = 45.00), 7.02 points ($\overline{x}$ = 49.46), and 10.80 points ($\overline{x}$ = 44.77), respectively. Asian Americans and Hispanics decreased their mean posttest scores by 5.00 points ($\overline{x}$ = 41.67) and 8.18 points ($\overline{x}$ = 41.11). The largest gap in mean scores is between Caucasian and Hispanic students with Caucasian students8.35 points higher. The mean posttest scores decreased for special education student by 0.69 points ($\overline{x}$ =32.37) and regular education students increase their scores by 8.05 points ($\overline{x}$ = 48.56). Regular education students outperformed the special education students by 16.19 points.

The descriptive data for the control group is found in Table 4. Mean posttest scores for all students that did not play the MMOG increased 6.37 points ($\overline{x}$ = 47.20). Mean posttest scores increased for both male and female groups, 5.32 ($\overline{x}$ = 43.15) and 7.57 ($\overline{x}$ = 51.17) respectively with females having a higher mean by 8.02 points. Students on free and reduced lunch saw an increase in the mean posttest scores by 8.51 points ($\overline{x}$ = 46.91) while those not free and reduced increased the mean posttest scores by 4.34 ($\overline{x}$ = 47.50). The difference between the SES mean posttest scores was 3.59

Table 4

Descriptive Statistics of Control Group Math Test Scores

Variable	$\overline{x}$ Pre	$\overline{x}$ Post		*sd* Pre	*sd* Post		n Pre	n Post
Group								
Control (No Game)	40.83	47.20	↑	22.81	19.49	↓	96	93
Gender								
Male	37.83	43.15	↑	20.99	20.04	↓	46	46
Female	43.60	51.17	↑	24.25	18.30	↓	50	47
Socio-Economic Status								
Low SES	38.40	46.91	↑	20.75	17.65	↓	47	47
Non- Low SES	43.16	47.50	↑	24.62	21.43	↓	49	46
Ethnicity								
African American	40.38	47.92	↑	26.26	18.89	↓	13	12
Asian American	75.00		↑			↓	1	0
Caucasian	47.22	50.34	↑	20.77	19.12	↓	45.	44
Hispanic	50.00	41.00	↓	36.06	34.89	↓	3	5
Native American	30.74	43.59	↑	19.74	17.42	↓	34	32
Education Program								
Special Education	34.50	28.18	↓	22.16	10.07	↓	10	11
Regular Education	41.57	49.76	↑	22.90	19.07	↓	86	82

Note: ↑ - Indicates an increase in $\overline{x}$ or sd ↓ - Indicates a decrease in $\overline{x}$ or *sd*

points higher for the non-low SES. African Americans, Caucasian, and Native Americans increased their mean posttest scores by 7.54 points ($\overline{x}$ = 47.92), 3.12 points ($\overline{x}$ = 50.34), and 12.85 points ($\overline{x}$ = 43.59), respectively. Hispanic students mean posttest scores decreased by 9.00 points ($\overline{x}$ = 41.00). The largest mean score gap in ethnicities is between Caucasian and Hispanic students with Caucasian students 9.34 points higher. The mean posttest

Table 5

Descriptive Statistics of Treatment Math Test Scores

Variable	$\bar{x}$ Pre	$\bar{x}$ Post		*sd* Pre	*sd* Post		n Pre	n Post
Group								
Treatment (Game)	39.25	47.13	↑	22.84	19.41	↓	127	127
Gender								
Male	37.58	45.75	↑	24.04	17.39	↓	62	60
Female	40.85	48.36	↑	21.72	21.11	↓	65	67
Socio-Economic Status								
Low SES	37.61	42.50	↑	23.80	18.07	↓	67	68
Non- Low SES	41.08	52.46	↑	25.11	19.68	↓	60	59
Ethnicity								
African American	41.15	42.08	↑	20.93	18.40	↓	13	12
Asian American	32.50	41.67	↑	31.82	7.64	↓	2	3
Caucasian	39.53	48.95	↑	23.80	20.43	↓	74	76
Hispanic	48.75	41.25	↓	13.15	9.47	↓	4	4
Native American	37.21	45.94	↑	22.67	19.03	↓	34	32
Education Program								
Special Education	31.25	38.13	↑	16.64	11.63	↓	8	8
Regular Education	39.79	47.73	↑	23.16	19.71	↓	119	119

Note: ↑ - Indicates an increase in $\bar{x}$ or *sd* ↓ - Indicates a decrease in $\bar{x}$ or *sd*

scores decreased for special education student by 6.32 points ($\bar{x}$ = 28.18) and regular education students increase their scores by 8.19 points ($\bar{x}$ = 48.56). Regular education student outperformed the special education students by 21.58 points.

The descriptive data for the treatment group are included in Table 5. Mean posttest scores for all students that did play the MMOG increased 7.88

points ($\bar{x}$ = 47.13). Mean posttest scores increased for both male and female groups, 8.17 ($\bar{x}$ = 45.75) and 7.51 ($\bar{x}$ = 48.36) respectively with females having a higher mean by 2.61 points. Students on free and reduced lunch had an increase in the mean posttest scores by 4.89 points ($\bar{x}$ = 42.50) while those not free and reduced increased the mean posttest scores by 11.38 points ($\bar{x}$ = 52.46). The difference between the SES mean posttest scores was 9.96 points higher for the non-low SES. African Americans, Asian Americans, Caucasian, and Native Americans increased their mean posttest scores by .93 points ($\bar{x}$ = 42.08), 9.17 points ($\bar{x}$ = 41.67), 9.42 points ($\bar{x}$ = 48.95), and 8.73 points ($\bar{x}$ = 45.94), respectively. Hispanic students' mean posttest scores decreased by 7.50 points ($\bar{x}$ = 41.25). The largest gap of 7.70 points is between Caucasian and Hispanic students with Caucasian students higher. The mean posttest scores increased for special education student by 6.88 points ($\bar{x}$ = 38.13) and regular education students increased their scores by 7.94 points ($\bar{x}$ = 47.73). Regular education student outperformed the special education students by 9.60 points.

To answer questions 2 through 4, a series of hierarchical regression models was used to determine the effect of playing an interdisciplinary MMOG has on ninth grade students' mathematics achievement. Variables such as group, SES, gender, and time playing the MMOG were examined. In each model the students' pretest scores were entered in step 1. As expected, students' pretest scores did predict students; posttest scores. To answer question 2, group (no game play or game play) was entered in Step 2 of the regression model. To answer question 3 and to test the interaction effects, SES was entered followed by gender. To answer question 4, the time spent in playing the games was entered as the second step of the regression model. The hierarchical regression results will be disclosed as each question is discussed.

Results for Question Two

Sequential regression analyses were conducted to answer the last three study questions concerning the impact of playing an interdisciplinary MMOG on students' mathematics achievement measured by a district created standards based mathematics test. The first sequential regression analysis determined if the pretest and posttests were parallel forms and if the pretest would impact the results of the posttest. As expected, the regression equation was significantly related with students' pretest scores and may predict

Table 6

The Prediction of Student's Posttest Score as Determined by the Pretest Score and Group: Control – No Play and Treatment – Play

	Independent Variable	df	ΔF	ΔR^2	β
Step 1	Pretest	1, 185	42.77**	.19**	.37**
Step 2	Pretest	1, 185	42.77**	.19**	.37**
	Group	2, 184	.04	.00	.51

Note: *p<0.05, **p<0.01

students' posttest scores, $F(1, 185) = 42.77$, $p < 0.01$, $R^2 = 0.19$. See Table 6 and Table 7 for regression results. The sample multiple correlation coefficient was .43, indicating that approximately 19 percent of the variance of the posttest scores can be accounted for by the pretest scores. In Step 2, pretest

Table 7

The Bivariate and Partial Correlations of the Predictors of Student's Posttest Score Determined by the Group

Independent Variable Predictor	Correlation between each predictor and the posttest scores	Correlation between each predictor and the posttest scores controlling for all other predictors
Step 1		
Pretest	.43	.42
Step 2		
Pretest	.43	.42
Group	.02	.02

Note: *p < 0.05, **p < 0.01

was entered followed by group to determine the effect of playing an MMOG or not playing an MMOG on mathematics posttest results. Again, significant results were found in pretest, $F(1, 185) = 42.77$, $p < .01$, $R^2 = 0.19$. The following are the results of adding group into the linear equation, ΔF (1, 184) =.04, $p > .05$, $\Delta R^2 = .00$. These results indicate that playing the MMOG had no impact of students' mathematics achievement on a district developed standardized test.

Results for Question Three

Another sequential regression analysis was conducted to test the determine if playing the MMOG and the demographics of SES, ethnicity,

Table 8

The Prediction of Student's Posttest Score as Determined by Group: Control and Treatment

	Independent Variable	df	ΔF	ΔR^2	β
Step 1	Pretest	1, 185	42.77**	0.19**	0.35**
Step 2	Group	1, 184	0.04	0.00	0.63
Step 3	SES	1, 183	4.01*	0.02*	-5.24*
Step 4	Gender	1, 182	2.70	0.01	-2.62

Note: *p<0.05, **p<0.01

gender, and education program would influence students' mathematical achievement. The dependent variable of posttest was entered and the independent variables of pretest, group, gender, and SES were entered in a sequential regression analysis. The predictors of students' posttest scores are summarized in Table 8. Regression results indicate that neither group nor gender have a significant effect on students' posttest score with $\Delta F(1,184) = .04$, $p > .05$ and $\Delta F(1, 182) = 2.70$, $p > .05$, respectively. However, students of low socioeconomic status (LSES) show negative impact by playing the MMOG $\Delta F(1, 183) = 4.01$, $p < 0.05$, and were negatively impacted by playing the MMOG by -5.24 points. The bivariate and partial correlation results of the IVs are summarized in Table 9.

Table 9

The Bivariate and Partial Correlations of the Predictors of Student's Posttest Score Determined by Group

Independent Variable Predictor	Correlation between each predictor and the posttest scores	Correlation between each predictor and the posttest scores controlling for all other predictors
Pretest	0.43	0.42
Group	0.02	0.02
SES	-0.15*	-0.15*
IEP	-0.10	-0.08

Note: *p < 0.05, **p < 0.01

Results for Question Four

To determine if there was a statistically significant relationship between the amount of time playing the MMOG and mathematics scores among ninth grade students, another regression analysis was conducted on the posttest scores of those who played the game. Step 1 pretest was entered followed by step 2 with time entered. The results of the analysis are indicated in Table 10 with ΔR2= 0.10, $\Delta F(1, 110) = 12.59$, $p < .01$, $\beta = 0.28$ and $\Delta R^2 = 0.10$, $\Delta F(2, 109) = 13.91$, $p < .01$, $\beta = 0.10$respectively. Approximately ten percent of the variance of student posttest scores may be accounted for by the pretest scores and ten percent of the variance may also be contributed to the amount of time students played the MMOG. The correlation coefficients were 0.32 and 0.36 for pretest and time playing the MMOG respectively (See Table 11).

Table 10

The Prediction of Student's Posttest Score as Determined by the Pretest Score and Minutes Played (Treatment Only)

	Independent Variable	df	ΔF	ΔR^2	β
Step 1	Pretest	1, 110	12.59**	.10**	.27**
Step 2	Pretest	1, 110	12.59**	.10**	.23**
	Time	2, 109	13.91**	.10**	.10**

Note: *p<0.05, **p<0.01

The results indicate that for every minute that a student plays the MMOG, their posttest results will increase by 0.10 points. If a student plays one hour, posttest results may increase by 6 points.

Table 11

The Bivariate and Partial Correlations of the Predictors of Student's Posttest Score Determined by the Minutes Played

Independent Variable Predictor	Correlation between each predictor and the posttest scores	Correlation between each predictor and the posttest scores controlling for all other predictors
Step 1		
Pretest	.32**	.32**
Step 2		
Pretest	.32**	.27**
Time	.36**	.32**

Note: *p < 0.05, **p < 0.01

To expand question 4, a sequential regression analysis was conducted with the independent variables of pretest, time (minutes) playing in the game, SES, and gender to determine the interactive effects. The results are indicated in Table 12. Pretest results again were significant,

Table 12

The Prediction of Student's Posttest Score as Determined by the Minutes Played (Treatment Only), SES, and Gender

	Independent Variable	df	ΔF	ΔR^2	β
Step 1	Pretest	1, 110	12.59**	.10**	.20**
Step 2	Time	1, 109	13.91**	.10**	.11**
Step 3	SES	1, 108	13.13**	.06**	-11.24**
Step 4	Gender	1, 107	0.35	.00	-1.85

Note: *p<0.05, **p<0.01

$\Delta R^2 = .10$, $\Delta F(1, 110) = 12.59$, $p < .01$, $\beta = 0.28$ with the sample multiple correlation coefficient of .28. However, results indicated that gender did not have a significant effect on students posttest score with $\Delta F(1, 109) = .35$, $p > .05$, $\beta = -1.85$ with the sample multiple correlation coefficient of -.08. Results did indicate significance in the interactions of the independent variables time played and SES, $\Delta R^2 = .10$, $\Delta F(1, 109) = 13.91$, $p < .01$, $\beta = 0.11$ and $\Delta R^2 = .06$, $\Delta F(1, 108) = 13.13$, $p < .01$, $\beta = -11.24$, respectively. The sample multiple correlation coefficients were .32, .36 and -.29 (see Table 13). Significant differences were found in the variables of pretest, minutes played, and SES with $p < .01$. The results for minutes played suggests that for every minute a student plays the game, posttest scores will increase .11 points. If a student plays for one hour, test scores may increase 6.6 points. However, the analysis also suggests that an economically disadvantaged student test results may decrease by 11.29 points, $p < .01$, if engaged in MMOG-play.

Table 13

The Bivariate and Partial Correlations of the Predictors of Student's Posttest Score Determined by the Time Played (Treatment Only), SES, and Gender

Independent Variable Predictor	Correlation between each predictor and the posttest scores	Correlation between each predictor and the posttest scores controlling for all other predictors
Pretest	.32**	.28**
Time	.36**	.37**
SES	-.29**	-.33**
Gender	-.07	-.06

Note: *p < 0.1, **p < 0.01

Summary

Chapter 4 provided statistical results of a research study conducted in a large rural high school. Two hundred eighty ninth grade students took a mathematic pretest and/or posttest. There were 185 students that completed both pretest and posttest with an overall rate of 66 percent. The data were analyzed using descriptive statics and sequential regression analysis. The chapter included tables reflecting the data and elucidations related to the research questions. Chapter 5 addresses conclusions, implications, and recommendations for further studies based upon these findings.

CHAPTER 5: CONCULSIONS, IMPLICATIONS, AND RECOMMENDATIONS

Introduction

Mathematics has been called "a gatekeeper of opportunities" (Buckley, 2010) for higher education and for those who will succeed or not succeed in critical careers necessary for our nation's economic future. The United States has fallen behind other industrialized nations in mathematics standardized test results (Hambleton, Sierci, & Smith, 2009). Putnam and Borko (2000) argue that students learn mathematics concepts better when they learn them in authentic problems in a situated learning environment. Digital game-based learning is immersed with constructivist practices and has been gaining much attention as the next era of teaching tools. When engaged in a MMOG, players are immersed in authentic problems in a virtual world. A myriad of skills are utilized when a person is involved in digital game play. Among the many skills are many twenty-first century skills (i.e., critical thinking, collaboration, etc.) that industry and universities expect of those leaving an educational institution.

Review of the Study

Chapter 1 of this study included a brief summary of twenty-first century skills, a brief background of education, a brief overview of technology and of digital game play among current students, the problem statement, purpose, and research questions. The significance of this study is found in the contributions made to the body of literature involving factors affecting ninth grade student mathematics achievement through the constructivist strategy of digital game-based learning with an interdisciplinary massively multiplayer online game (MMOG) as it relates to gender differences and socio-economic status. Results will provide a springboard for researchers and practitioners to continue research into the learning possibilities of using educational MMOGs.

Chapter 1 also included four research questions that guided this study:

1. What effect does digital-game play have on ninth grade students' mathematics achievement as measured by a district created standards-based exam?
2. Are there statistically significant differences in ninth grade students' mathematics achievement between students who play an interdisciplinary MMOG and students who do not play an interdisciplinary MMOG?
3. To what extent do students' gender, socioeconomic status, and the relationship of playing or not playing an interdisciplinary MMOG have on ninth grade students' mathematics achievement?
4. Is there a statistically significant relationship between the amount of time playing the MMOG and mathematics scores among ninth grade students who played the interdisciplinary MMOG?

Schools are mandated to use research driven curriculum and techniques to teach course content. Few empirical studies exist to support the claims that digital game-based learning is an effective learning tool (e.g., Gee, 2003; Squire, 2004; Warren & Dondlinger, 2009). This study will provide empirical evidence to the effectiveness of an interdisciplinary MMOG and its effect on ninth grade mathematics achievement. Practitioners must determine if using an interdisciplinary MMOG is an effective learning tool as it relates to gender differences and as it relates to socioeconomic differences.

Chapter 2 included the literature review which encompassed the following areas: mathematics education, twenty-first century skills, constructivism, and digital game-based learning. The research indicated that the gap in mathematics achievement between boys and girls is closing. Yet, the education gap still persists between children of poverty and children not in poverty. Studies indicate that student learning is more successful when engaged in a constructivist manner in which concepts are taught in situated learning environments. Proponents of digital game-based learning boasts that digital game-based learning is the next era of teaching (e.g., Barab et al., 2005; Gee, 2003; Prensky, 2006; 2007; Schaffer, 2006; Steinkuehler, 2008). Yet, there is little empirical evidence to relate the effectiveness of this teaching avenue.

A detailed method of study to answer the research questions was presented in Chapter 3. The population of the sample included ninth grade students from a large rural school district in a Midwestern state. Two groups were included in the study, a control group with no MMOG play and a treatment group with MMOG play. An experimental was designed to utilize quantitative methods to obtain data to evaluate the effectiveness of an interdisciplinary MMOG on students' mathematics achievement as measured by a standardized mathematics test. The processes for statistical analysis were thoroughly described.

The process of student data analysis is described in Chapter 4. Descriptive statistics of mathematics tests included mean and standard deviation of each group and subgroup were used to answer the first question. Tables included the descriptive statistics of the whole sample. The entire sample was separated into control and treatment groups. The remaining three questions were explored using sequential regression analyses to determine if there was a statistical significant difference in mathematics posttest scores after the treatment of playing an interdisciplinary MMOG between test groups, SES, and gender.

Summary of the Results

The results of this study indicate that a relationship may exist between ninth grade students' mathematics achievement scores on a district created standardized test and playing an interdisciplinary MMOG. This study's findings indicated that there are no statistical differences in mathematics test scores based upon gender and MMOG play. However, results inferred that statistical differences did occur based on socioeconomic status and the amount of time engaged in MMOG play. A discussion of each research question and the findings are included in the following paragraphs.

The first research question asks, "What effect does digital-game play have on ninth grade student mathematics achievement as measured by a district created standards-based exam?" Descriptive statistics summarizing pretest and posttest scores were found and summarized in Tables 3 – 5: all students, control group, and treatment group. The subgroups in the tables included group, control and treatment; gender, male and female; socioeconomic status, LSES and NLSES; ethnicity, African American, Asian American, Caucasian, Hispanic, and Native American; and educational program, special education and regular education. Results show that the difference in mean mathematics scores increased for each group with the exception of the control and treatment groups of Hispanic students, give a decrease of 9.00 and 7.50 respectively, and control group of special education students, a decrease of 6.32 points. However, the special education treatment group had an increase of 6.88 points. Females scored higher than males in both the control and treatment groups. The differences were females scoring higher by 8.02 points and 2.61 points, respectively. The male treatment group was nearly 3 points higher in mean scores than the male control group. The largest difference in mean scores was found in SES groups with NLSES mean scores of the treatment group increasing 11.38 points compared to the LSES group increasing the mean test results by 4.89 points. These results, and perhaps the level of math use and math course taking differences between the groups, indicated a need for further analysis to test for significance.

Research Question 2 asked, “Are there statistically significant differences in ninth grade student mathematics achievement between students who play an interdisciplinary MMOG and students who do not play an interdisciplinary MMOG?” A sequential regression analysis was conducted to measure the results of the mathematics scores of the control group and the treatment group. The regression analysis results found no significant difference in the main effect of the control and treatment group, indicating student engagement in digital-game play on an interdisciplinary MMOG had no effect on ninth grade student mathematics achievement as measured by a district created standardized mathematics exam.

Question 3 asked, “To what extent do students’ gender, SES, and the relationship of playing or not playing an interdisciplinary game have on ninth grade students’ mathematics achievement?” was determined by a sequential regression analysis. Sequential regression results did not associate statistically significant mean posttest differences in regard to group or gender. However, results indicate that SES status impacted students’ posttest scores. Lower mean mathematics posttest scores were associated with LSES students.

Research question 4 asked, “Is there a statistically significant relationship between the amount of time playing the MMOG and mathematics scores among ninth grade students who played the interdisciplinary MMOG?” This question examined only the students in the treatment group who played the interdisciplinary MMOG. A sequential regression analysis conducted on the treatment group posttest scores indicate statistically significant results of the independent variables: pretest, time (minutes played), and SES, $p < .01$. There is an associated increase of .11 points on the posttest scores for every minute a student was engaged in playing the interdisciplinary MMOG. Implying if a student plays for one hour on the MMOG, posttest scores may increase 6.6 points. However, the results also associated a decrease of 11.29

points on posttest results for LSES student's engaged in MMOG play. The possible net effect of one hour of MMOG play for a LSES student may be a decrease of 4.69 points. If a LSES student participated in two hours of MMOG play, the posttest scores may increase 1.91 points. Although the results of gender were not found to be significant, results indicate if a student who played one hour on the MMOG was LSES and female, her mathematics posttest score may be lower than the NLSES male student who played one hour on an interdisciplinary MMOG by 6.49 points (time, 6.6; LESE, -11.29, gender, -1.85).

Interpretation of the Findings

Descriptive statistics summarized results from mathematics pretests and posttests scores. Increases were found in all subgroups except Hispanic students, both control group and treatment group, and the special education students in the control group. However, special education students in the treatment group mean test scores increased. Although this study did not focus on ethnicity and education program, the mean results are interesting.

Female students mean scores were higher than male students in both the treatment and control groups. However, increase in the female control group's mean posttest score was 5.41 points higher than the increase of the treatment group. The increase in the mean posttest score was 3 points higher for the treatment group than the control group for male students.

An achievement gap has existed between LSES students and NLSES for centuries. The difference LSES students and NLSES students may be expected based on years of research and interventions from the federal government with policies such as the Elementary and Secondary Education Act (ESEA) of 1965 and No Child Left Behind (NCLB) of 2002 (Barr & Parrett, 2007). ESEA provided equal access and equal treatment for poor students in educational environments. NCLB demands academic proficiency for all students in reading, science, and math. However, the 6.49 points in the mean differences of the treatment NLSES, 11.38 points, and treatment LSES, 4.89 points, was unexpected. The differences in the mean scores may indicate that an interdisciplinary MMOG may provide an avenue to support male mathematics achievement and NLSES mathematics achievement more than female mathematics achievement and LSES mathematics achievement. Therefore, conducting the sequential regression analyses to determine if the differences are significant was needed.

A sequential regression analysis was conducted to determine if there was a significant main effect on ninth grade students' mathematics achievement as determined by a researcher created standardized standards based posttest instrument (see Appendix B). Students were randomly assigned to control (no MMOG play) and treatment (MMOG play) groups. The interdisciplinary MMOG contained scenarios that supported eighth and ninth grade mathematics, English, science, and social studies standard as reported by the game developers (see Appendix C). The scenarios were developed to challenge students to use 21st century skills (Casner-Lotto & Barrington, 2006; Stansbury, 2008; Sternburg & Subotnik, 2006) of critical thinking/problem solving, teamwork/collaboration, creativity/innovation, written communications, leadership, and work ethic to maneuver though the game. Although standardized testing may not the best method to determine if students can apply content knowledge to real world (or virtual world) scenarios, this is the most commonly used method for determining if students have mastered content (Jacobs, 2010b). No statistically significant main effect was found between students the control and treatment groups.

Game play occurred during 14 50-minute class periods. Procedures for checking out equipment and logging into the game varied among all classes. This may have limited the amount of time students were actually immerged in the digital environment. Constructivist practices include participatory environments in which students construct meaning through their individual experiences (Airasian & Walsh, 1997; Boethel & Dimock, n.d.; Brooks & Brooks, 1993; Cook, 2006; Honebien, Duffy, & Fishman, 1993). An interdisciplinary MMOG is such an environment (Dickey, 2006). If time was limited the student may not have the opportunity for full engagement. Therefore their results may tend to reflect that of the control group.

The interaction of playing the MMOG and the subgroups of group, gender and SES results from the sequential regression analysis indicated no significant main effect on mathematics scores between groups (control or treatment) or genders. Finding no statistical significance in the mathematics posttest results may indicate that the MMOG did not enhance students' learning in relationship with the mathematics achievement. However, no statistical significance between the groups may indicate that playing the MMOG did not deter mathematics achievement.

It is reported that dominate gender playing digital games are male (Dickey, 2006; Hayes, 2005; Royse, et.al., 2007; Williams, Yee, & Caplan, 2008). Science, technology, engineering, and mathematics careers have long been associated with men (Jackson, n.d.; James, 2007). Jackson reported that 74 percent of STEM careers are possessed by men compared to 26 percent possessed by women. Mathematics is the critical foundation of these careers. Weins (2007) indicated that the mathematics achievement gap was closing and ESA (2008) indicated that the fastest growing demographic of players is women. To find no statistically significant differences in the mathematics posttest scores between the genders and those who played the MMOG is a significant result.

A significant main effect was found between SES groups. This is not atypical of research concerning achievement of students from low socioeconomic background (Barr & Parrett, 2007; Barton, 2003; Smith, Lee, & Newmann, 2001). The achievement gap between students of poverty and students of middle classes and upper classes has been an issue of concern. The implementation of Title 1 in schools targeted students from LSES backgrounds to provide programs to improve achievement. Stevenson (2006) reported that students of poverty were known as the digitally divided because few disadvantaged households have computers and less have Internet access. Therefore, students of poverty may be unfamiliar with the participatory environment of a MMOG. Williams, Yee, and Caplan (2008) reported that the average income level of gamers in *Everquest 2* was $85,715 per year, far above the poverty level. Lewis (2007) reported that disadvantaged children rely on schools for internet access. Most schools have a system that filters out digital games therefore students of poverty are indeed digitally divided in regard to MMOGs. This research study implies that the interdisciplinary game may not be a viable tool to improve LESE student mathematics achievement.

Research question 4 focused only on the students that spent time in MMOG play (treatment group). If conducted on control group and treatment group, a linear relationship could not be found with time as a variable because all control times were zero minutes. Results showed a statistically significant difference in the main effect of mathematics achievement for the amount of time a student was logged in the interdisciplinary MMOG. The results indicated for every minute a student was logged in MMOG, mathematics posttest scores were increased by .11 points. Although no empirical evidence was found about the amount of time students engage in a MMOG in regard to achievement, much has been discussed about gamer engagement and emergence in digital games (Barab et al., 2005; Gee, 2003; Prensky, 2006; 2007; Schaffer, 2006; Steinkuehler, 2008). If a student engages in the MMOG for one hour, results indicate that mathematics achievement may increase by 6.6 points. These results indicate that a MMOG may be a viable tool to support student mathematics achievement if students engage in play for long periods of time.

The results of the interaction of time and student characteristics also reflected significant main effect for SES groups with LSES students scoring lower than NLSES. The difference in the mean score of the mathematics posttest scores was 11.14 points lower for LSES students. This may be expected based on the research on poverty (i.e., Barr & Parrett, 2007; Barton, 2003; Lewis,2007; Payne , 2003:Stevenson: 2009). Students of disadvantaged backgrounds generally start school behind students of advantage struggling to catch up, and many times fall farther behind (Barton, 2003). Disadvantaged students have limited resources (Barr & Parrett, 2007; Barton, 2003; Lewis, 2007; Payne, 2003) including computers and Internet access at home (Lewis, 2007; Stevenson, 2009). Lewis (2007) reported these students depend on schools to provide that access. The typical school has limited time for students to access computer for anything other than research and other school related assignments. Seldom are computer resources available to students at times other than the school day. Therefore, disadvantaged students experience another factor to increase the gap between themselves and students of advantaged backgrounds. However, the results on the amount of time engaged in game play are promising and may be a catalyst to bridge the gap between disadvantaged and advantaged students. If a student were to engage in the interdisciplinary MMOG, approximately 100 minutes of game engagement may close this gap. The analysis indicates that if a LSES student engages in the interdisciplinary MMOG for two hours (120 minutes), test scores of LSES students may increase 2.06 and three hours (180 minutes) mathematics scores may increase 8.66 points. Therefore, engaging LSES students in an interdisciplinary MMOG over long periods of time may be a promising learning tool.

There is an associated increase of .11 points on the posttest scores for every minute a student was engaged in playing the interdisciplinary MMOG. Implying if a student plays for one hour on the MMOG, posttest scores may increase 6.6 points. However, the results also associated a decrease of 11.29 points on posttest results for LSES student's engaged in MMOG play. The possible net effect of one hour of MMOG play for a LSES student may be a decrease of 4.69 points. If a LSES student participated in two hours of MMOG play, the posttest scores may increase 1.91 points. Although the results of gender were not found to be significant, results indicate if a student who played one hour on the MMOG was LSES and female, her mathematics posttest score may be lower than the NLSES male student who played one hour on an interdisciplinary MMOG by 6.49 points (time, 6.6; LESE, -11.24, gender, -1.85).

Implications for Practice

The results of this study point to important issues to be considered when integrating digital game-based learning into classrooms. Proponents of digital game-based learning argue that students' learn concepts better when applied to authentic problems in situated learning environments (i.e., Carroll, 2000; Rosen & Soloman, 2007; Smith, Lee, & Newman, 2001). The results of this study suggested that student engagement, specifically the amount of time playing the game has significant impact in the transfer of student learning. To integrate a MMOG as part of the curriculum, it may be necessary to schedule large chunks of time that will allow students to engage fully in game play whether in the school day or as after-school activities. MMOGs may be a beneficial intervention tool for students who struggle in mathematics and other subject matters whose standards are covered in the tasks of the game.

Historically, children of poverty score lower than other students. Although programs (i.e., Title I, headstart, and after-school programs) have been established to close the achievement gap between LSES and NLSES students, it still exists. While students today have been raised in this digital age, not all students play digital games as implied by some. Many students of poverty do not have a computer in the home or access to the Internet if one is in the home (Stevenson, 2009). This lack of equipment and Internet access is yet another disadvantage children of poverty must overcome. If digital game-based learning is a promising tool to increase student learning, it is important to find ways for children of poverty to be given every opportunity to have access to these tools.

Some educational researchers (e.g., Gee, 2003; 2005; Shaeffer, 2006) called for minimal teacher guidance during implementation of games. The implementation model followed this minimal-external-guidance model. The results, however suggested that teachers' scaffolding is crucial if digital game-based learning is to be successful. The results of this study supported the arguments by Kirschner, Sweller, and Clark (2006) which stated that minimally guided instructional approaches are less effective and less efficient than instructional approaches that place strong emphasis on guidance of the student learning process. Students of disadvantaged backgrounds may need extra scaffolding from teachers to experience success.

A resource that would enable teachers to integrate a digital game into their curriculum is access to information about the standards that are integrated into the game. If the objectives and standards are listed for the activities or scenarios, teachers can better integrate it within their curriculum. If scenarios are stand-alone, they can have students go to the particular location in the game to engage in the activity that supports the objective of the lesson being supported by the game. Another reason to have access to this information is to provide them with the objectives so they may better provide the scaffolding that students may need to work through a scenario.

Teacher access to student work is important for teachers to monitor the learning of students. This MMOG had a teacher site that provided teachers access to student data such as chat, spreadsheets, report submissions, time in the game, and number of tasks attempted and completed. However, the teacher website was developed on a PC platform and teachers' computers were Macintosh platform. Access to the teacher website that is web based is important. If it is web based, teachers should be able to access student information from any computer platform. Access to student work will enable teachers to incorporate the activity within the game into coursework and grading, leading to student accountability.

Recommendation for Leaders

Educational leaders are critical to guiding schools to develop practices that engage students and increase student learning. Leithwood, Louis, Anderson and Wahlstrom (2004) indicated that high-quality leadership is second to teaching in impacting student learning. Three leadership practices of great educational leaders are: setting directions, developing people, and redesigning the organization (Leithwood, Louis, Anderson, & Wahlstrom, 2004).

Developing and articulating a vision of quality instructional design is critical.   As educational leaders research, understand, and identify good endogenous games, they will come to realize that good game design encompasses good instructional design (Halverson, 2005). Games are successful partly because "of the underlying social, cognitive, and developmental learning principles" (Halverson, 2005) on which they are designed.   It is also important to understand digital game based learning to face assumptions about digital game play from teachers, school boards, parents, and other members of the community.

Developing partnerships with game designer and universities is important for public schools. The research conducted for this study could not have occurred if a partnership had not been developed between the educational leaders and the University of Oklahoma. They provided the MMOG, the ultra-mobile personal computers, professional development, and technical support throughout the study.

It is important to provide teacher training while incorporating digital game based learning into the curriculum. This training should continue throughout the school year. Just-in-time resources should also be available to provide the scaffolding that teachers need to implement this new learning tool. Clark and Dede (2008) reported that teacher training and ongoing training were important in integrating endogenous games into the classroom. They provided opportunities for face-to-face training, train-the-trainer for districts, just-in-time-webinars, and monthly online training sessions. Technical support is critical from the game designers and educational leaders should confirm that training for the game being incorporated into the classroom is provided.

Educational leaders must provide time. This may mean restructuring the organization by changing instructional time or design. Students need time to participate in authentic learning environments whether in a regular classroom or in a virtual environment. It is also important that any new instructional method be monitored for proper implementation and high expectations for student engagement and achievement. This research was successfully implemented because the researcher was an educational leader within the school system and provided a schedule within a transitional course with goals that aligned with the design of the MMOG (i.e., collaboration, teamwork, study skill, critical thinking). Bi-weekly meetings with teachers were also conducted to discuss implementation and technical issues. Educational leaders may need to provide time before school, after school, or during the school day to provide the technology necessary for those who have no access to the digital game environment other than at school. With appropriate planning and support, implementation of digital games can be successful in impacting student learning.

Recommendations for Further Research

This experimental study focused on the effect of digital game-based learning on 9th grade students' mathematics achievement. It examined the difference in group mean mathematics test results between those who played and MMOG and those who did not play an MMOG and examined the mean differences in the interaction of game play and student characteristics (gender and SES). It was determined when piloting the study that time engaged in game play could fluctuate between students therefore amount of time engaged was included in this study. This study also examined the amount of time students were engaged in digital game play and extended the examination to include game play and student characteristics (gender and SES). Study results indicated that the amount of time involved in playing the MMOG positively impacted student achievement. The following are recommendations for further research:

1. The effect of playing an MMOG on student achievement to validate this study.

2. The impact of time playing MMOGs on student achievement. Will it support this study?
3. The effect of the number of scenarios or tasks (both quantity and quality) completed in the MMOG on student achievement.
4. The effect of availability of computers and Internet on digital game play and on student achievement.
5. The effect of incorporating activities in an MMOG within the course curriculum on student achievement.

Summary

This experimental study provided insight to the impact of playing an interdisciplinary MMOG on ninth grade students' mathematics achievement. Students were randomly assigned to control and treatment groups. A standards-based mathematics pretest was given to students before the study began. Students played an interdisciplinary MMOG for 14 class periods in a seven week time frame within a 50-minute elective course. A posttest was administered after the 14 week period. Statistically significant differences were found in math achievement of SES, the interaction of group and SES, time playing the game, and interaction of time playing the game and SES.

The information provided by the data analysis reveals that LSES students lag behind NLSES. Results also indicated that interaction of game play and LSES students have a negative impact on mathematics achievement. However, when analyzing the data on the amount of time playing the MMOG, a positive result occurred implying that mathematics achievement may be impacted by .11 points for every minute students play the MMOG. This implies that students who play the MMOG for 100 minutes may increase mathematics achievement by 11 points. Data analysis for the interaction of time played and SES resulted negatively for SES. If a student was LSES, implications are a decrease of 11.29 points. However, a LSES student who plays the interdisciplinary MMOG for 120 minutes may be able to close the mathematics achievement gap. This study provides the empirical evidence needed to support the claims that digital games are a learning tool that can support student achievement.

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APPENDICES

APPENDIX A: IRB APPROVAL

The University of Oklahoma

OFFICE FOR HUMAN RESEARCH PARTICIPANT PROTECTION

IRB Number: 11582
Amendment Approval Date: January 08, 2008

January 09, 2008

Mary John O'Hair, Ph.D.
Dept. of Education/K20 Center
3100 Monitor Drive, Suite 200
Norman, OK 73019

RE: IRB No. 11582: STAR: Networks for Emerging Technology Schools (NETS) - Pilot

Dear Dr. O'Hair:

On behalf of the Institutional Review Board (IRB), I have reviewed your protocol modification form. It is my judgement that this modification allows for the rights and welfare of the research subjects to be respected. Further, it has been determined that the study will continue to be conducted in a manner consistent with the requirements of 45 CFR 46 as amended; and that the potential benefits to subjects and others warrant the risks subjects may choose to incur.

This letter documents approval to conduct the research as described in:

Amend Form Dated: December 21, 2007
Survey Instrument Dated: December 21, 2007 Leadership Pre-Test

Amendment Summary:

Change in procedure:

1) Addition of assessment instrument designed to measure the impact of the educational game used on students.
2) Addition of Dixie Swearingen, as part of study personnel.

This letter covers only the approval of the above referenced modification. All other conditions, including the original expiration date, from the approval granted December 12, 2007 are still effective.

If consent form revisions are a part of this modification, you will be provided with a new stamped copy of your consent form. Please use this stamped copy for all future consent documentation. Please discontinue use of all outdated versions of this consent form.

If you have any questions about these procedures or need additional assistance, please do not hesitate to call the IRB office at (405) 325-8110 or send an email to irb@ou.edu.

Cordially,

Donald Baker, Ph.D.
Vice Chair, Institutional Review Board

Ltr_Amend_Final_Appv_Exp

660 Parrington Oval, Suite 316, Norman, Oklahoma 73019-3085 PHONE: (405) 325-8110 FAX: (405) 325-2373

The University of Oklahoma

OFFICE FOR HUMAN RESEARCH PARTICIPANT PROTECTION

IRB Number: 11582
Approval Date: November 12, 2008

November 13, 2008

Mary John O'Hair, Ph.D.
Dept. of Education/K20 Center
3100 Monitor Drive, Suite 200
Norman, OK 73019

RE: STAR: Networks for Emerging Technology Schools (NETS) - Pilot

Dear Dr. O'Hair:

Thank you for completing and returning the IRB Application for Continuing Review (Progress Report) for the above-referenced study. You have indicated that the study is still active. I have reviewed and approved the Progress Report and determined that this study was appropriate for continuation.

This letter documents approval to conduct the research as described in:
Protocol Dated: October 28, 2008 Revised
Assent Form Dated: October 23, 2008 Revised
Consent form - Parental Dated: October 23, 2008 Revised
Other Dated: October 28, 2008 Summary of Results
Cont Review Form Dated: November 10, 2008 Revised

Please remember that any change in the protocol, consent document or other recruitment materials (adverstisements, etc.) must be approved by the IRB prior to its incorporation into the study procedures. Submit a completed Protocol Modification form to the IRB office.

Approximately two months prior to the expiration date of this approval, you will be contacted by the IRB staff about procedures necessary to maintain this approval in an active status. Although every attempt will be made to notify you when a study is due for review, it is the responsibility of the investigator to assure that their studies receive review prior to expiration.

The approval of this study expires on November 11, 2009 and must be reviewed by the convened IRB prior to this time if you wish to remain in an active status. Federal regulations do not allow for extensions to be given on the expiration date.

If we can be of further assistance, please call the IRB office at (405) 325-8110 or send an email to irb@ou.edu.

Cordially

Donald Baker, Ph.D.
Vice Chair, Institutional Review Board

Ltr_Prog_Appv_Active
660 Parrington Oval, Suite 316, Norman, Oklahoma 73019-3085 PHONE: (405) 325-8110 FAX:(405) 325-2373

The University of Oklahoma

OFFICE FOR HUMAN RESEARCH PARTICIPANT PROTECTION

IRB Number: 11582
Amendment Approval Date: November 12, 2008

November 13, 2008

Mary John O'Hair, Ph.D.
Dept. of Education/K20 Center
3100 Monitor Drive, Suite 200
Norman, OK 73019

RE: IRB No. 11582: STAR: Networks for Emerging Technology Schools (NETS) - Pilot

Dear Dr. O'Hair:

On behalf of the Institutional Review Board (IRB), I have reviewed your protocol modification form. It is my judgement that this modification allows for the rights and welfare of the research subjects to be respected. Further, it has been determined that the study will continue to be conducted in a manner consistent with the requirements of 45 CFR 46 as amended; and that the potential benefits to subjects and others warrant the risks subjects may choose to incur.

This letter documents approval to conduct the research as described in:

Amend Form Dated: October 27, 2008
Assent Form Dated: October 23, 2008 Revised
Consent form - Parental Dated: October 23, 2008 Revised
Protocol Dated: October 28, 2008 Revised

Amendment Summary:

1) Change in maximum number of participants from 8000 to 6000.
2) Change in length of participation from "three times through the school year" to "during the school year".
3) Revised protocol to reflect change in length of participation.
4) Revised Assent Form and Parental Consent Form to reflect change in length of participation and change in maximum subject enrollment.

This letter covers only the approval of the above referenced modification. All other conditions, including the original expiration date, from the approval granted November 12, 2008 are still effective.

If consent form revisions are a part of this modification, you will be provided with a new stamped copy of your consent form. Please use this stamped copy for all future consent documentation. Please discontinue use of all outdated versions of this consent form.

If you have any questions about these procedures or need additional assistance, please do not hesitate to call the IRB office at (405) 325-8110 or send an email to irb@ou.edu.

Cordially,

Donald Baker, Ph.D.
Vice Chair, Institutional Review Board

Ltr_Amend_Final_Appv_Exp

660 Parrington Oval, Suite 316, Norman, Oklahoma 73019-3085 PHONE: (405) 325-8110 FAX:(405) 325-2373

University of Oklahoma
Institutional Review Board
Informed Consent to Participate in a Research Study

Project Title: STAR: Networks for Emerging Technology Schools (NETS): Pilot – Parent Consent for Student
Principal Investigator: Dr. Mary John O'Hair
Department: Educational Leadership and Policy Studies and K20 Center

You are being asked to consent to have your student volunteer for this research study. This study is being conducted at the K20 Center for Educational and Community Renewal at the University of Oklahoma. Your student was selected as a possible participant because your student's school has been working with the K20 Center on technology use.

Please read this form and ask any questions that you may have before agreeing to take part in this study.

Purpose of the Research Study

The purpose of this study is: to study the impact of teacher learning and computer-based scenario effects on student learning. As a part of the star schools project, students have an option to participate in a think-talk-through trial of the scenarios. Students will be asked to take a survey or talk through their reactions to specific math, language, science and social studies scenarios. This activity of the study will provide feedback on the scenarios and how well they help students learn. These scenarios will later be programmed as computer-based scenarios to help students learn grade-appropriate content to teach PASS skills.

Number of Participants

About 6,000 people will take part in this study.

Procedures

If you agree to allow your student to be in this study, your student will be asked to do the following: Read or listen to a problem-based scenario from their grade-level's learning objectives, describe how they solve the scenario, and/or complete a survey about the process. They will be asked to solve the scenario and/or complete a survey about the process. They will be asked to share what they liked and did not like about the problem-based learning process. This will help us refine the scenarios, before we program into a computer simulation.

Length of Participation This phase of the project will take about an hour or less of your student's time three times during the school year. The study will last through the school year.

This study has the following risks:

None. The scenarios use state approved learning objectives.

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Benefits of being in the study are providing possible technology use in the classroom.

Alternate Procedures Students not participating in the study will be given a teacher-developed alternative assignment from the course's normal lessons.

Injury

In case of injury or illness resulting from this study, emergency medical treatment is available. However, you or your insurance company may be expected to pay the usual charge from this treatment. The University of Oklahoma Norman Campus has set aside no funds to compensate you in the event of injury.

Confidentiality

In published reports, there will be no information included that will make it possible to identify your student without your permission. Research records will be stored securely and only approved researchers will have access to the records.

There are organizations that may inspect and/or copy your research records for quality assurance and data analysis. These organizations include the K20 Center for Educational and Community Renewal, University of Oklahoma, and the OU Institutional Review Board.

Compensation

Your student will not be reimbursed for you time and participation in this study.

Voluntary Nature of the Study

Participation in this study is voluntary. If your student withdraws or declines participation, your student will not be penalized or lose benefits or services unrelated to the study. If you decide to allow your student to participate, your student may decline to answer any question and may choose to withdraw at any time.

Waivers of Elements of Confidentiality

Your student's name will not be linked with your responses unless you specifically agree to be identified. Please select one of the following options

_____ I consent to allow my student being quoted directly.

_____ I do not consent to allow my student being quoted directly.

Request for record information

If you approve, your student's confidential records will be used as data for this study. The records that will be used include individual test score data. These records will be

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APPROVAL NOV 1 1 2009

used for the following purpose(s): to determine whether or not the scenarios impact student learning.

______ I agree for my student's school records to be accessed and used for the purposes described above.

______ I do not agree for my student's school records to be accessed for use as research data.

Photographing of Study Participants/Activities

In order to preserve an image related to the research, photographs may be taken of participants. You have the right to refuse to allow photographs to be taken without penalty. Please select one of the following options.

I consent to have my student photographs. ___ Yes ___ No.

Contacts and Questions

If you have concerns or complaints about the research, the researcher(s) conducting this study can be contacted at Dr. Mary John O'Hair, 405-325-2228 or mjohair@ou.edu, 3100 Monitor Drive, Suite 200, Norman, OK 73072.
Contact the researcher(s) if you have questions or if you have experienced a research-related injury.

If you have any questions about your student's rights as a research participant, concerns, or complaints about the research and wish to talk to someone other than individuals on the research team or if you cannot reach the research team, you may contact the University of Oklahoma – Norman Campus Institutional Review Board (OU-NC IRB) at 405-325-8110 or irb@ou.edu.

You will be given a copy of this information to keep for your records. If you are not given a copy of this consent form, please request one.

Statement of Consent

I have read the above information. I have asked questions and have received satisfactory answers. I consent to allow my student to participate in the study.

Student's Name School

Parent's Signature Date

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NOV 1 1 2009
EXPIRES

University of Oklahoma
Institutional Review Board
Informed Consent to Participate in a Research Study

Project Title: STAR: Networks for Emerging Technology Schools (NETS): Pilot –Student Assent
Principal Investigator: Dr. Mary John O'Hair
Department: Educational Leadership and Policy Studies and K20 Center

You are being asked to volunteer for this research study. This study is being conducted at the K20 Center for Educational and Community Renewal at the University of Oklahoma. You were selected as a possible participant because your school has been working with the K20 Center on technology use.

Please read this form and ask any questions that you may have before agreeing to take part in this study.

Purpose of the Research Study

The purpose of this study is: to study the impact of teacher learning and computer-based scenario effects on student learning. As a part of the star schools project, students have an option to participate in a think-talk-through trial of the scenarios. Students will be asked to take a survey or talk through their reactions to specific math, language, science and social studies scenarios. This activity of the study will provide feedback on the scenarios and how well they help students learn. These scenarios will later be programmed as computer-based scenarios to help students learn grade-appropriate content to teach PASS skills.

Number of Participants

About 6,000 people will take part in this study.

Procedures

If you agree to be in this study, you will be asked to do the following: Read or listen to a problem-based scenario from their grade-level's learning objectives, describe how they solve the scenario, and/or complete a survey about the process. They will be asked to solve the scenario and/or complete a survey about the process. They will be asked to share what they liked and did not like about the problem-based learning process. This will help us refine the scenarios, before we program into a computer simulation.

Length of Participation This phase of the project will take about an hour or less of your time three times during the school year. The study will last through the school year.

This study has the following risks:

None. The scenarios use state approved learning objectives.

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Benefits of being in the study are providing possible technology use in the classroom.

Alternate Procedures Students not participating in the study will be given a teacher-developed alternative assignment from the course's normal lessons.

Injury

In case of injury or illness resulting from this study, emergency medical treatment is available. However, you or your insurance company may be expected to pay the usual charge from this treatment. The University of Oklahoma Norman Campus has set aside no funds to compensate you in the event of injury.

Confidentiality

In published reports, there will be no information included that will make it possible to identify you without your permission. Research records will be stored securely and only approved researchers will have access to the records.

There are organizations that may inspect and/or copy your research records for quality assurance and data analysis. These organizations include the K20 Center for Educational and Community Renewal, University of Oklahoma, and the OU Institutional Review Board.

Compensation

You will not be reimbursed for you time and participation in this study.

Voluntary Nature of the Study

Participation in this study is voluntary. If you withdraw or decline participation, you will not be penalized or lose benefits or services unrelated to the study. If you decide to participate, you may decline to answer any question and may choose to withdraw at any time.

Waivers of Elements of Confidentiality

Your name will not be linked with your responses unless you specifically agree to be identified. Please select one of the following options

_____ I consent to being quoted directly.

_____ I do not consent to being quoted directly.

Request for record information

If you approve, your confidential records will be used as data for this study. The records that will be used include individual test score data. These records will be used for the following purpose(s): to determine whether or not the scenarios impact student learning.

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_____ I do not agree for my school records to be accessed for use as research data.

Photographing of Study Participants/Activities

In order to preserve an image related to the research, photographs may be taken of participants. You have the right to refuse to allow photographs to be taken without penalty. Please select one of the following options.

I consent to have my photographs. ___ Yes ___ No.

Contacts and Questions

If you have concerns or complaints about the research, the researcher(s) conducting this study can be contacted at Dr. Mary John O'Hair, 405-325-2228 or mjohair@ou.edu, 3100 Monitor Drive, Suite 200, Norman, OK 73072.
Contact the researcher(s) if you have questions or if you have experienced a research-related injury.

If you have any questions about your rights as a research participant, concerns, or complaints about the research and wish to talk to someone other than individuals on the research team or if you cannot reach the research team, you may contact the University of Oklahoma – Norman Campus Institutional Review Board (OU-NC IRB) at 405-325-8110 or irb@ou.edu.

You will be given a copy of this information to keep for your records. If you are not given a copy of this consent form, please request one.

Statement of Consent

I have read the above information. I have asked questions and have received satisfactory answers. I consent to participate in the study.

____

Student's Name School

____

Signature Date

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OU-NC IRB

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EXPIRES

APPENDIX B : PRETEST AND POSTTEST

LEADERSHIP PRE-TEST (Part A) ID ________________________

1. What mathematics class are you taking this year?

______ Algebra I ______ Algebra I & Support ______ Algebra II or Geometry

2. Do you play digital/video games? ______ Yes ______ No

3. Approximately how long do you play daily?

______ 0 – 1 hour ______ 1 – 2 hours ______ more than 2 hours

4. What is your favorite game? ____________________________

Why? (Please be specific)

5. What must a digital/video game “have” to keep you engaged?

LEADERSHIP PRE-TEST Part B

ID ______________________

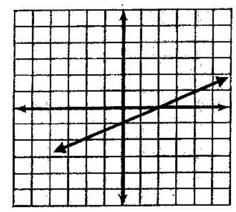
______ 1 What value of X makes this equation true? **4x - 10 = 18**

a) 2 b) 4 c) 7 d) 8

______ 2 Which line is graphed at right?

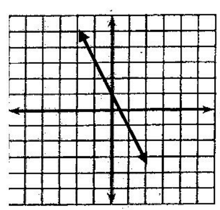
a) y = 1/2x - 1 c) y = 2x - 1

b) y = 1/2x + 2 d) y = -1/2x + 2

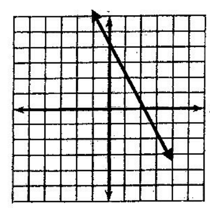


______ 3 Given the equation y = 2x + 1. Which line represents the equation when the slope is changed to -2?

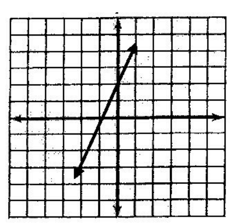
a)



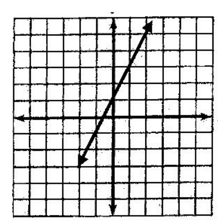
c)



b)



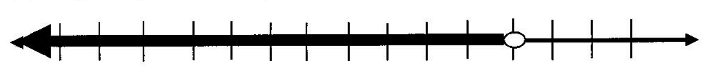
d)



______ 4 What is the solution to the inequality shown at right? **3x - 4 > -10**

a) x > -2 b) x<-2 c) x>2 d) x<2

______ 5 Which inequality is represented by the solution set shown:



a) x>5 b) x<5 c) $x \le 5$ d) $x \ge 5$

_______ 6 Adam, Dave, Kyla, and Dan gathered 100 eggs from the hen house. The table below shows what part of the total each one gathered.

NAME	PART GATHERED
Adam	1/4
Dave	0.31
Kyla	26%
Dan	9/50

Which lists the names in the order of the person who gathered the MOST eggs to the person who gathered the LEAST eggs?

a) Dan, Adam, Kyla, Dave

b) Adam, Kyla, Dave, Dan

c) Kyla, Dave, Dan, Adam

d) Dave, Kyla, Adam, Dan

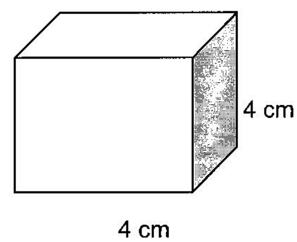
_______ 7 Ms. Johnson has a total of 325 papers to grade. She has graded 2/5 of the papers. How many more papers does Mrs. Johnson have left to grade?

a) 125 papers b) 130 papers c) 150 papers d) 195 papers

_______ 8 The length of each edge of the cube shown below is 4 centimeters (cm).

What is the surface area of the cube in square centimeters (cm^2)?

SA = $6e^2$



a) 32 cm^2 c) 48 cm^2

b) 64 cm^2 d) 96 cm^2

_______ 9 Find the volume of the cube shown above.
The answer will be in cubic centimeters. (cm^3)

Volume = e^3

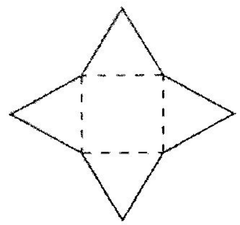
a) 64 cm^3 b) 16 cm^3 c) 12 cm^3 d) 96 cm^3

_______ 10 Given the following expression, translate it into an equation:
Four less than three times a number is the same as twice the number.

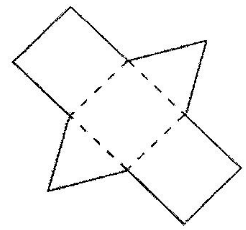
a) 3x - 4 = 2 b) 4 - 3x = 2x c) 3x - 4 = 2x d) 4 - 3x = 2x

______ 11 Which two-dimensional pattern can be folded to make a triangular prism?

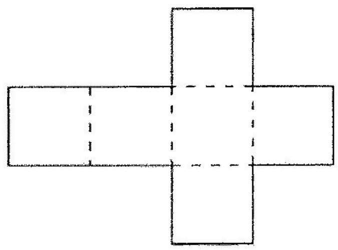
A



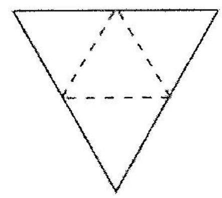
C



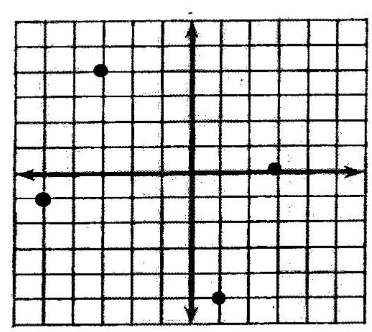
B



D



______ 12 Given the set of ordered pairs at right, which answer listed below has each point identified correctly?



a) (4, -3) (-1, -5) (0, 3) (-5, 1)

b) (4, -3) (-1, -5) (3, 0) (-5, 1)

c) (-3, 4), (-5, -1) (0, 3) (1, -5)

d) (-3, 4), (-5, -1) (3, 0) (1, -5)

______ 13 Simplify the following expression correctly:

$$\sqrt{144}$$

a) 72 c) 12

b) 36 d) 8

______ 14 Simplify the following expression: **3x - 5y - 2x + 11y**

a) x + 6y b) 5x + 16y c) $x^2 + 6y^2$ d) $5x^2 + 6y^2$

_______ 15 Given the following sets of numbers, find the mean, median, and mode:

75 87 0 84 74 85 74 81

a) mean: 80
median: 78
mode: 74

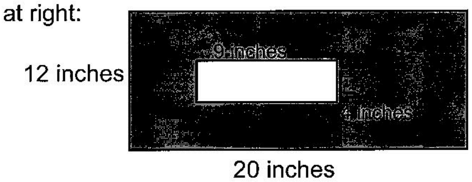
b) mean: 80
median: 79
mode: not one

c) mean: 70
median: 78
mode: 74

d) mean: 70
median: 79
mode: not one

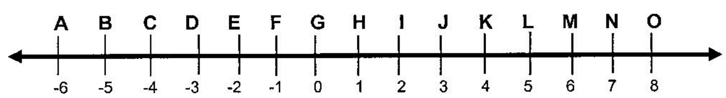
_______ 16 Find the area of the shaded region shown at right:
All measurements are in inches.

Area of rectangle = length x width



a) 204 in.^{2} b) 240 in.^{2} c) 276 in.^{2} d) 36 in.^{2}

_______ 17 Given the number line below, find the distance CM:



a) 10 b) -2 c) 2 d) 8

_______ 18 Simplify the following expression: **3X - 5Y, when X = -5 and Y = 7**

a) -50 b) -20 c) 50 d) 47

_______ 19 Find the absolute value of the problem at right: $|3x - 5|$ when x = -4

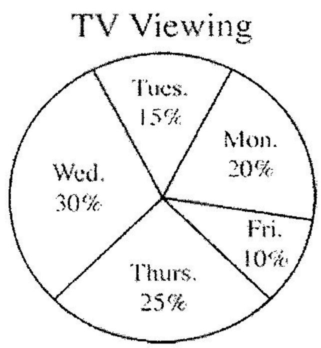
a) -17 b) 7 c) 17 d) -7

_______ 20 Eighth graders were asked about their favorite night to watch TV. The table below shows the results of the survey.

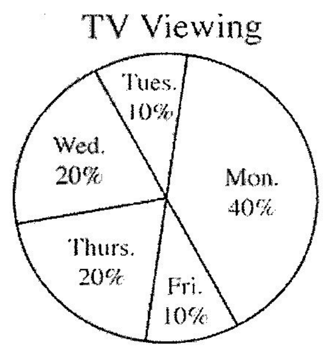
Day of Week	Percents
Monday	20
Tuesday	15
Wednesday	30
Thursday	25
Friday	10

Which graph below best shows the information from the table?

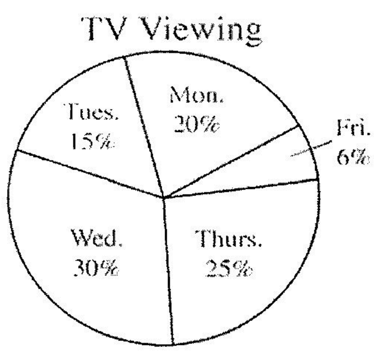
A



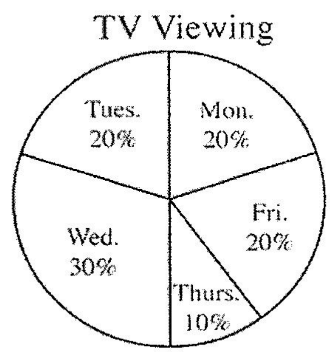
C



B



D



LEADERSHIP POST-TEST (Part A)   ID ______________________

1. Do you play digital/video games?   ______ Yes ______ No

2. Approximately how long do you play daily?

______ 0 – 1 hour   ______ 1 – 2 hours   ______ more than 2 hours

3. Have you used OddyseyWare during your math classes to sharpen your skills in mathematics?

______ Yes   ______ No

4. If you answered yes, approximately how often did you use this technology in school?

______ One period or less per week

______ Two periods per week

______ Three periods or more per week

5. Have you used any other technology, games or software to sharpen your skills in mathematics this semester?

______ Yes   ______ No

6. If you answered yes, approximately how long did you use the other technology weekly?

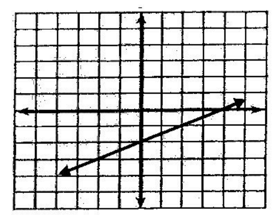
______ 0 – 1 hour   ______ 1 – 2 hours   ______ more than 2 hours

LEADERSHIP POST-TEST (Part B) ID # ____________________

______ 1 What value of X makes this equation true? $\frac{2}{3}x + -2 = -10$

a) -8 b) -10 c) -12 d) -24

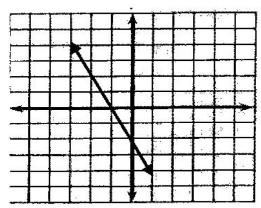
______ 2 Which line below is parallel to the line graphed at right?

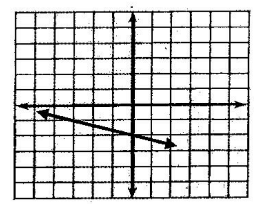


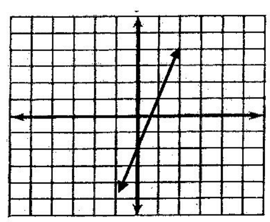
a) y = 1/2x +4 c) y = -2x - 1

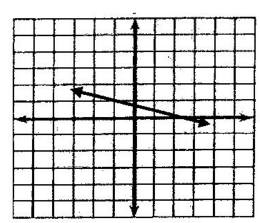
b) y = 2x + 2 d) y = -1/2x -5

______ 3 Given the equation y = 2x + 1. Which line represents the equation when the slope is changed to -1/3 and the y-intercept is changed to -2?

a)


c)


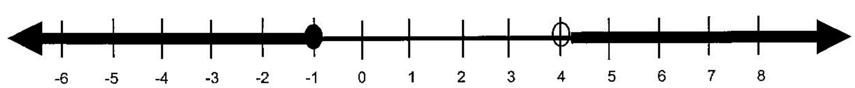
b)


d)


______ 4 What is the solution to the inequality shown at right? 5 - 2x > 9

a) x>-2 b) x<-2 c) x>2 d) x<2

______ 5 Which inequality is represented by the solution set shown:



a) $-1 \le x < 4$ b) $-1 < x < 4$

c) $x \le -1$ or $x > 4$ d) $x > 4$

_____ 6 Adam, Dave, Kyla, and Dan gathered 1000 eggs from the hen house. The table below shows what part of the total each one gathered.

NAME	PART GATHERED
Adam	1/3
Dave	34%
Kyla	.27
Dan	17/300

Which lists the names in the order of the person who gathered the MOST eggs to the person who gathered the LEAST eggs?

a) Dan, Kyla, Adam, Dave

b) Adam, Kyla, Dave, Dan

c) Kyla, Dave, Dan, Adam

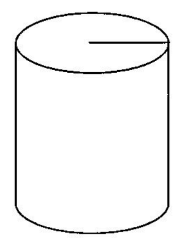
d) Dave, Adam, Kyla, Dan

_____ 7 Ms. Johnson has a total of 400 papers to grade. She has graded 2/5 of the papers but left 1/2 of the remaining papers at school. How many papers did she bring home to grade?

a) 120 papers b) 130 papers c) 160 papers d) 240 papers

_____ 8 The cylinder shown at right has a radius of 4 centimeters (cm). The height of the cylinder is 9 cm. What is the surface area of the cylinder in square centimeters (cm^2)?

$SA = 2\pi rh + 2\pi r^2$



a) 16π cm^2

b) 104π cm^2

c) 144π cm^2

d) 104 cm^2

_____ 9 Find the volume of the cylinder shown above.
The answer will be in cubic centimeters. (cm^3)

$V = \pi r^2 h$

a) 96π cm^3 b) 144π cm^3 c) 16π cm^3 d) 36π cm^3

_____ 10 Given the following expression, translate it into an equation:
four times the sum of a number and 11 is equal to -42

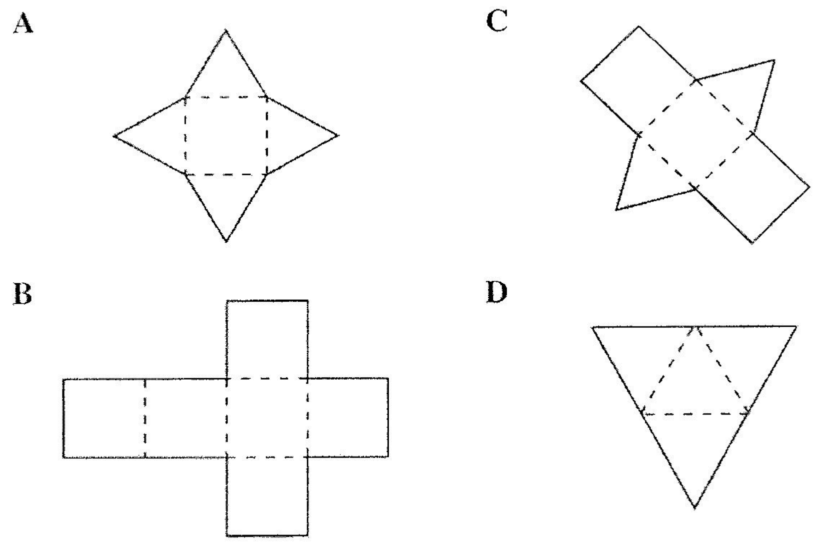
a) 4x + 11 = -42

b) 4(11x) = -42

c) 4 + x + 11 = -42

d) 4(x + 11) = -42

_______ 11 Which two-dimensional pattern can be folded to make a triangular prism?



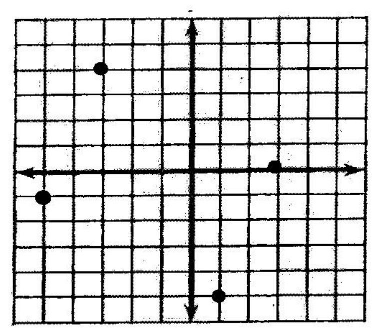
_______ 12 Given the set of ordered pairs at right, which answer listed below has each point identified correctly?

a) (4, -3) (-1, -5) (0, 3) (-5, 1)

b) (4, -3) (-1, -5) (3, 0) (-5, 1)

c) (-3, 4), (-5, -1) (0, 3) (1, -5)

d) (-3, 4), (-5, -1) (3, 0) (1, -5)



_______ 13 Simplify the following expression correctly:

$$\sqrt{144}$$

a) 72　　c) 12

b) 36　　d) 8

_______ 14 Simplify the following expression: **3x - 5y - 2x + 11y**

a) $x + 6y$　　b) $5x + 16y$　　c) $x^2 + 6y^2$　　d) $5x^2 + 6y^2$

_______ 15 Given the following sets of numbers, find the mean, median, and mode:

75 87 0 84 74 85 74 81

a) mean: 80
median: 78
mode: 74

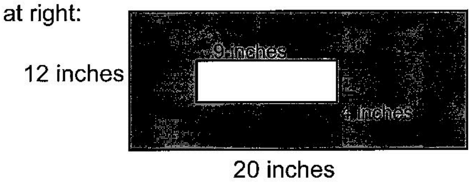
b) mean: 80
median: 79
mode: not one

c) mean: 70
median: 78
mode: 74

d) mean: 70
median: 79
mode: not one

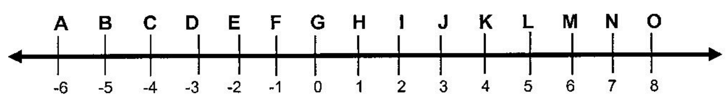
_______ 16 Find the area of the shaded region shown at right:
All measurements are in inches.

Area of rectangle = length x width



a) 204 in.^{2} b) 240 in.^{2} c) 276 in.^{2} d) 36 in.^{2}

_______ 17 Given the number line below, find the distance CM:



a) 10 b) -2 c) 2 d) 8

_______ 18 Simplify the following expression: **3X - 5Y, when X = -5 and Y = 7**

a) -50 b) -20 c) 50 d) 47

_______ 19 Find the absolute value of the problem at right: $|3x - 5|$ when x = -4

a) -17 b) 7 c) 17 d) -7

_______ 20 Eighth graders were asked about their favorite night to watch TV. The table below shows the results of the survey.

Day of Week	Percents
Monday	**20**
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Wednesday	**30**
Thursday	**25**
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Which graph below best shows the information from the table?

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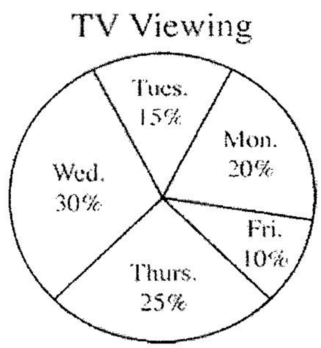
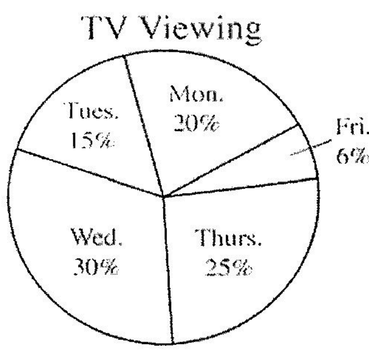
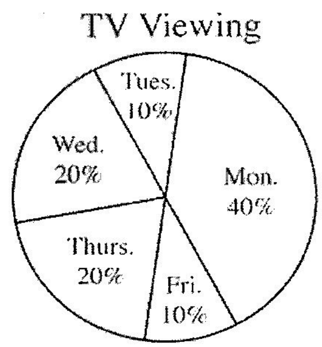


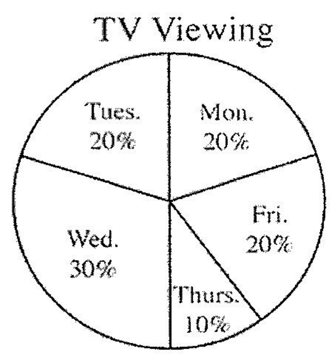
B



C



D



APPENDIX C: STAR SCHOOLS GAME CONTENT STANDARDS

STA\. CHOOLS
Game Content Standards
6.26.06

8TH & 9TH LANGUAGE ARTS	8TH MATH	ALGEBRA I	8TH SCIENCE	PHYSICAL SCIENCE	BIOLOGY I
	Measurement – use measurement to solve problems in a variety of contexts. Estimate surface area, apply knowledge of ratios and proportions, select and apply formulas for give situations, find a region of a region *C.4.*		**Observe & Measure** - SI, appropriate tools, qualitative and quantitative changes in a system ***P.1 all***	**Observe & Measure** - SI, appropriate tools, qualitative and quantitative changes in a system ***P.1 all***	**Observe & Measure** - SI, appropriate tools, qualitative and quantitative changes in a system ***P.1 all***
Comprehension/ Critical Literacy Literal understanding, inferences and interpretations, summary and generalization, analysis and evaluation ***8th Read& Lit3.1 all*** ***9th Read & Lit 2 all***	**Problem Solving** – develop & test strategies to solve practical, everyday problems, use technology to generate and analyze data. evaluate results, apply a variety of strategies, use multiple methods to model mathematical situations ***P.1 all***	**Problem Solving** – Apply a variety of problem solving strategies to solve problem within and outside mathematics, identify problem from describe situation, determine necessary data and apply problem-solving strategies ***P.1 all***	**Experimentation** – Ask questions about the world, evaluate the design of scientific evaluation, hypothesis, variables, & safety ***P.3.all***	**Experimentation** - Ask questions about the world, evaluate the design of scientific evaluation, hypothesis, variables, & safety ***P.3.all***	**Experimentation** - Ask questions about the world, evaluate the design of scientific evaluation, hypothesis, variables, & safety ***P.3.all***

8TH & 9TH LANGUAGE ARTS	8TH MATH	ALGEBRA I	8TH SCIENCE	PHYSICAL SCIENCE	BIOLOGY I
	Geometry – Classify solid figures *C3.1*		**Classify** ***P.2 al***	**Classify** ***P.2 all***	**Classify** ***P.2 all***
Grammar/Usage & Mechanics & Read/Information ***8 - Writing and Grammar 3 & Read & Lit 5 all*** ***9 – Writing & Grammar 1 all & Read & Lit 4 all*** **Modes & Forms of Writing** Write expository compositions, including analytical essays and research reports, reflective papers ***Writing and Grammar 2.2 all, 2.5 all***	**Communication** – discuss, interpret, translate, and evaluate mathematical idea, reflect on and justify reasoning, and select and use terminology when discussing mathematical concepts and ideas; use a variety of wasy to organize and record data ***P.2, 5 all***	**Communication** – use mathematical language and symbols to read and write math and to converse with others, demonstrate ideas orally and in writing, analyze math definitions and discover generalizations ***P.2, 5.2-3 all***	**Interpret & Communicate** – Graphs, Data Tables, predictions, & explanations ***P.4 all***	**Interpret & Communicate** – Graphs, Data Tables, predictions, & explanations ***P.4 all***	**Interpret & Communicate** – Graphs, Data Tables, predictions, & explanations ***P.4 all***

8th & 9TH LANGUAGE ARTS	8TH MATH	ALGEBRA I	8TH SCIENCE	PHYSICAL SCIENCE	BIOLOGY I
	Reasoning– identify and extend patterns, experiences, and observations to make suppositions. Use counter examples to disprove suppositions, develop and evaluate mathematical arguments, select & use various types of reasoning *P.3 all*	**Reasoning** – use various types of logical reasoning in mathematical contexts and real-world situations, prepare and evaluate suppositions and arguments, verify conclusions, identify counterexamples, test conjectures, and justify solutions to math problems, justify mathematical problems through proofs ***P.3 all***	**Inquiry** – use systematic observations, make accurate measurements, use technology to gather data, review and summarize data, make conclusions and/or explanations ***P.5 all***	**Inquiry** - use systematic observations, make accurate measurements, use technology to gather data, review and summarize data, make conclusions and/or explanations ***P.6 all***	**Inquiry** - use systematic observations, make accurate measurements, use technology to gather data, review and summarize data, make conclusions and/or explanations ***P.6 all***
Visual Literacy Interpret meaning, and compose visual messages ***Visual Literacy 1 & 3***	**Geometry** – Construct models, sketch and classify solid figures	**Representation** – Use algebraic, graphic, and numeric representations to model and interpret mathematical and real world situations ***P.5.1***		**Model** – Interpret a model based on observations, select predictions, and compare a given model to the physical world. ***P.5 all***	**Model** – Interpret a model based on observations, select predictions, and compare a given model to the physical world. ***P.5 all***
			Chemical Reactions – substances react and form new substances with different characteristics. *C.1.*	**tructure & Prop of Matter** - all matter is made of atoms and has characteristics *C.1 all*	

8th & 9TH LANGUAGE ARTS	8TH MATH	ALGEBRA I	8TH SCIENCE	PHYSICAL SCIENCE	BIOLOGY I
			Matter has properties that can be measured & matter is conserved *C. 1.2*	**Matter has characteristics that can be measured** *C.1.3*	**Matter is conserved** *C.5.2*
			Motion & Forces – Motion of an object can be measured and position, direction, and speed can be plotted on a graph. An object not subjected to a net force will continue in a straight line. ***C.2 all***	**Motion & Forces –** Motion of an object can be measured and position, direction, and speed can be plotted on a graph. An object not subjected to net force will continue in a straight line. Gravitation is universal force one mass exerts on another. ***C.2 all***	Specialized Cells enable organisms to monitor what is going on in the world around them eg: gravity ***C.6.1***

8th & 9TH LANGUAGE ARTS	8TH MATH	ALGEBRA I	8TH SCIENCE	PHYSICAL SCIENCE	BIOLOGY I
			Diversity & Adaptation of Organisms Classifying organisms, biologists consider internal and external structure which help the org to survive in a specific habitat ***C.3 all***		**Biological Diversity -** Species may look different but internal structures and chemical processes show evidence of common ancestry; species acquire characteristics through adaptation ***C.3 all***
			Structures & Forces of the Earth & Solar System Landforms result from constructive forces (volcanoes), rock cycle, and gravity governs motion of solar system; Earth History and fossils ***C.4all; C.5 all***	**Earth System & Gravity –** Geologists use fossils to correlate sequences of events, crust of earth exists in plates that press and pull apart at various locations (volcanoes), Gravitation is universal force one mass exerts on another. ***C.4 all; C.2.2***	

8^{th} & 9^{TH} LANGUAGE ARTS	8^{TH} MATH	ALGEBRA I	8^{TH} SCIENCE	PHYSICAL SCIENCE	BIOLOGY I
					Interdependence of Organisms – Organisms both cooperate and compete in ecosystems; population dynamics ***C.4.2-3***
		Calculate Slope, Graph Transformations, Interpret Slope, Equation of a line, equations, inequalities, system of equations, problem solving, and nonlinear funcions C.2.2-2.9			
				The Universe – Stars differ from each other but appear to be made of same elements on Earth; all stars have a life cycle ***C.5 all***	

8th & 9TH LANGUAGE ARTS	8TH MATH	ALGEBRA I	8TH SCIENCE	PHYSICAL SCIENCE	BIOLOGY I
				Interactions of Energy & Matter - energy interacts with matter and is transferred during these interactions. Waves have energy and transfer energy ***C.3 all***	**Matter and Energy Flow -** Complexity of organisms accommodates the need for energy flow. Matter and energy flow through living systems and the physical environment in different ways. ***C.5 all***
	Connections – Apply mathematical strategies to solve problems that arise from other disciplines, connect one area of math to another ***P.4 all***	**Connections –** link math ideas to the real world, apply math problem-solving skills to other disciplines, use math to solve problems in daily life, relate one area of math to another ***P 4 all***			
	Algebraic Reasoning Equations & Inequalities ***C.S. 1 all***	**Number Sense and AlgebraicOperations** Translate word phrases and sentences into equations and vice-versa. Simplify and evaluate linear, absolute value, rational, and radical expressions ***C.1 all***			

8th & 9TH LANGUAGE ARTS	8TH MATH	ALGEBRA I	8TH SCIENCE	PHYSICAL SCIENCE	BIOLOGY I
	Number Sense compare and order rational numbers, use basic operations on rational numbers to solve problems in real-life situations; ratios & proportions ***C.2.1***				
		Relations & Functions Distinguish between linear and nonlinear data, relations and functions, dependent and independent variables, tables, equations, and graphs ***C.2.1***			